Pegmatite Investigations 1942-45 New England

By EUGENE N. CAMERON and OTHERS

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This report is based on work done jointly by Eugene N. Cameron, David M. Larrabee, Andrew H. McNair, James J. Page, Glenn W. Stewart, and Vincent E. Shainin

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PEGMATITE INVESTIGATIONS, 1942–45, IN NEW ENGLAND

By Eugene N. Cameron, David M. Larrabee, Andrew H. McNair, James J. Page, Glenn W. Stewart, and Vincent E. Shainin

ABSTRACT

During 1942–46 the Geological Survey made an intensive study of New England pegmatites to aid in the exploration, development, and mining of pegmatite mineral deposits and to gain information concerning available reserves of mica, beryl, and other strategic pegmatite minerals. Detailed geologic maps were made of more than 300 pegmatites in Maine, Connecticut, and New Hampshire, and hundreds of other pegmatites were briefly examined. Most of the larger mines were mapped and studied periodically. The internal structure of the pegmatites was analyzed, and information on the distribution of minerals within pegmatites as well as on production, costs, and yields of deposits was accumulated.

New England pegmatites have been mined since 1803. From 1863 to 1869 the mica deposits of this region were the most productive in North America, and since 1869 have been an important domestic source of mica, although production has been intermittent. Mica production rose to record heights in 1943–44, under the stimulus of wartime demands. About 5,600 tons of crude mica was produced during this period and about 303,000 pounds of sheet and 503,000 pounds of punch with a total value of about $1,740,000 were obtained from the crude. Nearly all the mica came from Maine, New Hampshire, and Connecticut.

Feldspar mining in Connecticut was begun in 1825, and later spread to other New England states. Prior to 1920 the chief production was from Maine and Connecticut, but since that time New Hampshire has been the leading source of feldspar in New England. Production has fluctuated widely from year to year, but the general trend of production has been upward since 1920. The percentage of the total domestic production represented by that from New England, however, has markedly declined.

Most of the pegmatites examined lie in five districts: (1) the Topsham district, Maine; (2) the Paris-Rumford district, Maine; (3) the Grafton district, New Hampshire; (4) the Keene district, New Hampshire; and (5) the Middletown district, Connecticut. Most of the districts are in maturely dissected, glaciated uplands consisting of tree-covered hills separated by valleys that are occupied by permanent streams. Glacial till and soil form an extensive cover, and exposures are generally not abundant. The pegmatites crop out mostly on knolls and ridges. The exposed rock is not deeply weathered, and in most places the minerals are essentially unaltered, even at the surface.

The districts in which the pegmatites occur are underlain by metamorphic rocks, derived chiefly from Paleozoic sediments that have been metamorphosed as the result of folding and of repeated intrusion by igneous rocks. Quartz-mica schist is the most abundant rock type. The most widespread igneous rocks are granodiorites, quartz monzonites, and granites that form stocks, domes, sheets, and dikes, and have been intruded into the metamorphic rocks. Pegmatites are more abundant in the highly foliated metamorphic rocks than in the less distinctly foliated igneous rocks. The pegmatites range from bodies a few feet long and a few inches thick to those more than a mile long and hundreds of feet thick. Most bodies are less than 1,000 feet long and less than 100 feet thick.

Most of the pegmatites are flat, bluntly terminated lenses that seem to be greatly elongated along strike, but sheetlike bodies and some that are elliptical or even discoid are found. Although all the pegmatite mines in New England are shallow, several seem to have reached the bottoms of pegmatites. Some pegmatites are simple lenses constant in strike, dip, and thickness over much of their extent. Others show great variations in thickness, pinching, and swelling along strike or down dip. Many seeming irregularities in the walls are structural features that have systematic relationships to the form of the pegmatite body, and some are closely related to structural features of the country rock. Few of the pegmatites mapped show complete irregularity of form, although many have complex forms. In some districts the shapes of pegmatites in massive or poorly foliated rocks such as granite and granite-gneiss are simpler than those in well-foliated rocks, and in these districts simple discordant lenses are common in gneisses. Concordant bodies are the more common in schists.

The wall rocks of pegmatites are commonly tourmalinized, enriched in muscovite, or otherwise changed, but contacts of most of the pegmatites studied are sharp. The sharpness of contacts suggests that injection, either forceful or permissive, was the principal mechanism of pegmatite emplacement. Some pegmatites occupy tension fractures related to shear zones; dilatancy would appear to be a sufficient explanation of their emplacement. Other pegmatites appear to have been forcefully injected. This is shown by the patterns of minor folds in wall rocks adjacent to the pegmatites, as at the Strickland-Cramer mine, or by the pattern of flexures of foliation or bedding, or both, as in the Rice-Palermo area.

There are other pegmatites, however, that have gradational contacts with wall rocks, oriented inclusions with vague and gradational contacts, and inclusions in various stages of conversion to pegmatite. Room for pegmatites of this type has obviously been made in part by replacement of wall rocks. Whether replacement has been the major mechanism of emplacement or has been aided in greater or lesser degree by dilatancy or forceful injection is seldom clear.

Most of the pegmatites show some degree of systematic arrangement of their constituents and are divisible into two or more contrasting lithologic and structural units. Three principal types of lithologic and structural units are recognized: fracture fillings, replacement bodies, and zones. Fracture fillings are tabular bodies that fill fractures in existing pegmatite. They range from tiny veinlets to veinlike bodies about 100 feet in length and about 8 feet thick. They show a wide range in mineral composition, but most are composed of minerals that are late in the zone sequence. Replacement bodies are units formed by

replacement of existing pegmatite; most of them are controlled by fractures or other structural elements of a pegmatite body. They show a wide range of characteristics. Quartz, cleavelandite, and muscovite are especially characteristic of replacement bodies, and in most of the examples studied the muscovite is in wedge-shaped books. In many pegmatites, replacement bodies contain small amounts of comparatively rare minerals, but these minerals are not restricted to replacement bodies.

Zones are units of contrasting composition and texture that are systematically arranged with respect to the walls of a pegmatite body. In the ideal case, the zones are successive shells concentric about an innermost zone or core, but in many pegmatites the zones are incomplete, discontinuous, or asymmetrically developed. Four major types of zones are recognized: border zones, wall zones, intermediate zones, and cores. Pods are regarded as isolated segments of discontinuous cores and intermediate zones. The various types of zones differ in textural, mineralogical, and structural characteristics, and these differences have an important bearing on the distribution and extraction of commercially valuable minerals.

Study of the mineralogy of zones in individual pegmatites indicates that different mineral assemblages occur in a definite sequence from the walls of the pegmatites inward. The zones in nearly all the pegmatites have the following sequence: (1) Quartz-muscovite-plagioclase border zone; (2) quartz-plagioclase-sheet-muscovite zone; (3) plagioclase-perthite-quartz-muscovite zone with or without biotite; (4) perthite-quartz-plagioclase-muscovite zone with or without biotite; (5) perthite-quartz zone; (6) quartz core. Few pegmatites contain all the members of the sequence, but in any given pegmatite the members present occur in an order from the walls inward that corresponds to the general sequence given. Evidence at hand indicates that zones have developed successively from the walls inward, and not by replacement of existing massive pegmatite. Some fracture fillings are offshoots of inner zones into outer zones, and some replacement bodies have probably formed at the expense of outer zones during deposition of inner zones. Broadly considered, however, fracture fillings and replacement bodies are later than zones, entering into structural patterns that are imposed on zonal structure.

In this report, mineral deposits in pegmatites are classified according to the mode of distribution of the valuable minerals. On this basis, the following types of deposits are recognized: Border-zone, wall-zone, intermediate-zone, core, pod, fracture-filling, replacement, and disseminated deposits. Core-margin deposits are recognized as an additional special group. The name is applied to a deposit in the zone next to the core, commonly an inner intermediate zone.

Mineralogically the pegmatite bodies studied are mostly very simple, consisting essentially of quartz, plagioclase, perthite, and muscovite in various proportions. The common accessory minerals are biotite, black tourmaline, garnet, apatite, and beryl. Columbite-tantalite, spodumene, lepidolite, and amblygonite are common or abundant in a few pegmatite bodies but, like a host of other accessories, are generally rare in these pegmatites.

Nearly all the mica produced from the pegmatites during 1942–45 was muscovite, and the emphasis was on production of sheet and punch mica of grades and qualities suitable for war equipment. Most of the sheet and punch mica was sold to Colonial Mica Corporation, agent for Metals Reserve Company, and was prepared according to its specifications.

Five principal types of mica deposits are recognized: wall-zone, intermediate-zone, pod, fracture-filling, and disseminated deposits. Core and replacement deposits also occur but are of little economic importance. Core-margin deposits are an important subtype.

Wall-zone mica deposits are present in some pegmatites only adjacent to the hanging wall, but in others are present along both hanging and foot walls. In a very few pegmatites the wall-zone mica deposit is confined to the foot wall. Wall zones are more persistant and in general have been far more productive than any of the other types. The extent and richness of wall-zone deposits in some pegmatites are directly related to important structural features of the pegmatite walls. Essential minerals in wall-zone deposits are commonly quartz, albite or less commonly oligoclase, and muscovite. The general absence of potash feldspar and biotite is noteworthy.

The characteristics of intermediate-zone mica deposits vary with the positions of the zones in pegmatites. Generally, intermediate-zone deposits near the walls have structural and economic characteristics of wall-zone deposits. Deposits in zones near or adjacent to the core, however (such as core-margin deposits) commonly contain less mica than wall-zone deposits and are less uniform in mica content. These inner intermediate-zone deposits are discontinuous in many pegmatites, and extensive barren or nearly barren parts have led to abandonment of some operations. In most pegmatites that have an intermediate zone on both sides of the core, the two parts commonly differ in thickness, mica content, or content of recoverable sheet. Most core-margin deposits occur in pegmatites that have cores composed chiefly of quartz. Essential minerals in most of the intermediate-zone deposits are quartz, albite, and muscovite. Perthite is present in some deposits, particularly those adjacent to perthite-rich cores. Small amounts of tourmaline, beryl, columbite-tantalite, phosphates, and other minerals are present in some intermediate-zone deposits. Some inner intermediate-zone deposits contain only wedge or herring-bone mica.

In general, pods containing book mica also contain quartz, perthite, and plagioclase in various proportions. The mica books are intergrown with coarse plagioclase and quartz. The three minerals may occur along the pod margin or throughout the pod. Although they received much attention from prospectors during the war period, such deposits have not been important because most pegmatites contain only small, sparsely distributed pods. The pods are apt to differ in content and quality of mica in a given pegmatite, a feature that lends further uncertainty to mining operations.

Mica deposits of the fracture-filling type are common. The simplest are tabular bodies that fill simple fractures in pegmatite. Most are too small, too thin, and too low in average mica content to repay mining costs.

A pegmatite that contains sheet-bearing mica books scattered throughout its full width, except for the border zone, is called a disseminated deposit. In small parts of disseminated deposits the mica may be concentrated along the walls or in the vicinity of pods, but clearly defined, persistent concentrations are lacking. A few have been worth mining, but most are too low in content of sheet mica.

Replacement deposits are commonly irregular in shape, variable in mica content, and small. Muscovite in many of these deposits occurs in wedge-shaped books and is of inferior quality.

At the Nancy No. 1 mine, Groton, New Hampshire, a mica deposit has been formed in steeply dipping quartz-sillimanite schist that underlies a gently dipping pegmatite. The schist was impregnated with pegmatitic material, and many irregular lenses of pegmatite and isolated crystals of mica were formed by replacement of the schist.

Of the five principal types of mica deposits recognized, pod and disseminated deposits are probably most abundant. Few have been mined although many pod deposits have been prospected. Wall-zone and intermediate-zone deposits are less numerous. Replacement bodies of sufficient size to warrant prospecting appear to be rare. The core type is least common and was the only type not mined during World War II. Several pegmatites studied contain two types of deposits. The most common combination in operating mines consisted of a wall-zone and a core-margin deposit. Pod deposits and fracture-filling deposits occur together in some pegmatites, but though many have been prospected, few have sustained either profitable or lengthy operations.

Wall-zone and outer intermediate-zone mica deposits are richer in mica and have been far more productive than any other type. Next in richness and productivity are the inner intermediate-zone deposits.

Production statistics also indicate that wall and outer intermediate-zone deposits gave higher yields of sheet mica from crude mica than inner intermediate-zone deposits, but as other factors affect the yield the significance of the production record is in doubt.

No sharp distinction can be drawn between barren and productive pegmatites. Mica deposits are not coextensive with the pegmatites in which they occur. For profitable mining not only the right pegmatite, but the right part of it must be found. In general, the productive pegmatites are those that possess a series of clearly defined zones. Well-zoned pegmatites therefore deserve particular attention from prospectors, as they may contain wall-zone or intermediate-zone deposits, the principal sources of sheet mica in New England in the past. The presence of plagioclase-rich zones along the walls of a pegmatite, although by no means infallible, is the best known indication of the possible presence of a wall-zone deposit. The presence of much potash feldspar or biotite is an unfavorable indication.

During World War II the Keene district was the most productive of the five, the Grafton district second, and the Middletown district third. Production from Maine was small. The recovery of sheet and punch mica from crude mica was higher for the two New Hampshire districts than for the Middletown district. Nearly four-fifths of the total yield of sheet mica from New England mines was of No. 1 and No. 2 qualities. Of the three most productive districts the Grafton district produced the highest percentage of sheet mica of these qualities.

Some mines were much more productive than others, and 10 mines yielded 51.6 percent of the total New England production of crude mica, 56.9 percent of the sheet mica, and 59.2 percent of the punch mica. Compared to the less productive mines, the 10 most productive mines were characterized by higher yield of crude mica from rock mined and higher yield of sheet and punch mica (expressed as equivalent sheet). The yield of crude mica from rock moved at various mines ranged from 0.12 percent to 12.0 percent, and more than anything else this variation in yield explains why some mines were profitable, others highly unprofitable. Other important factors were efficiency in mining and processing the mica.

The postwar outlook for New England mica mines operated during the war is poor, as it seems likely that the dollar yield per ton of crude mica will be appreciably lower than during the war, and analysis of wartime operation indicates that with lower dollar yields few mines could be operated at a profit.

No clear-cut answer can be given to the question of how much mica is available in the deposits of New England. As a conservative estimate, it appears that under economic conditions comparable to those of 1943–44, minable reserves in known deposits would sustain operations for four years at the 1943–44 rate of about 2,550 tons of crude mica per year. Total reserves under such conditions may be much greater.

The rate of New England production during the war years was considerably below the maximum that could be achieved by concentrating effort on the richer and potentially more productive mines.

The ultimate life of the industry, of course, depends not only on the size of resreves in known deposits, but also on the future rate of discovery of new deposits sufficiently rich to repay mining costs. The discovery rate of 1942–44 is not encouraging; most of the production came from deposits already known. Surface prospecting appears to have reached the point of diminishing returns, hence further discoveries will depend in a large degree on the application of geologic data and modern methods of prospecting.

New England feldspar deposits have chiefly yielded potash feldspar for ceramic uses.

The commercial feldspar-producing pegmatites examined are of five types:

1. Distinctly zoned pegmatites containing a perthite core and an intermediate zone consisting of graphic granite or coarsely intergrown perthite and quartz.
2. Zoned pegmatites containing a core of perthite and quartz, graphically intergrown in part, and a wall zone relatively rich in quartz and plagioclase. In such deposits only the core is removed in feldspar operations.
3. Pegmatites containing a hood-shaped zone of perthite extending over the crest of a quartz core.
4. Pegmatites containing small isolated pods of microcline and quartz surrounded by an intermediate or wall zone of plagioclase, microcline, and quartz. Pod deposits have not been successfully exploited because only small quantities of feldspar can be removed from them.
5. Pegmatites containing mixed or intergrown feldspar minerals from wall to wall. Such pegmatites have not been very productive in the past because the feldspar is difficult to sort by hand. If inexpensive milling techniques were developed, numerous pegmatites of this type in New England could be used as sources of high-grade feldspar.

According to their mode of occurrence in pegmatites, New England beryl deposits can be classified into the following types: Border-zone, wall-zone, intermediate-zone (including core-margin), core, pod, and disseminated deposits, fracture-fillings, and replacement deposits. In general, beryl crystals large enough to be hand-sorted are most abundant in inner intermediate-zone, core, pod, fracture-controlled, and replacement deposits. Beryl in border-zone deposits occurs in crystals too small to repay hand-sorting. In none of the types of deposits is the content of beryl sufficient to justify mining for beryl alone and, barring a marked change in the value of beryl, this will probably hold true even while methods of separating the constituents of pegmatites by milling are developed.

One hundred and eighty mines and prospects are described in the report, and the geology of the pegmatites worked is discussed. Most of the mine and prospect descriptions are accompanied by geologic maps and sections. The occurrence of commercially valuable minerals in each mine is described and, wherever possible, a statement as to future potentialities is given.

INTRODUCTION

The manufacture of war equipment created shortages of mica, beryl, tantalite and other pegmatite minerals early in World War II. Therefore, in 1942 the War Production Board, through the Metals Reserve Company and the Colonial Mica Corporation, sponsored a program for intensive exploitation of domestic deposits. Geologic information to guide the exploration, development, and mining of pegmatite deposits was needed, and for this reason the Geological Survey included in its Strategic Minerals Investigations an intensive study of domestic pegmatite deposits. In New England this work began in 1942 and continued into 1945.

More than three hundred New England pegmatite bodies were mapped in detail, and some hundreds of others were given brief examinations. Attention was focused on tantalite in May and June of 1942 and on beryl and sheet-mica deposits in the latter part of 1942 and early 1943. When the demand for beryl declined in mid-1943, the emphasis was shifted to deposits of sheet mica, which continued to be in short supply until the latter half of 1944. Although the studies were chiefly concerned with mica and beryl pegmatites, much information on the occurrence of commercial deposits of feldspar and other pegmatite minerals also was obtained.

Under the stimulus of war-time demands, more pegmatite deposits were operated in New England in 1942–45 than during any previous period of comparable length. This intensive exploitation created a unique opportunity for systematic investigation of pegmatite deposits, and for the correlation of geologic features of the deposits with economic data. The investigations were thus carried on under exceptionally favorable conditions.

The structures of many pegmatites were analyzed in the course of the investigation, and the relationships of structural features to the distribution of valuable minerals were so clarified that the results can be applied to problems of mining, prospecting, and estimating of reserves. Deposits of mica, beryl, and other minerals in pegmatites comprise only a small number of structural types. The characteristics of the various types were studied and correlated with analyses of production data. In addition, information about available reserves of pegmatite minerals and about potentialities of individual mines was compiled.

In this report the characteristics of the pegmatite mineral deposits studied are discussed, and applications to mining, development, and exploration are indicated. The investigations are not complete, because it was necessary to work rapidly and to emphasize field work on the economic aspects of pegmatites at the expense of those laboratory studies that are essential to comprehensive scientific analysis of any group of mineral deposits. This is a progress report indicating the status of investigation and knowledge of the pegmatites of Connecticut, Maine, and New Hampshire at the end of 1945.

LOCATION OF PEGMATITE DISTRICTS

The deposits examined in the course of the present study lie in southwestern Maine (fig. 1), southwestern and central New Hampshire, and central and western Connecticut. Most of the deposits fall within five fairly well defined districts, as follows:

1. Topsham district, Maine. This district includes a number of deposits in the towns of Topsham, West Bath, Georgetown, and Phippsburg.
2. Paris-Rumford district, Maine, including the towns of Waterford, Rumford, Newry, Greenwood, Albany, Paris, and Peru.
3. Grafton district, New Hampshire, including the towns of Warren, Wentworth, Rumney, Grafton, Canaan, Alexandria, Orange, Groton, Dorchester, Wilmot, Springfield, and Danbury. The locations of individual mines and prospects examined in this district are shown on plate 1.
4. Keene district, New Hampshire, including the towns of Gilsum, Alstead, Marlow, and Keene. The locations of individual mines and prospects examined in this district are shown on plate 2.
5. Middletown district, Connecticut, including parts of the towns of Portland, Glastonbury, Haddam, Middletown, and East Hampton. The locations of mines and prospects examined in this district are shown in figure 6.

A few pegmatite deposits in Massachusetts yielded small amounts of mica and beryl during the war. These were not investigated by the authors and are not included in this report.

PREVIOUS WORK

New England pegmatites have attracted the attention of many geologists, as sources of various minerals, as a geologic problem of unusual interest, and as the locus of commercial deposits of mica, feldspar, and other minerals. Consequently the literature on New England pegmatite deposits is extensive. The articles are of two types: (1) papers describing the economic geology of pegmatite bodies, and (2) contributions to the mineralogy of pegmatites. The following summary is restricted to selected articles of the first type. An extensive bibliography of New England pegmatites, but including many other articles dealing with pegmatites is to be found on pages 341–347.

The reports of Jackson in 1844 and C. H. Hitchcock in 1874 refer briefly to New Hampshire pegmatite mines. Crosby and Fuller discussed the origin, structure, and genesis of pegmatites in 1897 and made numerous references to pegmatites in New Hampshire and Massachusetts. The first systematic study of a group of New England pegmatites, however, was presented by Bastin in a series of articles in 1907, 1910 and 1911. The feldspar deposits of New England, in particular those of southwestern Maine, were discussed, and the geologic setting and origin of Maine pegma-

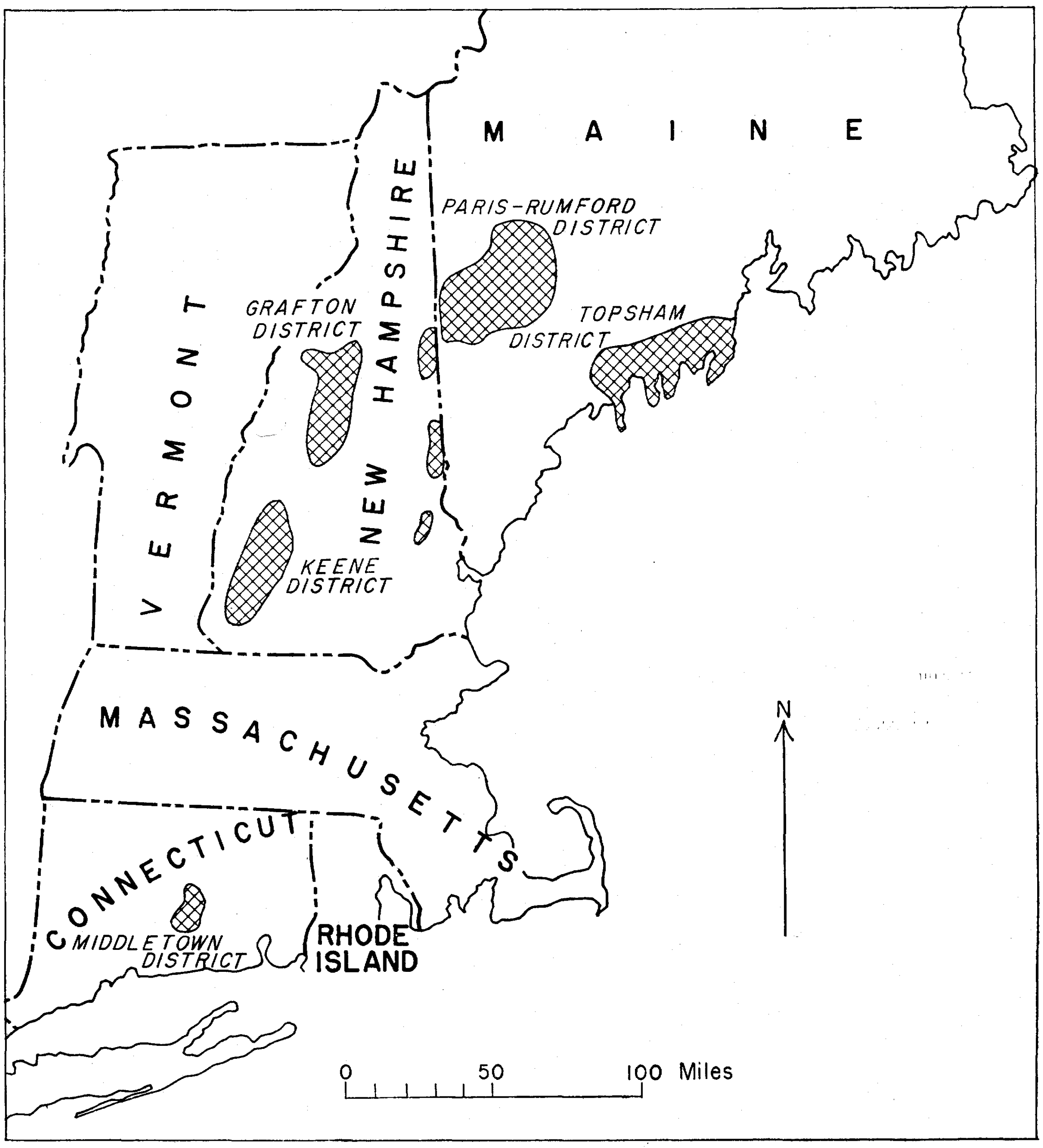

FIGURE 1.—Index map showing principal pegmatite districts of Maine, New Hampshire, and Connecticut.

tites was treated in these articles. In 1926, Watts described feldspar mines in Maine, Massachusetts, and Connecticut.

Investigations of mica deposits by Sterrett over a period of twenty years led (in 1914 and 1923) to two publications in which nearly 100 mines and prospects in Maine, New Hampshire, and Connecticut were described, and many were illustrated by maps and diagrams. This work has been the principal source of information regarding New England mica deposits for many years.

In 1929, G. R. Megathlin briefly discussed the characteristics and origin of a group of pegmatites in the Gilsum area, New Hampshire. In 1940, J. C. Olson examined most of the New Hampshire mica mines and prospects and mapped certain important mines. An area in the vicinity of Alstead, N. H., was mapped in detail to reveal the extent and structural relations of the pegmatites. Characteristics of the deposits were tabulated and discussed briefly, and a description of types of mica deposits was given.

Field studies by H. M. Bannerman in 1941–42 are of special interest, for the approach and techniques used in the present work are an outgrowth of Bannerman's work, which combined mapping of selected mica producing-areas in the Grafton district with studies of structure and mineral occurrence in individual pegmatites (Bannerman, 1943).

Studies by L. R. Page and J. B. Hanley, of the Geological Survey, in the spring and early summer of 1942, resulted in brief manuscript reports on a number of pegmatite deposits in Maine and New Hampshire. Their maps and reports have been used in the present report. Credit is given in appropriate places in the text. Detailed descriptions of a number of individual pegmatites have been given by various authors, among them Williams and Palache, Shaub, Switzer, Jenks, Landes, and Fraser.

Several general studies have furnished valuable information on the broader geologic relationships in the various districts. Studies by a group of investigators in New Hampshire under the direction of M. P. Billings have been particularly useful, as these workers have mapped and described a number of the quadrangles in which pegmatite deposits occur. The writers are indebted to Billings and his co-workers, in addition, for the use of the then unpublished maps of the Plymouth, Holderness, Claremont, Sunapee, and Bellows Falls quadrangles.

SCOPE AND PERSONNEL OF THE PRESENT INVESTIGATIONS

In the present investigations, techniques seldom applied to pegmatites but long used in studying other types of mineral deposits have been employed. The work has involved field study of the structure of pegmatites and the distribution of minerals within them, and depiction of these features by means of maps, structure sections, plans of workings, and other diagrams on scales commonly ranging from 80 feet to 1 inch to 10 feet to 1 inch. In the earlier stages of the work, scales as small as 200 feet to 1 inch were used for maps of deposits, but experience has shown that in studying individual deposits a scale of 20 feet to 1 inch is commonly necessary. Mapping was done by telescopic alidade or engineer's transit, unless otherwise stated on the accompanying maps. Progress maps of many mines were made periodically by use of tape and compass. Some mines were completely remapped at intervals. This was made necessary by the nature of New England pegmatite mining, particularly opencut mining. At some mines later stages of operations obliterated earlier workings making maps of the early workings useless.

Repeated visits to the mines have given a comprehensive picture of many pegmatites whose structures would not have been revealed by single visits, and have made it possible to keep maps abreast of mining operations. In many mines the geologic features observed during successive visits have been correlated with production data furnished by mine operators and by the Colonial Mica Corporation, making it possible to determine the bearing of geologic relationships on the practical problems involved in the recovery of pegmatite minerals.

In the course of the work, a vast amount of data on percentages of crude mica from rock mined, recovery of sheet mica from crude mica, and sizes and quantities of sheet mica produced at various mines was accumulated. Many of these data were obtained on a confidential basis and therefore few of them appear in the descriptions of individual mines. Syntheses of the data are presented, however, in the analysis of the wartime mica industry of New England (pp. 44–49).

Study of individual deposits was emphasized, but selected larger areas were mapped, mostly by pace-compass methods. Mapping was adopted chiefly as a means of prospecting for mica or beryl, but partly to disclose the group characteristics of pegmatites and their relationships to associated rocks.

The work was begun in New Hampshire in 1941 by J. C. Olson, and continued there and in Maine in May 1942 by L. R. Page and J. B. Hanley under general supervision of D. F. Hewett and G. R. Mansfield. It was expanded to cover Connecticut deposits in the fall of 1942. The program was under the general supervision of H. M. Bannerman from June 1942 to September 1944, during which period the scope of investigations expanded greatly. E. N. Cameron supervised the work from September 1944 through 1945. Field work in New England was directly in the charge of Bannerman, 1942 to 1943; Cameron, 1943 to 1944; and A. H. McNair, 1944 to 1945. Men in charge of field parties were E. N. Cameron (1942–44). D. M. Larrabee (1942–45), A. H. McNair (1942–45), J. J. Page (1943–45), L. R. Page (1942), V. E. Shainin [1] (1943–45), G. W. Stewart (1943–45), C. S. Maurice (1942), and J. B. Hadley (1944). They were assisted by K. S. Adams (1944–45), W. H. Ashley (1943), G. H. Brodie (1942), R. P. Brundage [2] (1943), G. B. Burnett (1942), J. T. Callihan (1942), D. W. Caldwell (1944), A. H. Chidester (1944), J. H. Chivers (1943), E. Ellingwood, III (1943), N. K. Flint (1943–44), I. S. Fisher (1942), P. W. Gates [2a] (1944), L. Goldthwait (1943), J. B. Hanley (1942), J. B. Headley, Jr. (1942), W. M. Hoag (1943), H. Kamensky (1943), H. R. Morris (1943), and F. H. Main (1944–45).

In addition to working in the field, K. S. Adams and F. H. Main redrafted and rearranged the maps,

[1] Died June 1950.
[2] Died in action on Okinawa, May 3, 1945.
[2a] Died in service, Fort Belvoir, Va., April 20, 1947.

sections, and other illustrations used in this report, prior to the final preparation for publication. Their contribution is gratefully acknowledged.

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The writers are indebted to mine operators and owners for many courtesies and for cordial cooperation that greatly facilitated the work and is responsible for much of its practical value. The work was carried on in close cooperation with officials of the New England office of the Colonial Mica Corporation, especially Messrs. O. P. Peterson and R. S. Dent, who have furnished production data indispensable to practical applications of the work. Exploratory projects carried on in cooperation with the U. S. Bureau of Mines have also contributed data on several deposits.

Dartmouth College, Hanover, N. H. furnished office, laboratory, drafting room, and library facilities to members of the Survey parties throughout the investigations, and assisted them in many ways. The writers are grateful to Prof. J. W. Goldthwait,[3] formerly Chairman of the Geology Department, and to his colleagues. Wesleyan University, Middletown, Conn., also furnished office and laboratory space in 1943 for parties working in the Middletown district, and the writers extend their thanks to Dr. C. S. Denny for his many courtesies in this connection.

During the investigations discussed in this report, the U. S. Bureau of Mines explored a number of pegmatite bodies by trenching, diamond-drilling, and other means. The Geological Survey examined the trenches and other surface works made during exploration, spotted drill holes at some deposits, and logged the cores of the drill holes. In this way much information pertinent to the present report was obtained.

Mr. Edward Ellingwood and Professor T. R. Meyers have also cooperated in furnishing maps and information at the disposal of the New Hampshire State Planning and Development Commission. Dr. Joseph M. Trefethen, Maine State Geologist, has cooperated in planning field work in Maine pegmatite districts and in the exchange of information. Dr. E. L. Troxell, Superintendent of the Connecticut Geological and Natural History Survey, has maintained a lively interest in the work. In the summer of 1944, an informal cooperative program of work on Connecticut pegmatities was arranged between his organization and the Federal Survey.

The work of the writers in 1943 and 1944 emphasized and further developed certain concepts of pegmatite structure and of the distribution of minerals within pegmatites that previously had been found to be useful in the analysis of pegmatite deposits. During this period groups were working along similar lines in the Southeastern United States, Idaho, Montana, Colorado, New Mexico, Wyoming, and South Dakota and were using techniques similar in all essential respects. Discussions between the New England group and the other groups held in the fall of 1944 and in 1945, have done much to clarify and extend the understanding of pegmatite structure and mineralogy and have also correlated findings in the various districts. The results are a uniform nomenclature for the features of pegmatites and a classification of pegmatite deposits that are a joint effort in every sense. The symbols and system of presentation used on accompanying maps and diagrams are likewise the results of joint agreement.

HISTORY OF PEGMATITE MINING IN NEW ENGLAND

Pegmatite mining in New England was begun in 1803 with the opening of the Ruggles mine in Grafton, New Hampshire.[4] Mica was the mineral sought at first, but feldspar mining was started in Connecticut about 1825 and in later years spread to other New England states. Since about 1900 the value of feldspar produced has in many years exceeded that of mica. Records of pegmatite mining are fragmentary. Most of the operations, particularly those for mica, have been intermittent, chiefly owing to fluctuations in the demand and prices for sheet mica.

MICA MINING

In 1810 the Big mine was opened and shortly thereafter other mica mines were opened in the Keene district of New Hampshire. Mount Mica, in Paris, Maine, may have yielded mica soon after its discovery in 1820. Between 1830 and 1840 the Ruggles mine and other mines in the vicinity are known to have been operated, and during this period New Hampshire and New Mexico were probably the only mica-producing states in the nation. As the demand for large-size sheet mica for stove use increased, the production from the state rose rapidly until 1869, when the Ruggles mine alone produced 26,250 pounds of sheet mica valued at $60,000 (Hitchcock, 1878, p. 90). In this year, however, New Hampshire yielded first place as a mica-producing state to North Carolina.

From 1870 to 1899 New Hampshire continued to be a leading producer of sheet mica, but its production declined owing to competition from the rapidly growing mica industry of North Carolina. In 1877 the production of the Ruggles mine was only 3,600 pounds of

[3] Died Dec. 31, 1947.

[4] Information for this section has been obtained chiefly from Dubois (1940), and from annual volumes of Mineral Industry (1892-1941), Mineral Resources of the United States (1882-1931), and Minerals Yearbook (1932-43).

sheet mica valued at $7,200 (Hitchcock, 1878, p. 90), and in 1880 the total production of New England was only 39,000 pounds; 36,000 pounds from three New Hampshire mines, the remainder from a mine in Massachusetts and one in Maine. Many mines were operated in New Hampshire during 1877–78—the Ruggles, Kilton, and Alger mines in Grafton; the Hoyt Hill mine in Orange; the Valencia and Palermo mines in Groton, the Mud mine in Alexandria, and the French mine in Alstead. The Valencia mine, opened in 1880, was a large producer between 1884 and 1896. The Mud mine, opened in 1883, produced 90 percent of the New England sheet mica output in 1885 and 60 percent in 1886. In Maine, mines in Edgecombe and at Mount Mica were active in 1883, and from 1890 to 1906 small amounts of mica were obtained as a byproduct of feldspar mining in Connecticut, at the Roebling mine in New Milford and the Strickland mine in Portland. The Elliot mica mine in Rumford, Maine, was opened in 1898.

A marked decline in mica production followed the first importation of India mica in 1884 and was accentuated by the importation of Canadian mica in 1886, when all mica entered duty free. In addition, the excessive cost of large-sized sheets of mica (up to $11.00 per pound) caused stove manufacturers, the principal consumers of sheet mica, to reduce the size of stove panels. A decline in production of large-sized sheet and in the average sale price of mine-run mica resulted. In 1890, however, the McKinley tariff against imported mica was established. Domestic production increased subsequently, but it is doubtful whether the increase was due to the tariff or to increasing demand by the electrical industry for small-sized sheet used in micanite (built-up mica).

In the late 1880's small sales of scrap mica for grinding partly offset the decline in the market for domestic sheet mica. Ground mica did not become a staple commodity, however, until 1894, when 106 tons of scrap mica was sold from New Hampshire.

Between 1900 and 1913 the production of sheet and scrap mica was greater than ever before, due partly to increased use of smaller-sized sheet mica and to acceptance of domestic sheet mica for use in the electrical industry. During the period, however, New England's production ranged from 43 percent (1900 and 1913) to less than 3 percent of total United States production. Most of the output came from New Hampshire, and was recovered from dumps of mines where the small-sized books had earlier been discarded. The Big, Hoyt Hill, United, Fletcher, Atwood, and Mud mines were among those worked. Scrap mica operations at Black Mountain, Maine, yielded an average of 250 tons per year from 1901 to 1905.

Fluctuations in production of mica from 1912 to 1944 are summarized in figure 2. Important producing mines between 1912 and 1941 were the Ruggles, Valencia, Strickland (1912–37), Mud (1916–30), French, Big, Ruby, Rice, and Standard mines. From 1924 to 1930 New Hempshire was the country's leading producing state, and in 1926 produced 63 percent of the total domestic mica. The production from Maine and Connecticut was largely a by-product of feldspar mining. In 1935, however, the output from the Strickland-Cramer deposit made Connecticut the leading mica-producing state in New England. Scrap mica production continued during the period, and in 1938 a grinding mill was built at Penacook, N. H., by the Concord Mica Company.

With the entry of the United States into World War II, demands for mica of the higher qualities were greatly increased, and various Government agencies undertook to stimulate domestic production. In June 1942, Colonial Mica Corporation, a non profit organization financed by Metals Reserve Company, was made agent of the War Production Board to purchase sheet mica for war industries. The corporation maintained offices in Newport, N. H. and Middletown, Conn.,

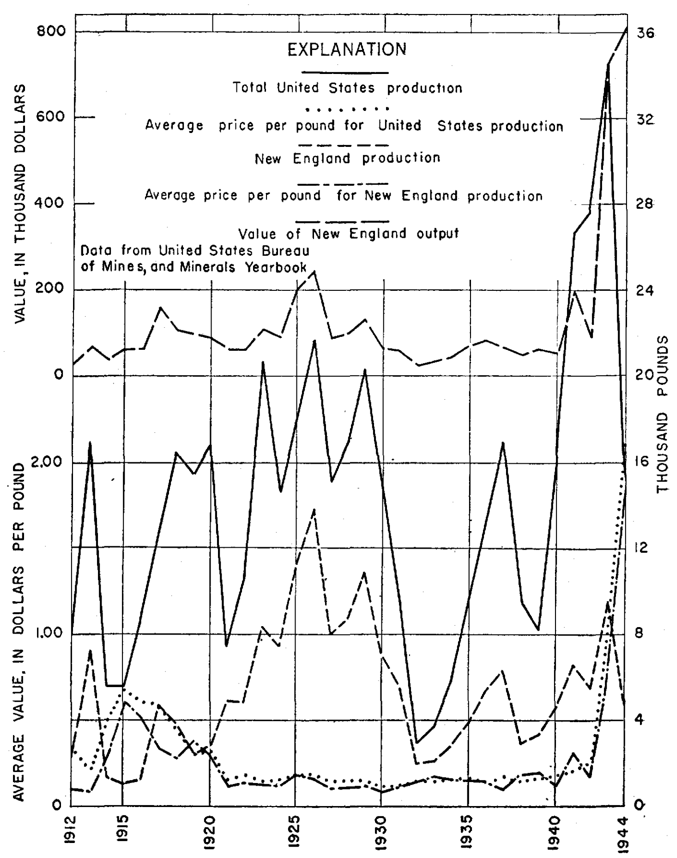


FIGURE 2.—Production of uncut sheet and punch mica in New England and in the United States, 1912–1944, weight in pounds, and value.

leased mining equipment and supplies, assisted in the development of mica deposits, and gave instruction to operators of mines and processing shops. Advances against production were made to mine operators.

Only a few mines (see table, p. 10) were in operation at the beginning of this period, but under the stimulus of high prices offered for certain qualities of sheet mica by Colonial Mica Corporation, many old mines were reopened and new prospects were investigated. Activity reached a peak in the second half of 1943 and the first half of 1944, when 70 to 80 mines were in operation. In September 1944 a decrease in subsidy prices was announced for the first quarter of 1945. By January 1945 most of the mines were closed, and as prices were further decreased for the second quarter of 1945, all mines were shut down by the end of May. The emphasis during the war was on production of sheet mica, but a second mica grinding plant was set up in New Hampshire at Rumney Depot in 1942, and this was operated through the war period.

Production totals for 1943 and 1944 given in figure 2 are less than the total for 1926. However, the figures for 1943–44 are not comparable with those for 1926, owing to differences in processing. Prior to the war, all domestic mica was sold as punch mica and half-trim or untrimmed sheet, whereas during 1942–45 a large share of the production consisted of three-quarter trimmed and full-trimmed sheet, so that the yield of sheet and punch mica per ton of crude mica was considerably less than during the prewar years. If the better-prepared sheet of the war years were converted into half-trimmed and untrimmed sheet, it is probable that the total poundages for 1943 and 1944 would be all-time highs for the New England mica industry. The proportion of full-trimmed sheet sold in 1944 was considerably higher than in 1943, so that a similar allowance must be made in comparing figures for the two years. Total crude mica production was slightly higher for 1944 than for 1943. Sales of sheet and punch mica to Colonial Mica Corporation during 1942–44 are summarized in the table on page 44. The value for sheet and punch mica given for 1944 indicates that the value given for the production of uncut sheet and punch in figure 2 is low (see note on chart).

FELDSPAR MINING

Many pegmatite mines were opened and mined for feldspar in Connecticut about 1825. Only the best grades were recovered, and these were shipped to England. Not until 1850 was the first feldspar grinding mill in the United States built, at the Toll Gate mine, in Middletown, Conn. Among the deposits opened subsequently, the Howe [5] quarry, in Glastonbury, was apparently the most important. Opened in 1866, it produced 200,000 tons of feldspar in the period 1866–98. Mines in Haddam, Middletown, East Hampton, Portland, and Branchville were opened before 1900.

Feldspar mining began in Maine between 1852 and 1860 on the John W. Fisher farm in Topsham. The Consolidated feldspar quarry in Georgetown was opened in 1868 or 1869. It became one of the largest pegmatite mines in the United States; a few years after opening it yielded 17,000 tons of feldspar in a single year (Dubois, 1940, p. 208). New quarries were opened at Bath and at Mount Apatite between 1870 and 1899. Massachusetts mines yielded small amounts during this period.

Although feldspar mining was begun at the Big mine in 1921, the first commercial production of feldspar in New Hampshire came from the Ruggles mine in 1914, and many other deposits were opened in subsequent years. The first grinding mill in the state was built in 1922 at Keene. Production increased, and New Hampshire was the second largest producer in the country in 1924 and 1925. Production from Maine and Connecticut was still large, but Connecticut production, coming chiefly from the Howe and Strickland mines, was on the wane. Mines were in operation in Maine in the towns of Topsham, Paris, Cathance, Bowdoinham, Georgetown, Buckfield, and Albany.

By 1925 total domestic production had increased considerably, owing to demands for feldspar for container glass; but New England production declined rapidly from 1927 to 1932. The trend was reversed in 1933. Production reached record heights in 1941 but in 1942–45 again declined. New Hampshire continued to be the major producing State, but both Maine and Connecticut showed substantial annual increases. The Colony mine, New Hampshire, was opened in 1939 and by 1941 had the largest output of any New England mine.

Experiments in froth flotation and agglomerate tabling, and revival of investigations of electrostatic separation were some of the technologic developments during this period. A pilot froth-flotation plant was designed by the U. S. Bureau of Mines and built in Keene, N. H., by Golding-Keene Company in 1938. Exploratory diamond drilling was done at the Ruggles mine in 1940 by the Whitehall Company. In 1941 the Golding-Keene Company began grinding feldspar at their new mill in Rumney and in 1945 began building a new flotation plant at Keene.

Available information on the production of crude feldspar in the United States and in New England during the period 1921–44 is summarized in figure 3.

[5] The particular mine then known by this name is uncertain.

New England mica mines and prospects worked during 1942–45, by months

[Mines that were first opened and that produced substantial amounts of mica during World War II are indicated by asterisk (*). Records of about 30 prospects that yielded small amounts of mica sold to Colonial Mica Corporation during 1942–1945 are not available.]

New Hampshire

Name	Location	1942												1943												1944												1945					
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Acme	Dorchester																	X	X																								
African	Orange									X	X	X	X	X	X	X						X	X																				
Alger	Grafton																																X	X									
Ashley	Rumney											X		X	X	X		X		X	X	X																					
Atwood	do																				X	X	X	X	X	X	X	X	X	X	X	X	X										
Beauregard	Alstead																					X	X	X	X																		
Belden	Rumney																																X	X	X	X	X	X	X	X			
Big	Alstead	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
*Blister	do								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X				
Brown	Wentworth																						X	X	X	X	X	X															
*Buffum	Grafton																	X	X	X	X	X	X	*	*	*	*	*	*	*													
Burgess	Rumney																			X																							
Carpenter	Grafton																			X	X	X	X	X	X							X	X										
Chandler Mills	Newport																	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Coleman	Orange										X	X	X	X	X	(?)																											
Columbian Gem	Grafton																		X																								
*Crystal	Campton											X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
Davis, Charles	Groton																								X	X	X	X	X	X	X	X	(?)										
Demott	Grafton																		X																								
Fairburn	Dorchester												X																														
*Fellows	Wentworth								X	X	X	X						X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Fitzgibbon	Alstead																			X																							
Fletcher	Groton										X	X							X	X	X																						
Globe	Springfield																														X	X	X	X	X	X	X						
Hackett	Groton																				X	X	X	X																			
Hale	Grafton																				X	X																					
Hoyt Hill	Orange									X	X	X	X	X	X	(?)															X	X	X										
Hutchins Hill	Alexandria																																X	X									
Keyes	Orange	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					(?)		X	X	X									
Kilton	Grafton																																	X	X								
Kimball Hill	Dorchester																		X	X	X	X																					
Kirk No. 1	Gilsum														X	X	X	X	X												(?)	X	X	(?)									
Kirk No. 2	do																														X	X											
Ledge Pond	Sunapee																													X	X	X	X										
Leggett	Rumney																				X	X																					
Lyman	Alstead																											(?)	(?)	X	X	X	X	X	X	X	X						
Marston	Alexandria																			X		X	X	X	X																		
McGinnis	Wentworth									X																					X	X	X	X	X	X	X	X	X	X	X		
Melvin Hill	Springfield																		X	X	X	X							X	X	X												
Mud	Alexandria				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																							
Nancy No. 1	Groton																			X	X	X	X								X	X											
Nancy No. 2	do																					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Nichols	Gilsum																		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Nichols, Justin	Springfield																														X	X	X	X									
Palermo No. 2	Groton									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
Palermo No. 3	do																		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
Patten, Truman	Alexandria																																		X	X							
*Pattuck	do																	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Paul	Sunapee																															X	X										
Pettes	Orange																															X	X										

Pickwick	Danbury											X	X	X	X																												
Pikes Ledge	Groton								X	X																																	
Pinnacle	Orange																				X	X																					
Porter, George	Alstead																	X	X	X	X																						
Powell	Wilmot																					X	X	X	X	X	X	X	X	X	X												
Powell, Thurman	Grafton																															X	X										
Provencher	Alstead								X	X	X																																
Rice	Groton																			X																							
Ruggles	Grafton	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ruggles New Hill	do																			X																							
Saunders	do																					X	X	X	X	X	X	X	X	X	X	X	X	X									
*Sargeant	Claremont							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
Smith, E. E	Alexandria	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X									
*Smith, G. F	Newport																	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
Standard	Orange																					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
Strain	do																					X	X																				
Union	Groton																																	X	X								
United	Grafton																				X	X	X	X	X	X	X	X	X	X	X	X											
Valencia	Groton						X	X	X	X	X	X	X							X	X	X	X	X	X	X	X	X	X						X								
Wadhams-Tucker	Alexandria																								X	X	X	X	X	X	X	X	X										
White	Gilsum							X	X				X	X	X	X	X																										
*White Mtn	Thornton							X	X	X	X																																
Williams	Orange							X	X	X	X	X																															
Wood	Warren											X	X	X	X	X																											
*Woodward	Orford																						X	X	X	X	X	X	X	X	X	X	X	X									

Maine

Black Mtn	Rumford				X	X	X	X	X	X	X																																
Davis, Warren	West Bath																										X	X	X	X	X	X	X	X									
Donahue	Albany							X																																			
Elliot, George	Rumford												X	X	X	X	X	X	X	X	X	X																					
Gogan	Mexico																			X																							
Harvard	Greenwood																			X	X	X	X	X	X																		
Johnson, Guy	Albany																				X	X																					
LaChance	Brunswick																	X	X	X	X	X																					
*Lobikis	Peru																		X	X	X	X	X			X					X	X											
Russell Brothers	Topsham																					X	X	X	X	X	X	X	X	X	X	X	X	X									
Saunders	Waterford																	X	X	X	X	X																					
Scribner	Albany																		X	X	X	X																					
Trott Cove	Woolwich											X	X				X																										
Waisanen	Greenwood														X	X	X	X	X	X	X	X	X	X	X	X																	
Wardwell	Albany	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																								
Warren, Willis	Stoneham																			X	X	X	X	X	X	X																	

Connecticut

Anderson No. 1	East Hampton																	X	X	X	X	X	X	X	X	X	X	X															
Anderson No. 2	do									X	X																		X	X	X	X											
Bailey	do									X							X																										
Branchville	Redding																					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Case	Portland								X		X																																
Cramer	Portland	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Enegren	East Hampton							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
Gillette	do											X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
Knapp	Canton																										X	X															
Markham	East Hampton																							X	X	X	X	X															
Reeb	do							X	X	X	(?)	(?)	X	X	X	(?)	X	X	X	(?)	X	X	X	X	X	X	X	X	X	X	X												
Roebling	New Milford																															X	X										
State Forest No. 1	East Hampton											X	X						X	X	X																						
State Forest No. 2	do							X	X	X					X	X	X	X	X	X	X	X																					
Strickland	Portland									X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
Toll Gate	Middletown																			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						

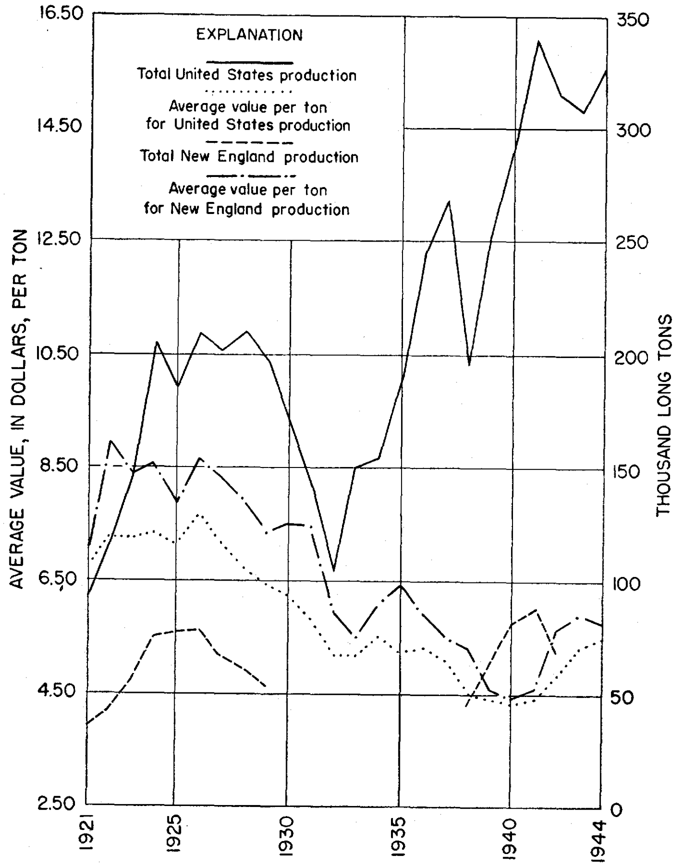


FIGURE 3.—Crude feldspar production, 1921-1944.

MINING METHODS

Most of the pegmatite mines in New England have been worked by open-pit methods. Many mines are extensions of open pits into underground workings; only a few have been worked primarily underground. The simplest methods have generally been employed because most of the operations have been very small and based on the assumption that mining must yield a quick return for a small investment. Long-term operations are few; almost every mine has a history of intermittent operation. Since 1803, changes in methods of mining mica and feldspar have been chiefly those due to development of improved equipment. In the late eighteen-nineties steam and pneumatic drills were introduced in some of the larger mines, and since the turn of the century electrical and gasoline-powered equipment have been adopted. During 1941–45, portable gasoline-driven compressors were used to run jackhammers, drifters, and stopers, and portable gasoline hoists were in common use.

Methods of mining and equipment used during 1941–45 depended in part upon the size, shape, attitude, and structure of the pegmatite deposit to be mined. Overburden was removed by hand tools, or by dragline scraper, bulldozer, or power shovel. Most of the open-pit mines were extended and deepened by benches. Waste rock and mica or feldspar were commonly removed by derrick and hoist, or by aerial tramway. In some of the large feldspar mines combining open pits and open stopes, feldspar was hauled or pushed from the working faces to the main hoist in the pit by car or wheelbarrow. In underground workings with a vertical shaft, a derrick with a bucket, or a bucket on an aerial tramway, was used. In underground workings with inclined shafts, ore cars were hoisted on tracks, or a bucket was pulled up a timbered skidway. Wheelbarrows were used to remove mica and waste rock from several mines. Several operators used draglines or power shovels, and one used a dragline scraper.

After the drilling and firing of each round, the mica was hand-picked or broken from large blocks and bagged before being hoisted to the surface. At some mines where feldspar was recovered as a byproduct, the broken rock was hoisted to the surface after recovery of loose mica by hand-picking. Feldspar and more mica were then recovered. Crushers and picking belts were used in several feldspar mines to decrease the cost of hand-sorting. At the Allen mine, Alstead, N. H., the broken rock was loaded by gasoline shovel into trucks at the working face of the open pit, then carried to the crusher and picking belt.

GEOLOGIC SETTING OF THE DEPOSITS

Large areas in New England are underlain by schists, quartzites, and gneisses formed chiefly by metamorphism of sediments during folding and repeated intrusion by igneous rocks. Quartz-mica schist is probably the most abundant metasediment. The most widespread igneous rocks are granodiorites, quartz monzonites, and granites that form stocks, domes, sheets, and dikes intruded into the metamorphic rocks. Associated with some of these granitic rocks are numerous pegmatites that individually are small but collectively are an important element in the bedrock complex. Four series of granitic rocks of different ages have been distinguished in New Hampshire; hence, it is probable that groups of pegmatites of different ages and sources are present. This undoubtedly is reflected in the contrasts among groups of pegmatites in different areas, and even among pegmatites within areas.

The pegmatites of New England were formed at considerable depths beneath the surface of the earth and are exposed only because thousands of feet of rock has been eroded. Undoubtedly, erosion has destroyed many pegmatites contained in the overlying rocks, and many other pegmatites must lie beneath the surface. The degree to which a pegmatite is now exposed depends upon the original position of the body in the earth's crust relative to the depth locally attained by erosion. Erosion has exposed only the tops of some pegmatite bodies, others have been half or more than half removed, and still others have been almost completely destroyed.

All the pegmatite districts lie in maturely dissected glaciated uplands consisting of rolling, tree-covered hills and valleys with permanent streams. Relief ranges from 1,000 feet in the Middletown district, Conn., to 2,000 feet in the Paris-Rumford district, Maine. The floors and lower valley sides are covered by glacial deposits and soil and generally have few outcrops either of pegmatite or of country rock. The upper slopes and crests of the hills are covered by a thinner glacial and soil mantle, and have more abundant exposures.

Pegmatites in general are more resistant to erosion than their wall rocks and therefore form small ridges and terraces. Some large pegmatites and groups of closely spaced smaller bodies sustain the crests of hills and ridges. Although pegmatites are more fully exposed than their wall rocks, probably less than 10 percent of the surface of the average pegmatite is exposed on the upper slopes and crests of hills and ridges; surely many are concealed entirely by surficial deposits.

The Pleistocene ice sheet covered New England and moved across it in a southeasterly direction. Rock material carried by the ice abraded and polished the exposed western and northwestern surfaces of some of the pegmatites and plucked rock from the eastern and southeastern sides of others that cropped out as elongate ridges prior to the advance of the ice. It has been possible to trace some pegmatite boulders to their parent ledges.

In New Hampshire and Maine, and to a less extent in Connecticut, low temperatures and deep snow seriously curtail mine production in winter, especially in opencut mines and in underground mines situated some distance from roads that are kept open. Severe winter conditions from late December until late February or March are followed in April and part of May by a period in which all but the well-graded gravel roads and hard-surfaced roads are impassable by automobile or truck.

Pegmatites containing workable deposits of mica, feldspar, and beryl are far more abundant in some districts of New England than in others. Prospecting for pegmatite deposits has been carried on in New England for decades, especially in times of high prices or unemployment. It is improbable that all the potentially productive deposits of New England have been discovered, but the results of past prospecting should provide a fair measure of the relative potential productivity of various parts of the region. More than 90 percent of New England production has come from areas totaling about 500 square miles in Maine, New Hampshire, and Connecticut. Few prospects have been found in Massachusetts, and none have been very productive.

GEOLOGY OF THE PEGMATITE DISTRICTS OF MAINE

Pegmatites are widespread and abundant in western Maine, but most of those exploited commercially are in the Paris-Rumford and Topsham districts, in the southwestern part of the State. Figure 4 shows the distribution of pegmatite quarries and prospects as well as the approximate distribution of metamorphic and granitic rocks. Little detailed areal geology has been done within either district. Bastian (1911, p. 10) located the larger granite areas, pointed out the genetic relationship of the granites to the pegmatites and described the country rocks briefly. Shainin (1948, p. 17) described some of the pegmatites and associated rocks in the Topsham district. Katz (1917), Fisher (1941), and Hanley (1939), worked in areas adjacent to the pegmatite districts and added information concerning them. A geologic map compiled by Keith (1933) shows the general distribution of metamorphic and granitic rocks of the pegmatite districts, and this information is incorporated in figure 4.

METAMORPHIC ROCKS

Most of southwestern Maine is underlain by low- to high-grade metamorphic rocks. These are sedimentary and volcanic rocks that have been folded, metamorphosed, and intruded by large bodies of granitic rocks. The metamorphic rocks are quartz-mica schist, garnet and sillimanite schist, marble, lime-silicate gneiss, actinolite schist, amphibolite, and quartzite. They are complexly folded and contorted but trend N. 20° E. in general. In the Lewiston area (Fisher, 1941, p. 134), the rocks form part of a synclinorium that plunges northeast, and Fisher believes that the metamorphic rocks northwest of the Lewiston area have similar structures.

Various ages have been attributed to the metamorphic rocks. Bastin (1911, p. 11), correlated the metasediments with the Penobscot formation, believed to be of Cambrian age (Bastin, 1907, p. 3). Katz (1917, p. 166) concluded that the rocks he studied were probably Algonkian and Pennsylvanian. The area he studied lies northwest of the pegmatite districts, but the formations he mapped extend into the pegmatite areas. Keith (1933) indicated the metamorphic rocks within the pegmatite districts to be pre-Cambrian. Fisher (1941, p. 137) has traced the Waterville formation, which contains Silurian fossils, southwestward into the more highly metamorphosed Winthrop and

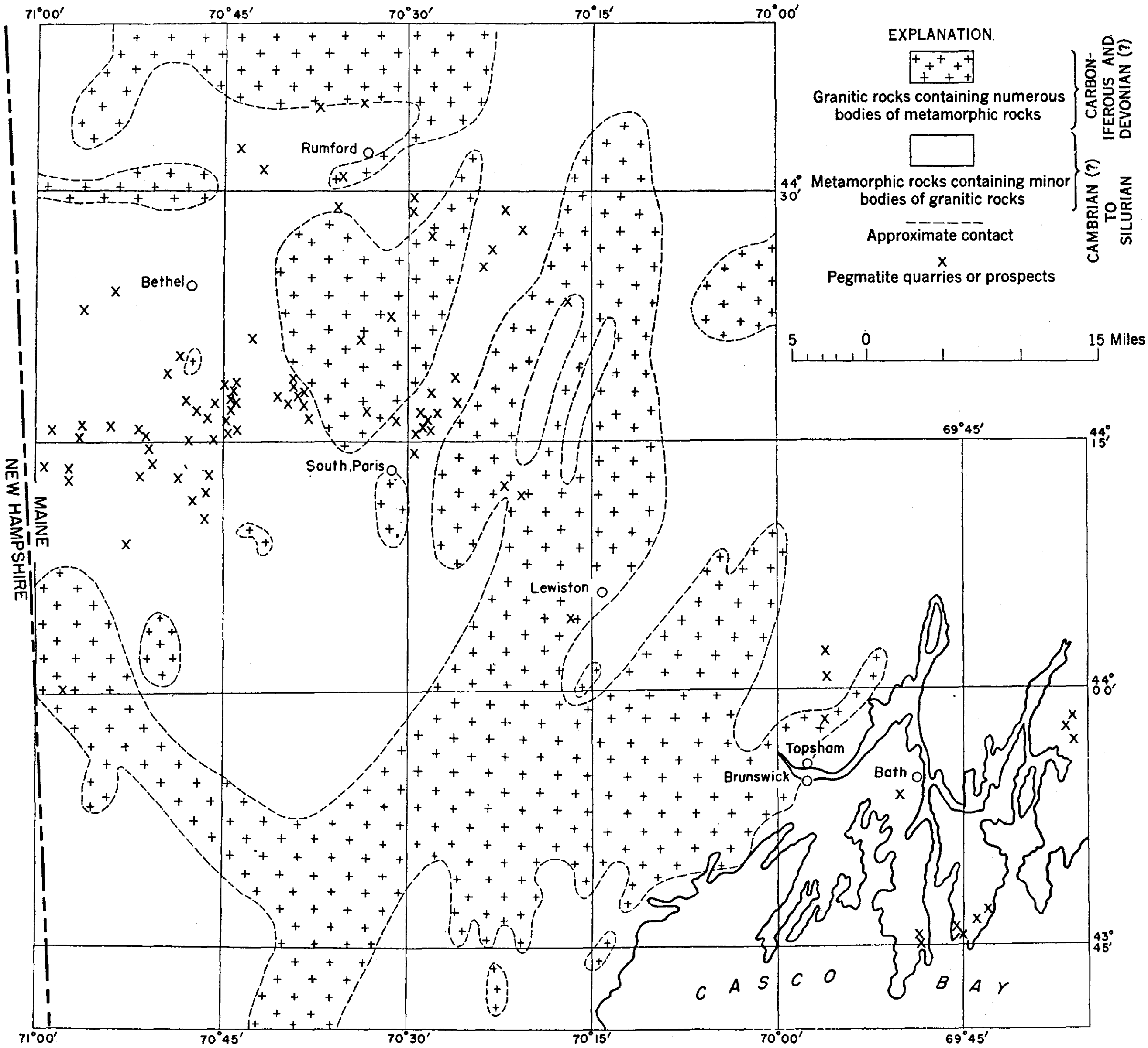


FIGURE 4.—Generalized geologic map of part of southwestern Maine showing the distribution of metamorphic rocks, granites, pegmatite quarries and prospects. Outlines of areas of granitic rocks from Arthur Keith, 1935.

Sabattus formations. He cites evidence that the Androscoggin formation (Ordovician(?)), which underlies the Waterville, is equivalent to the Berwick formation, earlier assigned to the pre-Cambrian by Katz. Fisher's work indicates that all the metamorphic rocks in the pegmatite districts are of early Paleozoic age.

In Maine large pegmatites are much more abundant in the metamorphic rocks than in the massive granitic rocks. This was first pointed out by Bastin (1911, p. 11) and conforms to their occurrence in other New England pegmatite districts.

IGNEOUS ROCKS

Granites and granodiorites crop out in many places throughout the pegmatite districts. Except in the Lewiston region (Fisher, 1941, p. 143) and the Poland quadrangle,[6] they have not been studied or mapped in detail. Both Bastin and Fisher noted that the granites in some places have impregnated the surrounding wall rock and made it difficult to determine exact contacts. Bastin (1911, p. 43) stated that the granite bodies of eastern Maine commonly have sharp contacts with the country rocks and few are associated with pegmatites. In explanation of the indefinite boundaries of the granites in southwestern Maine and their numerous

[6] Hanley, J. B., Geology of the Poland quadrangle, Maine: Unpublished doctorate thesis, The Johns Hopkins University, 1939.

pegmatites, he suggested that the broad injected zones represent the roofs of granite batholiths which structurally were favorably located for the addition of granitic and pegmatitic materials. The sharply bounded granites of eastern Maine he regarded as the sides of deeply eroded granite masses. Landes (1925, p. 361) suggested that the Bennett (Buckfield) pegmatite is probably related to a nearby light-colored, fine-grained aplitic granite.

Various ages have been determined for the granites and their associated pegmatites. Keith regarded the granites and associated intrusives as probably pre-Cambrian. Bastin suggested that they are all late Silurian or Devonian. Fisher concluded that all of the granites in the Lewiston region are Carboniferous; this was supported by Gonyer (1937, p. 59) on the basis of an analysis of samarskite from a pegmatite near Topsham.

Small basic dikes are fairly abundant in southwestern Maine. They cut all the other rocks, follow sharply defined fractures, and average 2 feet in thickness. Urry (personal communication to L. W. Fisher) has determined the age of the dikes to be Triassic.

PEGMATITES

In the Lewiston-Poland region (Hanley, thesis) granite is associated with numerous small and large pegmatites, but in general large pegmatites are more abundant in the metamorphosed sediments and volcanics. This was first pointed out by Bastin and is consistent with their occurrence in other New England pegmatite districts.

The pegmatites in Maine occur in the same variety of forms as those of the other New England States, but a higher proportion are large, gently dipping sheets. Such sheets are well known in the Poland quadrangle, according to Hanley, and similar bodies have been noted elsewhere. The largest pegmatite examined, forming the summit of Whitecap Mountain in Rumford, crops out over an area about 9,000 by 6,000 feet. Outcrops of border-zone material and numerous remnants of wall rock, which occur on the sides and upper surfaces of the closely spaced pegmatites in the Parker Head area in Phippsburg, suggest that these pegmatites represent undulations in the hanging walls of large, gently dipping sheets. The rocks overlying gently dipping pegmatites commonly contain much pegmatitic material.

GEOLOGY OF THE PEGMATITE DISTRICTS OF NEW HAMPSHIRE

Pegmatites are especially abundant in New Hampshire in two northeast-trending belts. The western belt, extending from Keene and Gilsum to Groton and Wentworth, contains most of the feldspar, mica, and beryl-bearing pegmatites exploited in the past. The northern part of the belt, extending from Springfield northward to Wentworth, is known as the Grafton district. The southern part, extending from Claremont southward to Swanzey, is the Keene district. A less clearly defined belt extends through the southeastern part of the state from Strafford through Wakefield to Conway and probably continues into the Paris-Rumford district in western Maine.

The geology of much of the western belt is known from the work of Billings (1937, 1938), Chapman (1939, 1941, 1946), Fowler-Lunn and Kingsley (1937), Hadley (1942), Kruger and Linehan (1941), and Page (1942), and the description of the major rock units and structures given below is taken largely from their findings. The geology of the eastern belt is little known. Early work by Hitchcock (1874) and later reconnaissance surveys show that the eastern belt is one of metamorphic and igneous rocks broadly similar to those of the western belt. No important mines were developed in the eastern belt or studied during the war; hence, the following discussion is limited to the western belt. Figure 5 shows the distribution of pegmatite mines and prospects in it.

ROCK UNITS

Much of the western belt is underlain by quartz-mica schist, quartzite and amphibolite, middle- and high-grade metamorphic rocks. These represent sedimentary and volcanic rocks, Ordovician(?) to Early Devonian in age, that were folded, faulted, intruded, and metamorphosed in Devonian time.

The oldest rocks are amphibolites, quartzites, mica schists, and staurolite or staurolite-kyanite schists of the Orfordville formation. Overlying these are the Ammonoosuc volcanics, consisting of amphibolite, biotite gneiss, micaceous quartzite and hornblende schist. Mica schists, quartzite, and sillimanite schist of the Partridge formation overlie the Ammonoosuc volcanics in turn. Probably, both formations are of Ordovician age. Above them are the Silurian Clough quartzite and the Fitch formation, thin but persistent formations, overlain by the Early Devonian Littleton formation, which contains most of the larger pegmatites in the belt. The Littleton formation consists of mica schist, quartz-mica schist, biotite gneiss, staurolite schist, sillimanite schist, quartzite, and amphibolite. The variations in lithology are due partly to original differences in composition, partly to differences in degree of metamorphism.

The Ordovician, Silurian, and Devonian rocks were intruded by a complex sequence of Devonian(?) and Carboniferous(?) igneous rocks. The earliest are quartz monzonite gneiss, quartz diorite, granodiorite,

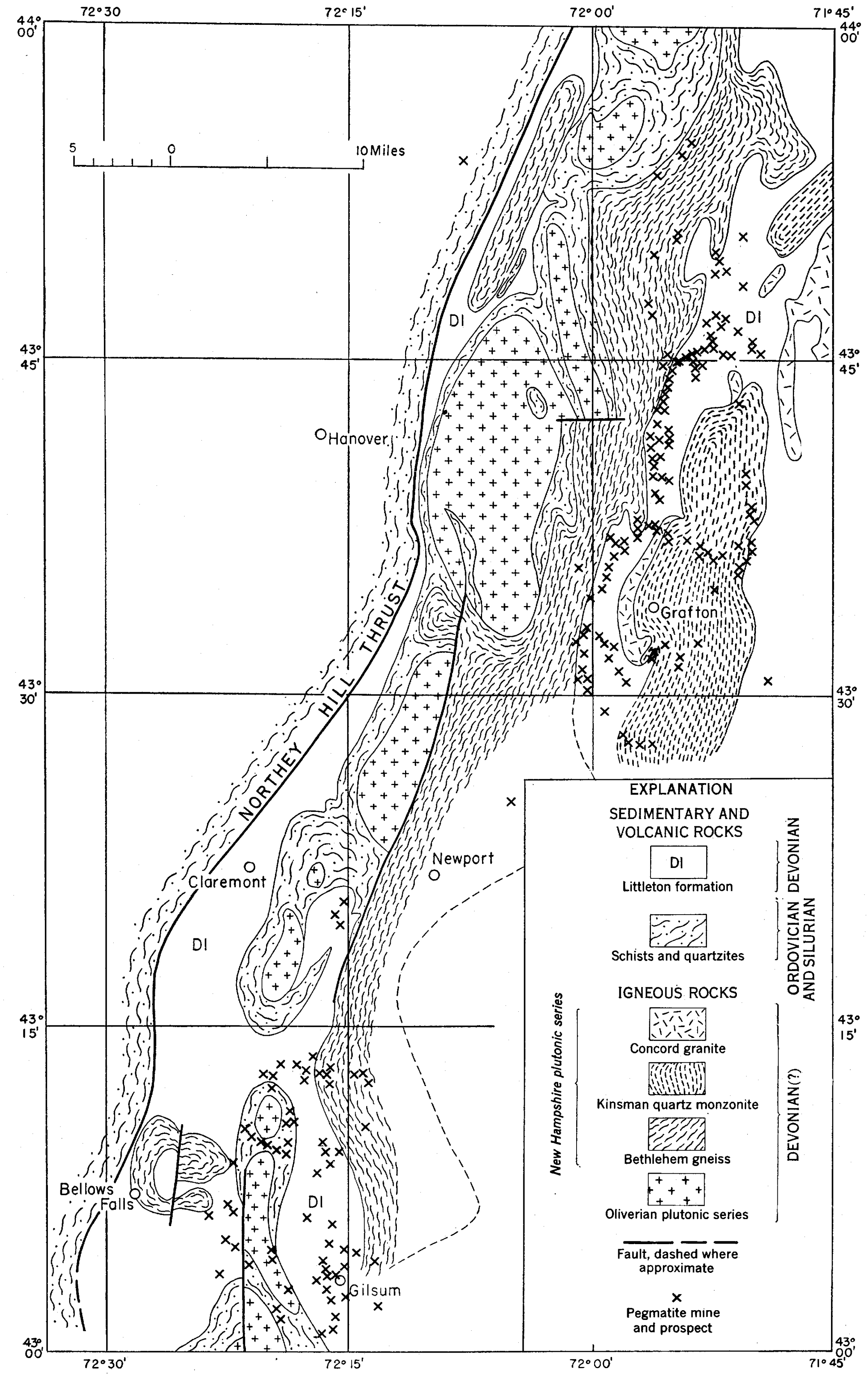


FIGURE 5.—Generalized geologic map of southwestern New Hampshire showing distribution of pegmatite mines and prospects. Modified from F. C. Kruger and D. Linehan, 1941.

and granite belonging to Billings' Oliverian magma series of late Devonian(?) age. They form large and small elliptical gneissic domes, surrounded almost without exception by the Ammonoosuc and Partridge formations. Billings (1937, p. 502, 535; 1945, p. 40–68) and Chapman (1942, p. 897) cite evidence that the Oliverian rocks were intruded prior to the major folding and metamorphism of the region. Few of the pegmatites studied appear to be genetically related to the Oliverian rocks.

The rocks of Billings' New Hampshire magma series are believed to have been injected shortly after the intrusion of Oliverian rocks, during and following the last stages of regional folding. The Bethlehem gneiss consists of medium- to coarse-grained gray quartz monzonite, granodiorite, and minor amounts of granite. It is composed of quartz, andesine, oligoclase-andesine, orthoclase, microcline, biotite, and muscovite, and is well-foliated parallel to the schistosity of the surrounding rocks. The main body of gneiss, designated the Mount Clough pluton by Chapman (1939, p. 161), is a sheet ½ mile to 7 miles wide and at least 75 miles long. In the Grafton district it was conformably intruded, between the Ammonoosuc and Littleton formations, and dips approximately 40° eastward. In the Keene district the pluton is intrusive into the Littleton formation and once extended westward over the crest of the Bronson Hill anticline, as indicated by the presence of a remnant of Bethlehem gneiss in a synclinal basin west of the anticline. A similar, small synclinal basin has been mapped in the Mascoma quadrangle. The area of Bethlehem gneiss west of the anticline at the north end of the area shown on figure 5 may also be a synclinal remnant. Small concordant injections are abundant above the main body of the gneiss in the Mascoma and Cardigan quadrangles, and similar injections occur below it in the eastern part of the Bellows Falls quadrangle.

The Kinsman quartz monzonite is a gray coarse-grained, porphyritic gneiss. It contains quartz, oligoclase-andesine, microcline, biotite, and muscovite. Large conspicuous orthoclase phenocrysts and biotite flakes give it a distinct foliation, which is parallel to the wall rock foliation. The gneiss crops out in an elongate area east of the Mount Clough pluton. This body is 3 to 7 miles wide and at least 20 miles long; it strikes N. 10° E. and dips 35° to 50° E. It is tabular and concordant to the foliation of the enclosing schist of the Littleton formation.

The Kinsman and Bethlehem formations are the earlier members of Billings' New Hampshire magma series. They are similar mineralogically and probably were intruded at about the same time. They have a more distinct gneissic structure and contain plagioclase of higher anorthite content than the later members. The two rocks are nowhere in contact, but the Kinsman appears to be slightly younger than the Bethlehem. Small pegmatites are abundant in the Bethlehem gneiss, but large pegmatites are rare. Many pegmatites in the Bethlehem gneiss, or in the Littleton formation overlying it, appear to have been derived from the gneiss. The Kinsman contains many small- and medium-sized pegmatites in the Grafton district.

The Concord granite, the youngest intrusive rock of Billings' New Hampshire magma series, is a fine- to coarse-grained, light-gray granite containing microcline, oligoclase, quartz, biotite, and muscovite. Locally it is gneissic or aplitic. In the Grafton district it occurs as large elongate stocks and small dikelike bodies east of the outcrop of the Littleton formation. It is intrusive into the Kinsman quartz monzonite and the Littleton formation. Small masses of granite in the Keene district are believed to be equivalent to the Concord and suggest that bodies of the Concord granite not exposed by erosion may underlie parts of the pegmatite belt. The Concord was not appreciably affected by regional folding and was presumably intruded after deformation. A few small pegmatites that lie within the granite indicate that some of the pegmatites are definitely younger than the Concord.

Most of the pegmatites in the Concord granite and many in the Littleton formation east of the Mount Clough pluton in the Grafton district are associated with aplitic stocks and dikes. The aplite consists essentially of quartz, muscovite, albite (An_4), microcline, and equant crystals of black tourmaline or small red or pink garnet is present locally. Biotite is present only rarely. The contacts between pegmatite and aplite are sharp in some pegmatites and gradational in others. At the Ruggles mine in Grafton, aplite appears to have been an early phase in the development of the pegmatite. In most places the pegmatites have distinct border zones against aplite, and contain rounded and angular blocks of aplite that are rimmed in places by black tourmaline or by red or pink garnet. Aplite occurs as irregular bands at one or both margins of pegmatites, and some of these pegmatites appear to have been emplaced preferentially along aplite bodies. Aplite along the margins of other pegmatites, however, appears to be due to wall rock alteration.

The uraninite from the Ruggles pegmatite in Grafton is Late Devonian in age (Shaub, 1938, p. 339). This pegmatite was intruded into the Littleton formation of Early Devonian age and appears to have been derived from the Bethlehem gneiss or from the Concord granite. Both the intrusion of Billings' New Hampshire magma series and the regional folding and metamorphism, therefore, appear to be of Late Devonian age.

Gabbro, quartz, syenite, volcanic breccia, and camptonite of the Carboniferous(?) White Mountain magma series of Billings form small stocks and dikes in the pegmatite belt. The pegmatites are believed to be older than these rocks. Narrow basic dikes, probably of Triassic age, cut pegmatites and all other rocks of the region. They average 2 feet in thickness, have steep dips, and follow sharp fractures.

STRUCTURAL FEATURES

The major geologic structural features in the western pegmatite belt are the northeast-trending Salmon Hole Brook syncline, and the Bronson Hill anticline that lies parallel to and east of the syncline. The westward-dipping Northey Hill thrust fault extends along the west flank of the anticline. This fault was formed prior to metamorphism. The axis of the anticline is occupied by isolated, elongate domes of Oliverian rocks surrounded by Ordovician(?) and Silurian formations. Chapman (1942, p. 907) cites evidence that the domes were intruded as laccoliths before the major period of folding and metamorphism.

In western New Hampshire the metamorphism increases from low grade west of the pegmatite belt to middle and high grade in the belt (Billings, 1937, p. 537; 1938, p. 289–302; Chapman, 1937, p. 170; Fowler-Lunn and Kingsley, 1937, p. 1379; and Hanley, thesis) and the intrusion of Billings' New Hampshire magma series seems to have been the chief cause of the regional metamorphism. In the Grafton district the Littleton formation consists of high grade schists. Parts of the Littleton in the Keene district are of middle grade. Pegmatites are most abundant in the high grade zone. With the exception of the pegmatite at the Stone prospect and nearby pegmatites, which are believed to have been derived from the Oliverian magma series, none of the pegmatites seem to have been affected by regional metamorphism.

Faults and shear zones are few in New Hampshire pegmatites; hence, the pegmatites were formed after the major deformation of the region. The Ruby and Barney pegmatite, in Grafton, is the only pegmatite studied that was faulted during its formation. The Kirk No. 1 pegmatite and a few others have been cut by faults of small displacement.

DISTRIBUTION OF PEGMATITES

Commercial pegmatites are more abundant in some types of rock in the western belt than in others. The following is the approximate distribution of the known larger pegmatite bodies; pegmatite dikes, small lenses, and stringers less than 1 foot thick are not included:

	Percent
Littleton formation	60
Kinsman quartz monzonite	16
Bethlehem gneiss	14
Gneiss and mica quartzite of Ordovician(?) age	6
Concord granite	2
Granodiorite gneiss of Billings' Oliverian magma series	2

Eighty-five percent of the pegmatites in the Littleton formation are estimated to occur in the high-grade zone and 15 percent in the middle-grade zone.

The structural position and attitude of foliation of the wall rock, the presence of shear zones, and the composition and texture of the wall rock are believed to have been the chief factors controlling the distribution of pegmatites. Proximity of source magma was presumably a contributing cause. The schistose Littleton formation was the most favorable host rock. The igneous rocks contain relatively few large pegmatites.

PEGMATITES OF THE GRAFTPN AND KEENE DISTRICTS

In the Grafton district most of the commercial pegmatites occur in the Littleton formation, directly above the east or hanging wall contact of the main body of Bethlehem gneiss. In the Keene district they are most abundant in the Littleton formation on the west or footwall side of the Bethlehem gneiss. Most of the pegmatites in the Littleton formation are concordant lenses. They are commonly arranged in echelon, and wall rock relations indicate that wall rock was pushed aside by the pegmatites. Plagioclase in pegmatites in the Littleton formation generally ranges from An_2 to An_{14}. The table on page 31 shows the anorthite variation in New Hampshire pegmatites studied.

Most of the pegmatites in the gneissic Bethlehem and Kinsman rocks are discordant and appear to have been controlled by fractures. Some of these are in echelon tension fractures, probably along shear zones. They are more abundant near the hanging wall contacts of sheets of the Bethlehem and Kinsman rocks than elsewhere. Plagioclase in pegmatites from the Bethlehem gneiss ranges from An_{14} to An_{22}. The plagioclase from pegmatites in the Kinsman quartz monsonite ranges from An_2 to An_{12}.

Pegmatites associated with bodies of the Concord granite generally contain brecciated blocks of granite and much aplite. Pegmatites in Concord granite contain plagioclase that ranges from An_4 to An_6.

Pegmatites in the gneiss and mica quartzite of Ordovician(?) age in the north end of the Keene district commonly cut across foliation, especially along dip, and were emplaced along fractures and incipient ruptures that may be related to the anticline.

Few pegmatites are found in the Oliverian rocks, and the Stone feldspar prospect in Canaan is the only one about which adequate information is available. This pegmatite is discordant to the wall rock and contains closely jointed pink microcline perthite and contorted biotite. Chapman, Billings, and Chapman (1944, p. 507) found pegmatites containing pink perthite associated with Oliverian rocks in the Mount Washington region.

SOURCES OF THE PEGMATITES

Fowler-Lunn and Kingsley (1937, p. 1381) believed that the Bethlehem, Kinsman, and Concord rocks were intruded in that order and that each unit gave rise to pegmatites. This belief appears to be supported by the distribution of pegmatities in the Grafton district. If pegmatites of two or more ages are present, however, it is remarkable that among the hundreds of pegmatites studied in the district, none has been found to transect another. Furthermore, the larger pegmatities in the Grafton district have not been folded or metamorphosed, even those associated with the Bethlehem gneiss, which is believed to have been emplaced during the later stages of deformation. If the pegmatites were derived from the Bethlehem, considerable time must have elapsed between intrusion of the gneiss and intrusion of the pegmatite.

Chapman, who regarded the Bethlehem gneiss as the source of the pegmatites of the Grafton district, accounted for the great abundance of pegmatites in the schist of the Littleton formation east of the outcrop of the Bethlehem gneiss and the lack of them to the west by supposing that residual liquors would escape more easily through the hanging wall than through the footwall (1941, p. 381). It seems equally possible, however, that the Concord granite is the source of the bulk of the pegmatites in the schist, for Concord granite occurs as discordant small and large bodies east of the eastward-dipping schist of the Littleton formation. The pegmatitic solutions from the granite may have traveled upward within the Littleton formation (a favorable host rock) several miles before they were emplaced.

Much more work needs to be done to establish the source or sources of the pegmatites in the Grafton district. Spectrographic work might throw light on this problem. Goldschmidt (1933, p. 370–378) and Bray (1942, p. 765–814) have shown from spectrographic analyses that individual igneous rocks have characteristic combinations of minor constituents. Shimer (1943, p. 1059) demonstrated a similar distribution in certain New England granite bodies and found that although minor constituents are less abundant in pegmatite minerals than in their parent granites, they occur in the same combinations. A similar relationship may exist between the pegmatites and the various members of Billings' New Hampshire magma series.

In the Keene district, pegmatites occur on both flanks of the Bronson Hill anticline but are most abundant in the Littleton formation on the west (footwall) side of the Bethlehem gneiss. Few pegmatites are found in the Bethlehem gneiss or in the Ordovician(?) metamorphic rocks. The pegmatites do not seem to be mineralogically different from those in the Grafton district. If they were derived from the Bethlehem, the pegmatitic solutions migrated downward from it. There is no evidence to connect the pegmatites with the Oliverian rocks, and such a connection seems unlikely, inasmuch as the pegmatites have not been affected by regional metamorphism. They may have been derived from underlying bodies of the New Hampshire magma series not yet exposed by erosion, or they may be related to the concordant injections of Bethlehem gneiss that occur abundantly in the Littleton formation on the east flank of the Bronson Hill anticline.

GEOLOGY OF THE PEGMATITE DISTRICTS OF CONNECTICUT

Pegmatite bodies are widely distributed in the metamorphic and igneous rocks of the Eastern Highlands and Western Highlands of Connecticut, but most of those that have yielded feldspar, mica, beryl, and other minerals occur in the Middletown district in the Eastern Highlands. During World War II slightly more than 90 percent of the mica and all the beryl produced in Connecticut came from the Middletown district. Only the Branchville mine and a few prospects lie outside this district.

GEOLOGY OF THE MIDDLETOWN DISTRICT

The Middletown district (fig. 6) is an area 14 miles long and 9 miles wide. Its geographical center lies near the town of Middle Haddam, which is 5 miles east of Middletown. The area is a heavily wooded rolling upland with a relief of about 1,000 feet. It is bounded abruptly on the west by the fault-line escarpment separating it from the clastic sediments, basaltic lavas, and diabasic intrusives of the Central Connecticit Lowland. The Connecticut River flows southeastward through the district, passing from the Lowland into the Eastern Highlands a few miles southeast of Middletown.

ROCK UNITS

The Eastern Highlands is underlain by various igneous and metamorphic rocks. Figure 6 shows the distribution of the major rock units of the Middletown district and the locations of pegmatite mines and prospects. Six formations crop out in the district: the Bolton schist, the Middletown gneiss, the Monson gneiss, the Maromas granite gneiss, the Haddam granite gneiss, and the Hebron gneiss. Publications (Rice and Gregory, 1906; Gregory and Robinson, 1907; Barrell and Loughlin, 1910; Dale and Gregory, 1911; Foye, 1922a; Rice and Foye, 1927; and Foye and Lane, 1934) on the geology of the district are chiefly descriptions of lithology. The age, origin, and structure of most of the rock formations are doubtful or unknown.

The most productive mica- and beryl-bearing pegmatites are in the Bolton schist and Monson gneiss (granite gneiss). The Bolton schist crops out in long narrow belts, and the pattern of its outcrop in the Middletown district resembles the letter "H." In general, foliation and bedding are parallel. The formation is much crumpled and folded. It dips westward at moderate angles in the northwestern and northeastern belts. The southwestern belt probably dips westward, and the southeastern belt appears to have a moderate to steep easterly dip. The formation is composed of quartz-mica schists, mica gneiss, lenses of amphibole schist, and beds of quartzite and marble. Quartz-mica schist is the most common type. Analyses of radioactive minerals from pegmatites in the formation suggest that the pegmatites were injected in Late Devonian time (Foye and Lane, 1934, p. 135, 137, 138). The Bolton schist, therefore, is probably older than Late Devonian

The granitic Monson gneiss has been intruded into the Bolton schist in the northern part of the Middletown district, and it crops out in two separate belts (fig. 6). The western contact of the western belt dips moderately westward and foliation in the gneiss along this contact is generally concordant to the contact and to the foliation in the bordering schist. Foye and Lane (p. 131) have called the Monson gneiss a "batholithic mass."

The Monson gneiss varies considerably in composition from place to place. Dale (1910, p. 259) called the corresponding rock unit in southern Massachusetts a quartz monzonite gneiss, whereas Emerson (1917, p. 241) called it a granodiorite. Foye and Lane (1934, p. 131) called the Monson gneiss in Connecticut a granodiorite but gave no petrographic evidence. The Monson gneiss in Connecticut was described by Dale and Gregory (Dale and Gregory, 1911) under the old name "Glastonbury granite gneiss", as a medium-grained biotite granite gneiss, composed of microcline, orthoclase, quartz, oligoclase or oligoclase-andesine, biotite, and muscovite. Accessory minerals are epidote, titanite, allanite, apatite, zircon, garnet, and magnetite. On this basis, the rock is designated a granite gneiss in the present report.

The western part of the western belt of Monson gneiss (Rice and Gregory, 1906, pp. 116, 117) is more strongly foliated and contains more biotite, hornblende, and epidote than the eastern part. Foye and Lane (1934, p. 131) stated that some pegmatites in the Bolton schist near the western contact of the Monson gneiss "are distinctly connected with the Monson granodiorite and may be seen grading into this rock directly east of the Strickland quarry." The writers' observations do not support this statement.

The Maromas granite gneiss occurs in the central and northern parts of the Middletown district. Bolton schist almost completely surrounds the gneiss, and the foliation of the schist appears to wrap around and dip away from the large oval part of the Maromas granite gneiss in the center of the district. This suggests that the gneiss may be a dome. The Maromas granite gneiss is a gray, biotite-hornblende granite gneiss that has a fine-grained gneissic texture. The chief constituents are microcline, orthoclase, quartz, oligoclase, biotite, and hornblende (Dale and Gregory, 1911, p. 76). The rock is of igneous origin, and Foye and Lane (1934, p. 131) believe that it is a part of the Monson gneiss that has been injected by the Sterling granite of Carboniferous age.

The Haddam granite gneiss has a large oval outcrop, the northern part of which lies in the southern portion of the Middletown district. Foye (1922a, p. 147), who called the rock a tonalite, believes that it is a dome-shaped batholith. The Haddam granite gneiss was described by Rice and Gregory (1906, p. 145) as a light-colored, fine-grained aggregate of quartz, orthoclase, plagioclase, biotite, hornblende, and garnet. Foye and Lane (1934, p. 131) inferred that the Haddam and Monson gneisses are roughly of the same age.

The Middletown gneiss crops out in a narrow belt around the Haddam batholith and dips gently away from it on all sides (Foye, 1922a, p. 147). The Middletown gneiss is a series of metamorphosed sedimentary rocks of unknown age. It consists chiefly of hornblende gneiss, with much amphibolite and injected granite (Rice and Gregory, 1906, p. 143). Foye (1922b, p. 6) believed that it is closely allied to the Bolton schist.

The Hebron gneiss crops out in the eastern part of the Middletown district, but its structure is not known. The formation is composed of fine-grained quartz-rich gneiss, granite gneiss, porphyritic granite, amphibolite, and highly fissile schist.

PEGMATITES

Pegmatites are common in most of the rock units of the Middletown district. Areal studies have not been

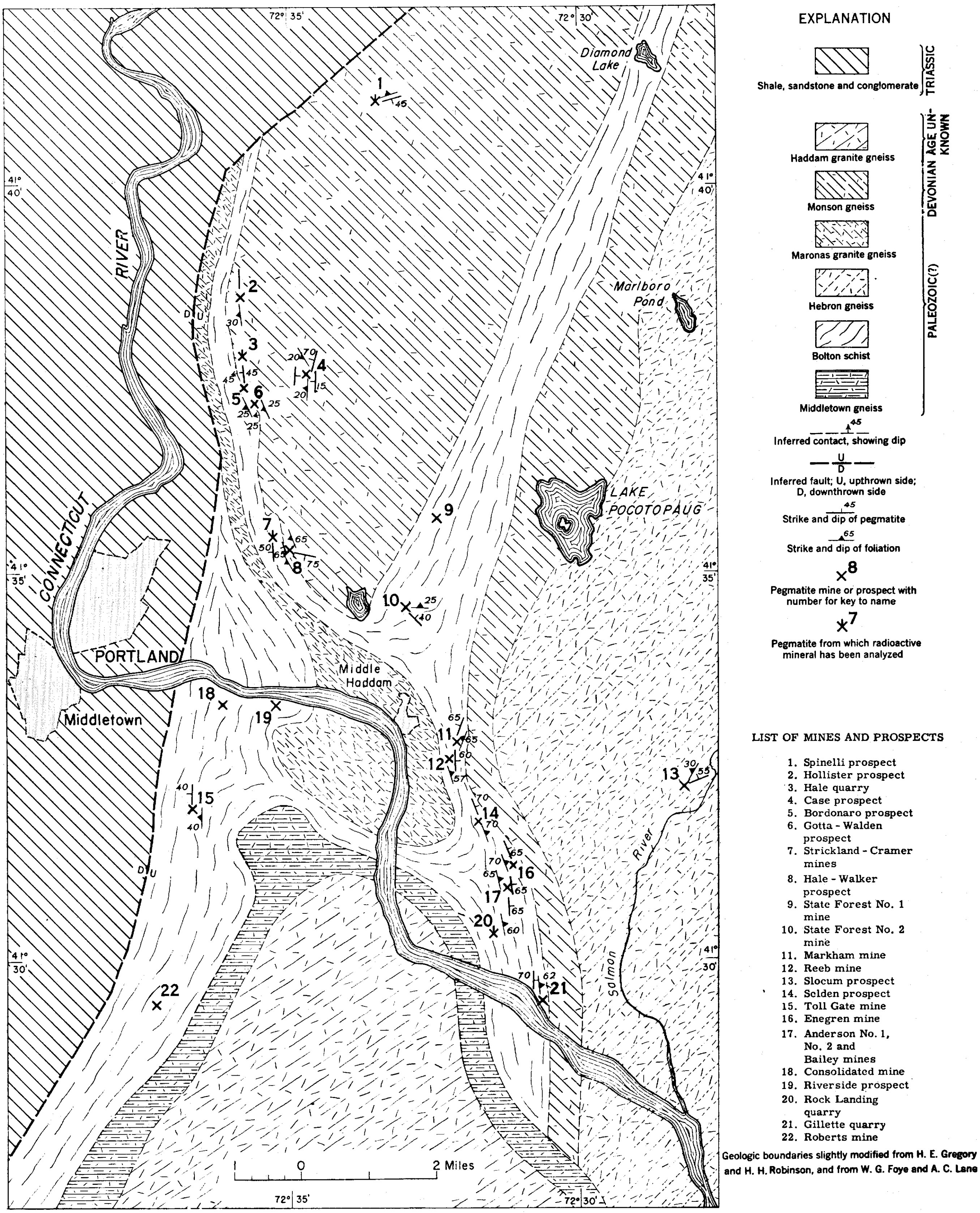


FIGURE 6. –Generalized geologic map of the Middletown district, Connecticut, showing distribution of pegmatite mines and prospects. (Geologic boundaries slightly modified from H. E. Gregory and H. H. Robinson, 1906, and W. G. Foye and A. C. Lane, 1934.)

detailed enough to indicate the relative abundance of pegmatites in the different rock units. It is known, however, that many more pegmatites occur in the Bolton schist than in the western area of Monson gneiss. During World War II, 95 percent of the mica produced in the district, and more than 87 percent of the mica produced in Connecticut, came from nine pegmatites in a belt 8½ miles long and half a mile wide. The belt lies wholly within the Bolton schist, and extends from the Cramer mine, Portland, southeastward to the Gillette quarry, East Hampton. Most of the productive pegmatites in the mica belt lie less than a quarter of a mile west of the contact between the schist and the Monson gneiss. Mica from pegmatites in the Bolton schist is almost invariably rum or ruby, whereas many of the pegmatites in the Monson gneiss are characterized by green muscovite.

Feldspar has been produced chiefly from pegmatites in the Bolton schist and the Monson gneiss. In general, the feldspar-rich pegmatites are not large producers of either mica or beryl. There are exceptions, however, such as the Strickland pegmatite in Portland, which has produced large amounts of both feldspar and mica.

Beryl is found in small quantities in many of the pegmatites in the Bolton schist, but the richest beryl-bearing pegmatites apparently occur either in the western area of Monson gneiss, or along the western contact between this body of Monson gneiss and the Bolton schist. The beryl-bearing pegmatites in the Monson gneiss are discordant, and those occurring along the contact between the gneiss and schist in general cut obliquely across the contact.

Analyses of radioactive minerals from four pegmatites in the Middletown district are given below (data from Shaub, 1938, p. 339), and the locations of the pegmatites from which the radioactive minerals were collected are indicated on figure 6.

Locality	*Mineral analyzed*	*Age in millions of years (corrected for Ac–D)*
Hale Quarry, Portland	Monazite	266
Do	Uraninite	280
Spinelli Prospect, Glastonbury	Samarskite	280
Strickland Quarry, Portland	Uraninite	293
Rock Landing Quarry, Haddam	do	269

The analyses suggest that at least some of the pegmatites in the Bolton schist and Monson gneiss were formed in Late Devonian time. Evidence regarding the source of the pegmatites is inconclusive, for too little is known at present of the relationship of the pegmatites to the various granitic rocks. The conclusion of Foye and Lane that some of the pegmatites are related to the Monson gneiss needs confirmation, for it does not appear to be supported by present observations in the area of the Strickland quarry.

The range in the calculated ages of the pegmatites listed above is appreciable, and it is possible that more than one generation of pegmatites is represented even if all the pegmatites were formed in Late Devonian time. Pegmatites of at least two ages occur in the Middletown district. The productive Strickland mica-feldspar pegmatite cuts an older, barren pegmatite, and at the Slocum prospect the beryl-bearing pegmatite likewise cuts a barren pegmatite. It is uncertain, however, whether the older pegmatites belong to an entirely different genetic group or are merely the earlier stages of a single epoch of pegmatite intrusion. Similarly, until areal studies have been done, the significance of contrasts between the mica and beryl-bearing pegmatites, and between these and the large number of unproductive pegmatites will not be understood.

BRANCHVILLE PEGMATITE

During 1942–45 the pegmatite at the Branchville mine, Redding, (Shainin, 1946 pp. 329–345), was the only pegmatite in the state outside of the Middletown district that yielded mica, although pegmatites widely scattered over the western highlands were examined or prospected. The geology of the Branchville area is not fully known. The country rock at the mine is an amphibolite which is cut by gneissoid biotite-muscovite granite lithologically similar to the Thomaston granite. The Thomaston granite was regarded by Agar (1934) as the intrusive from which the pegmatite was derived. He states (p. 373) that "the age of the Thomaston granite as derived from the radioactive minerals in its accompanying pegmatites is late Ordovician."

PEGMATITES

SIZE

New England pegmatites range from bodies measurable in inches to those more than 1 mile long and hundreds of feet thick. Most of the pegmatites studied are less than 1,000 feet long and 100 feet thick. The writers' observations strongly support Landes' conclusion (1933, p. 35) that pegmatites do not extend downward for great distances. Although New England mines are shallow, the bottoms of several pegmatites have been reached. The bottom of the pegmatite (fig. 100) has been exposed in several places. Exploration and mining indicate bottoming of several pegmatites on the Strickland-Cramer property. The United (fig. 99), Mica Queen (pl. 38), Sargeant (pl. 40), and Black Mountain mines (pl. 4) are in pegmatites that end close to the surface. Stringers of pegmatite extend outward from some of these pegmatites, but it is questionable whether these are the feeding channels or simply apophyses of the main bodies.

SHAPES

Most of the pegmatites studied are lenticular. Ratios of length to breadth to depth vary widely. Most are partly exposed elongate lenses that seem to be tabular bodies. For these the term dike or sheet has frequently been used. Plumbago Mountain beryl prospect and Peabody Mountain quarry are in sheetlike pegmatites. At the other extreme are bodies elliptical in plan and nearly as thick as they are long. The Blister pegmatite seems to show a variant of the lens form, having a cross section of an inverted teardrop. Exploratory drilling suggests that several of the pegmatites in the Strickland-Cramer property are very elongate flattened lenses. The edges of lenses may be tapering but more commonly are bluntly rounded.

Some pegmatites are simple lenses and are constant in strike, dip, and thickness over much of their extent. Others show great variation in thickness, pinching and swelling along strike or down dip. Strikes and dips of the walls of these bodies may show a wide range. If only isolated parts of the walls of such a pegmatite are viewed, the body may appear to be irregular. Many apparent "irregularities," however, are actually structural features, such as rolls, that have a systematic arrangement with respect to the gross form of the body, and some show a close relationship to structural features of the wall rocks. The pegmatite of the Valencia mine (fig. 100), for example, has a floor and walls that are characterized by deep "rolls" alternating with pronounced keels. These plunge almost uniformly northward at angles of 15° to 25°. The rolls, in general, are parallel to the long axis of the pegmatite body, and the recognition of this relationship is an important clue to the position and subsurface extent of the pegmatite. The size of rolls in pegmatite walls varies. Some are small in arc and radius and in plunge length. Others are of such size as to affect plans and methods of mining. Exceptionally deep rolls result in forking of a pegmatite, as at the Atwood mine. The hanging wall of this pegmatite shows a number of rolls that plunge steeply eastward. Near the east end of the main workings the pegmatite branches; the west branch occupies a deep roll of the wall that likewise plunges eastward. In other pegmatites there may be no systematic relationship between the axes of rolls and the form of the pegmatite. In the Strickland pegmatite, for example, axes of rolls and keels show diverse trends, even within limited parts of the body. In the northern part of the pegmatite, however, in the upper levels of the Cramer mine, the prevailing plunge of the rolls is northward—roughly parallel to the inferred crest of the pegmatite.

Several mines are in pegmatites of complex outline that appear to be lenses, partly separated by wedges or discontinuous screens of wall rock. Pegmatites at at the Gillette quarry and the Nichols mine are examples. Compound bodies commonly show a broad concordance with the regional foliation, but are sharply discordant in places, where their outlines seem partly controlled by fracturing or replacement of the wall rocks. For such bodies it is difficult to predict structure in depth with any degree of certainty.

Very few pegmatites are truly irregular. The Columbian Gem pegmatites (fig. 112) and the upper pegmatite at the Black Mountain quarry (pl. 4) probably are as irregular as any that have been studied. A less common form is the stockwork type, best represented in the Hoyt Hill mine, where pegmatite in places cements brecciated older rocks.

RELATION BETWEEN SHAPE OF PEGMATITE BODIES AND TYPE OF WALL ROCK

Pegmatites in relatively massive rocks such as granite and granite gneiss have simpler forms in general than those in the markedly foliated rocks. Simple discordant lenses are common. Concordant pegmatites are the more common in schists and strongly foliated rocks, whereas discordant pegmatites are more common in massive or poorly foliated rocks. In the northern part of the Grafton district, for example, the gneisses of the Bethlehem and Kinsman formations are more massive than the quartz-mica and quartz-mica-sillimanite schists of the Littleton formation, and all of the pegmatites that have been mapped in the Bethlehem and Kinsman formations are discordant to the wall rock foliation. About 60 percent of the pegmatites in the Littleton are concordant and 40 percent are discordant to the foliation.

Concordance or discordance in foliated rocks may be difficult to determine. Along some discordant pegmatites, the foliation planes are bent into virtual parallelism with contacts. Secondary foliation developed along contacts in places so obscures relationships that only study of the surrounding areas indicates whether the pegmatites are concordant or discordant. Determination is the more difficult because many pegmatites that are essentially concordant locally cut across foliation planes. Some large pegmatites in the Rice-Palermo area, though elongate parallel to foliation, are irregular, and their contacts cut sharply across foliation of the enclosing schists in many places. Contacts of the pegmatites at the Strickland and Cramer mines appear to indicate that in general the pegmatites are concordant to the foliation, though locally transecting. The Strickland pegmatite itself, however, intersects an older pegmatite that likewise appears concordant. The fact is that secondary foliation developed along the contacts of the pegmatites obscures the relationships of the pegmatites to the regional foliation. Similar relationships have been noted at other mines.

Broader features of pegmatite structure and distribution are best brought out by detailed areal mapping, of which little has been done in the present work, but several striking examples of structural control of pegmatite emplacement have been found. The pegmatites in the Parker Head area, Maine, are in general parallel and seemingly controlled by planes of weakness that are parallel to the strike of the foliation but cut the dip at a low angle. The three large pegmatites of the E. E. Smith property are arranged in echelon and were evidently emplaced along tension cracks in a shear zone. The pegmatites of the Powell, Marston, and Rice mines are other examples. The pegmatites in the Pikes Ledge area show features in common that are evidently an expression of structural environment.

MECHANISM OF EMPLACEMENT OF THE PEGMATITES

A major aspect of the problem of pegmatite formation is whether pegmatite bodies have made room for themselves by replacement or by simple intrusion. The relationships that bear on this problem have not been studied in detail. The conclusions given below are drawn from the structural relations of wall-rock contacts and from megascopic examination of the wall rocks of pegmatites mapped for economic reasons. More comprehensive study may require modification of the statements.

The contacts of most of the pegmatites studied are sharp, although the adjacent rocks are commonly tourmalinized, enriched in muscovite, or otherwise changed. Contacts, therefore, give little indication that replacement of wall rock has been a major factor in pegmatite emplacement. Furthermore, the wall rocks are bent parallel to the rounded ends of many concordant pegmatites and are crumpled and distorted near contacts with discordant pegmatites. Both relationships suggest forceful injection. At pegmatite no. 13, in the Rice-Palermo area, the schist is bent parallel to irregularities in the contact for 50 feet from the margin of a pegmatite that is only 100 feet wide. The bending of the foliation around the pegmatite bodies in this area, coupled with the almost complete absence of deformation in the pegmatites themselves, indicates that the schist yielded by flow. The paucity of pegmatites containing xenoliths and the rarity of apophyses of pegmatites in wall rock also indicate injection under conditions of flowage rather than fracturing.

Xenoliths are present in some of the pegmatites studied in New England but are abundant only in a few. Commonly they are only slightly affected by the surrounding pegmatite. The foliation of most xenoliths is parallel to wall rock foliation, but some have random orientation.

Some pegmatites, such as the Chandler Mills pegmatite, have gradational contacts and partly digested wall rock inclusions. Others, such as the upper E. E. Smith pegmatite, and the Anderson no. 1 pegmatite, have irregular contacts and rounded projections along which the foliation is not deformed. Such pegmatites seem to have made room for themselves by replacement, at least in part. Most of these pegmatites are roughly tabular bodies, the shapes of which suggest that tension cracks, shear surfaces, or foliation surfaces guided emplacement.

In some of the localities studied regional drag folds in wall rock are parallel to the pegmatite contact and have axes parallel to the plunge of pegmatite bodies, and this relationship suggests that the wall rock structures have guided emplacement of the pegmatites. At other localities, however, such structures are developed only in the vicinities of pegmatite bodies, and the presumption is strong that they resulted from its intrusion. In either case, the wall rock structures are clues to the attitudes of the pegmatite bodies.

Available evidence indicates ingress of the pegmatites along definite channels produced by deformation, in such a manner that the pegmatites came to occupy the spaces between the walls of the channels. Both permissive and forceful injection, as well as replacement, appear to have taken place, but replacement appears to have been decidedly subordinate.

INTERNAL STRUCTURAL FEATURES OF PEGMATITES

GENERAL FEATURES

Pegmatites have long been known for their varied textures and structures, and some observers have emphasized a lack of system in the arrangement of minerals within them. Many students, however, have recognized in pegmatites fairly distinct lithologic units which they designated as streaks, bands, veins, layers, shoots, lenses, or zones. The first American geologist to recognize a systematic internal structure in pegmatites is Hunt (1871, p. 182–186), who noted that many "granitic vein-stones" in Brunswick, Topsham, and Newry, Maine, had a remarkable banded arrangement that was "formed by successive deposits of mineral matter." The concentric structure of the Etta pegmatite, Keystone, South Dakota, was recognized in 1885 by Blake (p. 606–607), who described three zones and a central core and published a map, made by G. E. Bailey, which showed the zonal structure of the pegmatite. Brögger (1890 p. 33–46, 61–71) recognized that some pegmatites have zonal structures and concluded that they were formed in successive magmatic and hydrothermal stages. Brögger's contribution to pegmatite structure and genesis has been confirmed in many subsequent works. Crosby and Fuller (1897, p.157) described "bands" of albite along the walls and a median band of smoky quartz in a narrow pegmatite from Chesterfield, Massachusetts, and stated that the distinct banding indicated that the minerals were deposited in succession. Adams (1898, p. 172,) stated that the "banded structure often seen in pegmatites . . . may and usually does result from the primary crystallization of the cooling magma." Spurr (1898, p. 231) and Julien (1901, p. 508) described pegmatites that contained marginal zones and centrally located cores. Warren and Palache in 1911 (p.125–168) described a concentric zonal arrangement of the minerals in the pipelike pegmatites at Quincy, Massachusetts, and stated that the structure and composition of each zone showed that there was a progressive segregation of mineral-forming compounds. One of their maps shows three distinct zones and a core. Makinen (1913, p. 22), Ziegler (1914, p–264–267), Galpin (1915, p. 27), Laubmann and Steinmetz (1915–1920, p. 584), Lacroix (1922, p. 310, 355–356), Foye (1922b, p. 4–12), and others made contributions to the early concepts of late replacement structures in pegmatites. Special recognition should be given to Fersmann for his excellent work in 1923 (p. 65–80, 275–290) and 1924 (p. 89–92) on the role of late hydrothermal solutions. Sterrett in 1923 (p. 6–7) recognized that mica occurred in "veins" along one or both walls of certain pegmatites and that, if a quartz "streak" (core) was present, mica might occur on either or both sides of it.

In 1925 papers by Cooke (p. 185–188), Hess (p. 289–298), Landes (p. 355–411), Müllbauer (p. 318–336), and Schaller (p. 269–279) described replacement features in pegmatites and emphasized the role of hydrothermal activity in the later stages of pegmatite formation. Campbell (1927, p. 158), in describing the cleftlike lens-shaped Alpine mineral deposits, stated that all the deposits showed concentric zoning and recognized three zones in most of the deposits. A similar relationship was noted in the Conway, N. H., druse pockets by Gillson in 1927 (p. 309). Andersen in 1931 (p. 1–56) described in detail several pegmatites of southern Norway that have sharply defined zones. He attributed the zonal structure to successive stages of crystallization from the wall rock toward the center of the body. He accounted for the lack of mineral replacement (excepting widespread muscovitization and albitization) to the absence of a late lithium "phase" in the pegmatites. Derry (1931, p. 454–475) also recognized concentric zonal structures and mapped the zones in the Silver Leaf lithium pegmatite in the Winnipeg area, Canada. Landes (1932, p. 382, and 1935, p. 326) and Hitchen (1935, p. 9) described zoned pegmatites briefly. Other zoned pegmatites were noted by McLaughlin (1940, p. 46–68) and Shaub (1940, p. 675–678). Smith and Page (1941, p. 595–630) described layered structures in the tin-bearing pegmatites of the Tinton district, S. Dak. They noted that the layers differed in grain size or mineral composition, and listed the age sequence of the pegmatite layers. Olson (1942, p. 374–375) described in considerable detail the generalized zonal structure of many New Hampshire pegmatites. Later work by other Geological Survey geologists in New England has, in general, substantiated Olson's concepts. Field studies by H. M. Bannerman (1943, p. 1–22) in New Hampshire in 1941–42 laid the foundations for the structural approach and field techniques employed by the present writers. Later papers by Pecora (1942, p. 406), Uspensky (1943, p. 437–447), de Almeida and others (1944, p. 209), and Norman (1945, p. 1–17) also contain descriptions of pegmatites that exhibit systematic zoning. Many papers written after 1925 contributed information on replacement in pegmatites (Bjørlykke, 1937; Derry, 1931; Fersmann, 1931; Fraser, 1930; Gevers, 1937; Hess, 1933, 1940; Landes, 1928, 1932, 1933, 1935, and 1937; Palache, 1934; Pegau, 1929; Schaller, 1926a, 1926b, and 1933; and Switzer, 1938).

Despite the amount of work that has been done on pegmatites, however, detailed mapping and structural analysis of pegmatites in general have become accepted practice only in recent years, and it is largely for this reason that geologic data have not been useful to the mine operator, who must plan mining operations with reference to the structure of a deposit. For the operator and prospector, the data on lithologic units occurring in pegmatites never have been systematized, and although definite types of units have been recognized by many, the relationships of these types to one another and to the overall structure of pegmatite bodies have not been clarified.

Most of the pegmatites studied during the present investigations show some degree of systematic arrangement of their constituents, and are divisible into two or more persistent lithologic units. Boundaries between lithologic units are marked by changes in mineral composition, mineral proportions, texture, or some combination of these features. In some pegmatites, boundaries are made obvious by contrasts between units as, for example, where a strongly colored mineral is present in one unit and not another. The boundary between two lithologic units may appear virtually as a line crossing a mine heading. In general, however, boundaries between units are gradational, marked by a transition over a space measured in inches or even in feet, and where such boundaries are shown on maps they are somewhat arbitrarily drawn. Where contrasts between lithologic units are not obvious, boundaries between the units, especially in weathered outcrops, may be difficult to trace, and only careful study reveals the existence of different units. Some pegmatites that were regarded as homogeneous in the early stages of the present investigation were found upon reexamination and more detailed study to consist of several lithologic units. The arrangement of these units in most of the pegmatites studied is related to the walls of the pegmatite bodies. Haphazard arrangements of units is rare. Through repeated visits to active mines, this generalization has been corroborated many times and has proved extremely useful in the analysis of mineral deposits within pegmatites. Most pegmatites show a definite pattern in terms of which mineral deposits at depth can be predicted, at least in some degree.

NAMES USED FOR LITHOLOGIC UNITS IN PEGMATITES

In this report, the name of a lithologic unit is formed by hyphenating the names of the more important rock and mineral components of the unit, the names appearing ordinarily in the approximate order of abundance, such as, "perthite-quartz-graphic granite-oligoclase pegmatite." (See fig. 110.)

TYPES OF LITHOLOGIC UNITS IN PEGMATITES

Parties working in various pegmatite districts during the war found that most lithologic units in pegmatites could be classified according to their structural relationships to the pegmatite bodies. To develop a classification broad enough for general application to pegmatites, discussions were held in 1944 and 1945 among the various Geological Survey field parties studying pegmatites in South Dakota, New Mexico, Colorado, Idaho, and Montana, and in the Southeastern States. The classification used in the present report is based on the results of these discussions, which are also summarized in a paper by Cameron, Jahns, McNair, and Page (1949).

FRACTURE FILLINGS

Fracture fillings are bodies, commonly tabular, that fill fractures in previously consolidated pegmatite (fig. 7, pegmatite *A*). In New England pegmatites they range from tiny veinlets to veinlike bodies at least 20 feet long and at least 1 foot thick. Commonly these bodies have strikes and dips discordant with the pegmatite body as a whole. In the Gotta-Walden pegmatite, a series of steeply dipping veins composed of quartz, microcline, and beryl trends at right angles to the strike of the pegmatite. The Woodward pegmatite contained a small, sharply defined vein of muscovite and quartz that extended from the wall zone through the core of the pegmatite. Veins of fine-grained purple lepidolite 6 to 8 inches thick cut the eastern pegmatite at the Black Mountain quarries, Rumford, Maine. Normally, fracture fillings are restricted to the pegmatite bodies they cut. It is not always possible to tell how closely such fillings are related to the bodies in which they occur, but in most cases they appear to represent the last stages in the development of the enclosing pegmatite. It is to be expected that in the last stages of crystallization of a pegmatite any fracture produced by cooling or deformation would be filled by the residue of the pegmatite liquid, or by material brought by hydrothermal solutions from the source of the pegmatite.

Fracture fillings show a wide range of composition but are commonly composed of minerals that are late in the zone sequence. Fracture fillings are economically unimportant.

REPLACEMENT BODIES

Replacement bodies are units formed by replacement of pegmatite along fractures, along boundaries between other lithologic units within the pegmatites, along contacts between pegmatite and wall rock, or along other structural features of pegmatite bodies. Many replacement bodies are fracture controlled. These range from tabular bodies, differing from fracture fillings only in that slight replacement of the fracture walls is shown, to irregular bodies developed by extensive replacement of fracture walls. The tabular bodies are as much as 8 feet thick and 100 feet or more long. Probably, the mica deposit at the Saunders mine (fig. 95) is an example, and others are found in the Standard, Buffum, and New Hill mines in Grafton, N. H. The Ruby and Barney pegmatite in Grafton contains an extraordinary tabular replacement body along a steeply dipping normal fault that is traceable for 460 feet and seems to cross the pegmatite diagonally. A persistent sheet-mica bearing unit has been formed by replacement of the pegmatite along the footwall of the fault.

The irregular bodies, found in many pegmatites (fig. 7, pegmatite *A*), show a wide range of form and size, but most are small. Replacement bodies in the Strickland-Cramer deposit have yielded part of its production of mica and all the beryl. On the whole, however, irregular replacement bodies have furnished only a very small part of the mineral production from the pegmatites studied.

Quartz, cleavelandite, and muscovite are especially characteristic of replacement bodies, and in most New Hampshire and Maine examples the muscovite is in wedge-shaped books. Many replacement bodies contain small amounts of rare minerals.

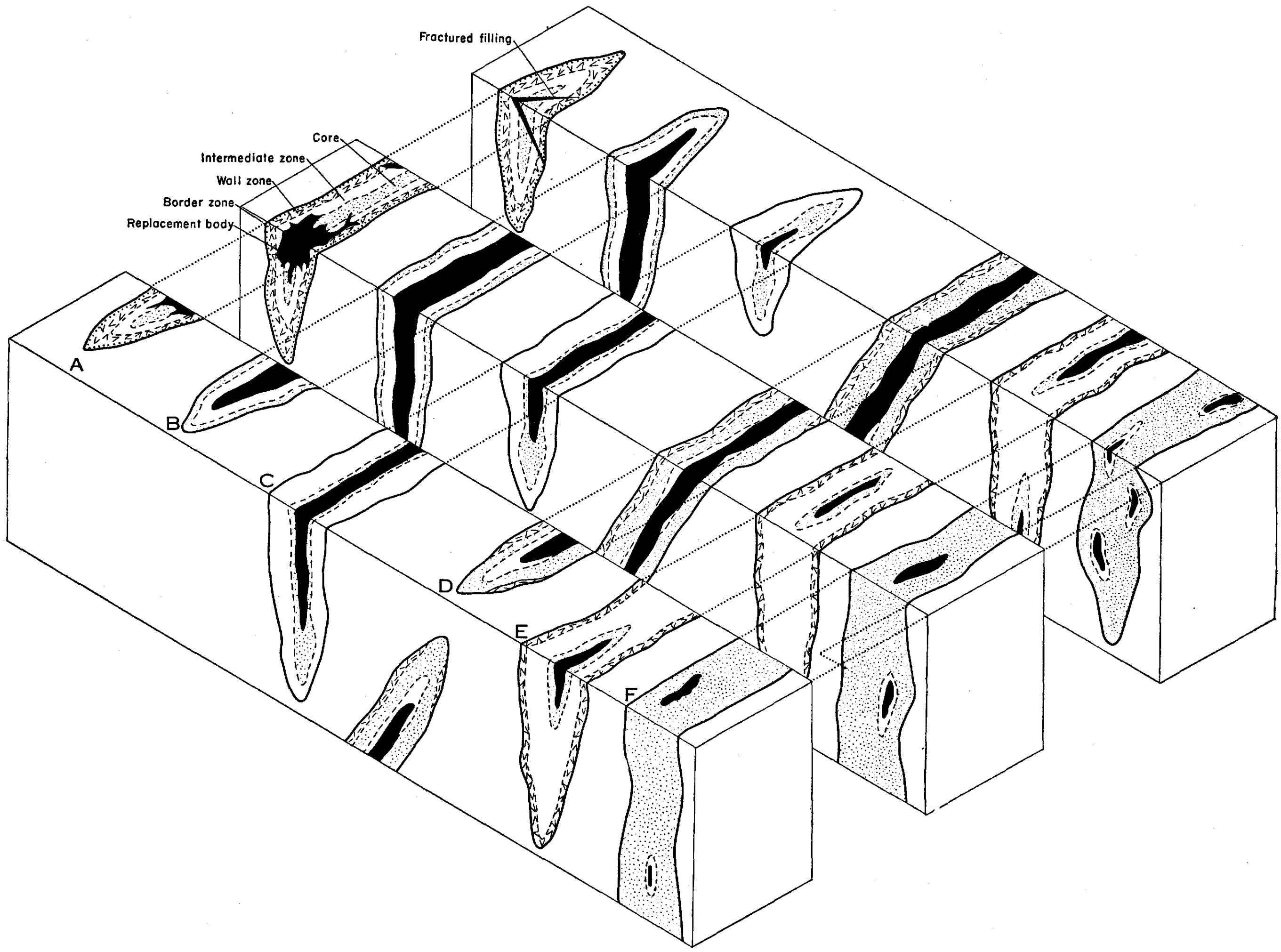


FIGURE 7.—Types of pegmatite units and variations in their form. Pegmatite A—Idealized diagram showing types of zones and relations of fracture-fillings and replacement bodies to zones. Pegmatites B-E—Idealized diagrams showing variations in the forms, symmetry, and continuity of zones. Border zone omitted from each diagram. Outermost zone shown is wall zone, black=core. Pegmatite F—Pegmatite with pods (black), some enclosed in thin intermediate zones. Border zone omitted.

ZONES

GENERAL DESCRIPTION

Zones are successive shells, complete or incomplete, that commonly reflect the shape of a pegmatite body. In ideal development (fig. 7, pegmatite *B*) the zones of a pegmatite are successive shells concentric about an innermost zone or core, and the sequence of zones inward toward the core from any given point along the walls is the same. Commonly, however, the zones are not developed with ideal symmetry. In some pegmatites a zone or group of zones is thicker or thinner on the flanks of a pegmatite than on the keel or crest (fig. 7, pegmatite *C*). In some pegmatites one or more zones are missing on the keel, on the crest, or on one or both flanks (fig. 7, pegmatite *D*). In other pegmatites a zone that is well developed along the keel or crest of a pegmatite is represented on the flanks by scattered patches of pegmatite having a composition appropriate to the zone (fig. 7, pegmatite *D*). There are many examples of discontinous zones, represented by patches of some distinctive type of pegmatite appearing at intervals around the periphery of the zone next inside.

In general, zones nearest the walls of pegmatite bodies are more extensive and more continuous than zones nearest the core. Zones nearest the core are commonly asymmetric, vary in thickness, occur only between the core and the crest, occur only between the core and keel, or are developed only along the flanks. Such asymmetric development is especially characteristic of the inner zones in tabular bodies of the kinds commonly termed dikes or sheets (fig. 7, pegmatite *D*). The core may be so asymmetrically located that it is exposed only after the major part of a pegmatite has been eroded or after mine workings have penetrated it deeply. In other pegmatites, the cores are restricted to small parts of the pegmatite bodies and may thus be concealed until the pegmatites have been well exposed. The core therefore may not be recognized in the early stages of mining a deposit. In general, the core in a tabular or lenticular body is likely to be nearer the keel of the pegmatite than the crest, whereas the zone next outside the core is likely to be best developed between the core and the crest.

Zones reflect, more or less faithfully, the shape of the walls of a pegmatite, and variations in the thicknesses of zones are commonly closely related to structural features of the walls, particularly to pinching and swelling of the pegmatite and to sharp changes in the attitude of a wall. Some changes in zone thicknesses are clearly related to rolls of a wall or reversals of the dip. The mica zone near the west wall of the Gilsum-Victory pegmatite (pl. 11) is an example.

The test of zones, as against other lithologic units within pegmatites, is in their sequential relationships. The mineral assemblages that form zones in a body occur in a definite order from the walls toward the center. A given mineral assemblage, even though asymmetric or discontinuous, is found only in a certain position in the sequence. The constancy of such sequences in different parts of a pegmatite was determined repeatedly during 1942–46, as mining operations in New England pegmatites progressed, and the data at hand show clearly that the arrangement of zones in pegmatites is basically concentric. Some concentric bodies, however, are replacement bodies or fracture fillings formed either along contacts of the pegmatite with its walls or along existing zone boundaries. Most such units can be distinguished from true zones, however, by the fact that other units formed by similar material transect zones inside the concentric unit in question, or offshoots of the concentric unit extend across zones that lie inside the unit (that is, toward the core).

Discontinuous cores deserve special mention. Such a core is represented by a series of lenses or pods centrally located in a pegmatite (fig. 7, pegmatite *E*). Classification of such pods as segments of a discontinuous core rests on the fact that outward from each pod toward the wall the order of lithologic units is the same. In pegmatites having discontinuous cores one segment of the core may be much larger than others. In the Keyes No. 1 mine the main segment of the core is 88 feet long and as much as 15 feet thick. In the headwall of the main working a small segment of the core only 6 feet long and 1 to 2 feet thick is exposed. In the Ruggles mine, similarly, mining operations have been confined largely to one segment of a perthite core that is far larger than any other segment exposed by mining operations. In pegmatites having discontinuous cores, one or more inner zones may be restricted to the peripheries of the core segments, as in pegmatite of figure 7. Such zones are likewise discontinuous. They may be lacking entirely around one or more segments of the core.

Many of the larger pegmatites of New England contain pods of coarse quartz, perthite, plagioclase, muscovite, beryl, and other minerals in various combinations and proportions. The pods (fig. 7, pegmatite *F*) are embedded in pegmatite of different composition that forms by far the larger part of the pegmatite. Surrounding each pod there may be a thin shell differing both from the pod and from the surrounding rock. The sequence of lithologic units outward from a pod is commonly consistent for any given pegmatite. If these pods are aligned along the center, they are easily recognized as segments of a core and the thin shells, if present, as parts of a discontinuous intermediate zone. In some of the large pegmatites, however, the pods are distributed irregularly. Some are close to the margins; some are near the center. The test of the sequence of lithologic units applies to these pods just as it does to the segments of any discontinuous zone, and pods are regarded as limiting cases of zonal structure.

Cores and other inner zones may be restricted to the thickest part of a pegmatite body or, if not thus restricted, have their maximum development there. Thus, in the United mine (fig. 99) the quartz core is found only in the thickest part of the pegmatite, mined largely before World War II. If several segments of a core are found, they commonly coincide with bulges in the pegmatite, and the size of each is roughly proportional to the size of the bulge.

A pair of adjacent zones may be clearly distinguishable in one part of a pegmatite, but in another part it may be represented only by a single layer, commonly thin and discontinuous, in which the minerals of the two zones are intergrown. Such layers are regarded as telescoped zones. In all such cases, the telescoped zones (taken as a unit) will bear the same sequential relationship to the other zones of the pegmatite as does the pair of zones where clearly distinguishable. There are many examples of telescoped zones, particularly in pegmatites where the inner zones are asymmetrically developed. The cores of very narrow pegmatites may consist of minerals that in thicker pegmatites or in thicker parts of the same pegmatite are segregated into two or more distinct zones. The group of pegmatites in the Rice-Palermo area, Groton, N. H., includes several examples.

CLASSIFICATION OF ZONES

It has been found desirable to classify zones into types. During the past three years, several attempts at classification have been made, based on differences in mineralogy, texture, and structural position within the pegmatite. These attempts have shown clearly that a consistent classification applicable to any large group of pegmatites is possible only if the classification is based on structure. On this basis four general types of pegmatite zones (fig. 7, pegmatite *A*) are recognized, as follows: Border zone—the zone directly in contact with the wall rock; wall zone—the zone next inside the border zone; intermediate zone—any zone lying between the wall zone and the core; and the core—the innermost zone of a pegmatite body.

The border zones of most pegmatites are thin. Most are less than 6 inches thick, and border zones more than 4 feet thick are exceptional. Thin border zones cannot be shown accurately on maps at scales of 20 feet to 1 inch or smaller and have therefore been omitted from many of the maps in the present report. Border zones, however, are extremely useful in New England. Contacts of most New England pegmatites are concealed beneath overburden. Glaciation has barely removed the wall rock from the tops or sides of many pegmatites, leaving the border zone as a thin skin coating parts of the pegmatite. By identification of this zone the position, and commonly the attitude, of the contact surface can be recognized even where no wall rock is exposed. Border-zone material is commonly finer grained than the remainder of a pegmatite. Many border zones are composed of aplitic material.[7]

The term "wall zone" is applied to the second zone of a pegmatite. On a strictly logical basis, the term "wall zone" should be applied to the zone immediately adjacent to the wallrock. The use of the term for the second zone, however, has been adopted because many of the mines of New England produce mica from the second zones of pegmatites, and for many years this zone, owing to its nearness to the wall, has been known as the wall zone. The usage of the term "border zone" is not always consistant. By definition the boundaries of zones are mapped on the basis of contrasts in texture or mineral composition of adjacent zones. In practice, however, this usage has not always been followed rigidly. Some of the units designated as border zones in the present report consist of two or more thin layers of contrasting composition, although all are fine-grained.[8] The designation of such a group of layers as a border zone is a concession to practical necessities. While it is possible to define a zone in precise terms, the application of the definition in mapping cannot be a rigid one. The identification of zones in the field must be done on megascopic characteristics and within the limitations imposed by the scale employed. Some of the units shown as zones on accompanying maps could with more detailed study be further subdivided.

A core-margin zone is a special type of intermediate zone that is defined as the zone next outside the core. A core-margin zone cannot be identified as such until it can be shown that the zone everywhere within the pegmatite follows the margin of the core. In one part of a pegmatite an intermediate zone may be separated from the core by one or more other intermediate zones. Elsewhere these intervening zones may be absent so that the zone is in contact with the core and in such places appears to be a core-margin zone. Zone 2 (fig. 7, *D*) is an example. The true relationship of such a zone to the core cannot ordinarily be determined until the pegmatite is well exposed. Similarly, if a core is restricted to parts of a pegmatite which are not exposed, an intermediate zone may be mistaken for the core.

In New England it is rarely possible to determine the full three-dimensional structure of a pegmatite. Relief is not great. Exposures are poor, so that pegmatites are exposed incompletely in two dimensions and very little in the third. For most of the pegmatites studied, information on zones is, therefore, incomplete. Where erosion has barely unroofed a pegmatite, only a single zone or pair of zones may be exposed, and at the other extreme, erosion may have removed the pegmatite except for the keel. The full zonal structure can be understood only when the parts of genetically related pegmatites within small areas have been correlated and a composite picture derived. The largest irregular lepidolite unit in the pegmatite at Black Mountain may prove to be a core.

SEQUENCE OF MINERAL ASSEMBLAGES

Groups of pegmatites that have similar forms and similar relations to the enclosing rocks generally have similar zonal structures and sequences of mineral assemblages. Thus, in the 22 pegmatites of the Rice Mine-Pikes Ledge area, the kinds and sequences of mineral assemblages are fundamentally the same. Still broader sequential relationships can also be recognized. These are shown diagrammatically in figure 8.

The border zone in most pegmatites consists of quartz, muscovite, and plagioclase, with quartz the most abundant mineral. Wall zones show various lithologic units, but units consisting of combinations of quartz, muscovite, plagioclase, perthite, and biotite are most common. In general, wall zones have a higher plagioclase content than border zones and have a lower perthite content than intermediate zones.

Intermediate zones also show great ranges in the

[7] The terms "aplite" and "aplitic material," as used in this report, refer to fine-grained, granular mixtures of quartz and feldspar. No specific mode of genesis is implied by use of the terms.

[8] The terms "fine-grained," "medium-grained," "coarse-grained" are used in this report to represent minerals having the following sizes: fine-grained—less than ½ inch in diameter; medium-grained—½ to 3 inches in diameter; coarse-grained—larger than 3 inches.

lithology of their units. The most common intermediate zones consist of plagioclase, perthite, quartz, muscovite, and biotite. Intermediate zones contain more perthite than wall zones, and generally have less plagioclase. Many have conspicuous long, thin biotite strips. A few pegmatites (such as the Globe in Springfield, N. H., and the Pattuck in Alexandria, N. H.) have core-margin zones that contain abundant plagioclase. Few pegmatites have intermediate zones composed almost entirely of perthite, but where such a zone is present it is commonly in the form of a hood or cap extending over the core.

The cores of most distinctly zoned pegmatites consist of perthite and quartz, although many pegmatites have cores consisting essentially of quartz or perthite alone. Poorly zoned pegmatites generally have quartz-perthite-plagioclase cores. The Anderson No. 1 pegmatite, Portland, Conn., and the Black Mountain pegmatite, Rumford, Maine, are the only ones studied which may have lepidolite cores, and even in these it is not clear whether the lepidolite or the adjacent quartz unit is the core.

New England pegmatites show considerable variety of lithologic units, but a broad sequence of zones is apparent when the arrangements in individual pegmatites are compared. The following is the general sequence of zones for most pegmatites: (1) Quartz-muscovite-plagioclase border zone; (2) quartz-plagioclase zone with or without biotite; (5) perthite-quartz zone; (6) quartz core.

The proportions of quartz, plagioclase, muscovite, biotite, and perthite, the essential minerals of most New England pegmatites, vary from zone to zone, as shown on figure 9. Muscovite and plagioclase, abundant in the border and wall zones, are less important minerals in the intermediate zones and in the cores of most pegmatites. Perthite, uncommon in the border and wall zones, is common in the intermediate zones and core. Quartz, abundant in the border and wall zones, decreases in abundance in the intermediate zones and is most abundant, generally, in the core. Biotite is clase-muscovite zones; (3) plagioclase-perthite-quartz-muscovite zone (with or without biotite); (4) perthite-rare in the border zones and does not form a large percentage of any zone. It is common in wall zones, abundant in the intermediate zones, and absent from the cores of most pegmatites.

Preliminary studies of some pegmatites have been made to determine variation in the anorthite content of plagioclase from zone to zone. The refractive indices of about 150 plagioclase specimens were determined by the single variation method, and about 200 determinations by ordinary immersion methods. The table below summarizes the results obtained from New Hampshire pegmatites. Pegmatites from Maine and Connecticut yielded similar results.

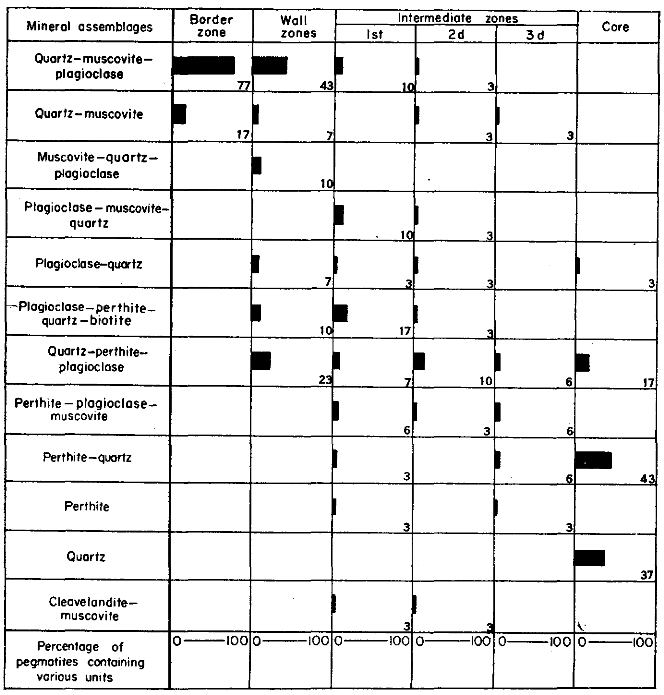


FIGURE 8.—Distribution and abundance of mineral assemblages in certain zoned pegmatites of Maine, New Hampshire, and Connecticut.

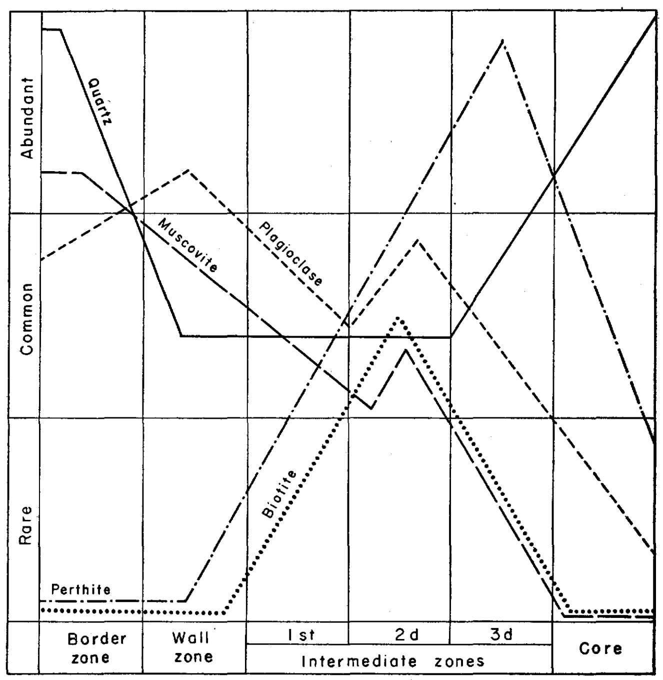


FIGURE 9.—Relative abundance of the most common minerals in zoned pegmatites.

Variation in the anorthite content (percent) of plagioclase feldspar in New Hampshire pegmatites

Mine	Border zone	Wall zone	Intermediate zones	Cleavelandite unit or replacement bodies
Wall rock of Bethlehem gneiss containing oligoclase-andesine or andesine				
E. E. Smith No. 2			16–18	
Fellows		18–19		
J. Nichols	14			
Ledge Pond	16–17	18–19		
Leggett			14+	
McGinnis	20+	14+		
Melvin Hill No. 2			17+	
United	18–20			
Woods	20–22			
Range	14–22	14–19	14–18	
Average	18	17	16	
Wall rock of Kinsman quartz monzonite containing oligoclase-andesine				
Itaska			6+?	
Marston		6+		
Mica Queen	9–10	2–4		
Monarch		4+		
Pattuck	6+	6+	5–7	
T. Patten		12–13	12–13	
Wad.-Tucker	6+	2–4		
E. E. Smith*	2–6	4–7	2–3	
Range	6–10	2–13	2–13	
Average	7	5. 5	6. 5	
Wall rock of Concord granite containing oligoclase				
Hoyt Hill	6–7	6+?		
Wall rock of Littleton schist, containing small amounts of albite, oligoclase and andesine				
Atwood	8–9	4+	4+	
Belden	6+		3–4	
Buffum	14+	10+	6+	
Eight-Ball	6–7	5–6	5–6	
Nancy No. 2	6	6	6	
Palermo No. 1	12	7	7	2+ –6
Pikes Ledge			5–6	
Pinnacle			6+	
Standard				2–3
Valencia			6+	
Victory*	14+	5–12	5–12?	
Ruggles*	7+	2	2–6, 4–6, 4–5, 2–2	2
Keyes*	2–6	2–4	2–4	
Range	2–14	2–12	2–12	2–6
Average	9	6	5	3. 5

*Determination by single variation method; all others by ordinary immersion methods.

In most pegmatites the border zone plagioclase has a higher anorthite content than plagioclase from the other zones. It ranges from albite to andesine, and is highest in anorthite in pegmatites enclosed in the Bethlehem gneiss. In some pegmatites the plagioclase of the wall zone is similar to that of the border zone but generally has a slightly lower anorthite content. Wall and intermediate zones generally show only small differences except where cleavelandite is present. Replacement bodies are characterized by albite with a low anorthite content in all samples studied.

In New Hampshire, plagioclase from pegmatites enclosed in the Bethlehem gneiss is, in general, richer in anorthite than plagioclase from pegmatites in the Kinsman, Concord, or Littleton rocks. The high anorthite content of plagioclase in pegmatites in the Bethlehem gneiss may be due to assimilation of the wallrock by pegmatitic solutions or may reflect the derivation of the pegmatites from the gneiss. It is known that plagioclase in gneiss contains more anorthite than plagioclase in other igneous rocks in the pegmatite districts.

Most of the pegmatites studied in New Hampshire are enclosed in schist of the Littleton formation. These pegmatites contain plagioclase similar in anorthite content to plagioclase in pegmatites found in the Kinsman and Concord rocks. This similarity indicates that most pegmatites in the Littleton formation may be genetically related to the Kinsman or Concord rocks.

RELATIONSHIPS OF MINERALS WITHIN ZONES

Zones are records of the stages in the development of a pegmatite body. The chronologic sequence of stages must be sought in arrangement of zones and in the interrelations of the component minerals. The present work has, of necessity, emphasized other problems, and detailed information on mineral relationships is not available. It is apparent that the different components of a given zone have not always developed simultaneously. In the Keyes no. 1 pegmatite, for example, in the biotite-bearing intermediate zone, muscovite and plagioclase are euhedral against perthite and quartz, which appear to have filled spaces that remained after crystallization of the earlier minerals. It is significant that in this zone the minerals that appear to be early are the minerals that make up the bulk of the outer zones, whereas the two minerals that appear to have crystallized later are characteristic of the core and core-margin zone of the pegmatite.

Many zones, particularly those rich in perthite, contain muscovite and albite that were introduced after the formation of the zone. Both minerals, intergrown in places, or occurring singly, are found as scattered flakes, irregular nests, or vein-like shoots. They rarely make up an important part of the zone. The muscovite is white, yellowish green or greenish brown, and is easily distinguished from the muscovite found in the wall or core-margin zones. Other pegmatites (for example the Woodward) have zones that contain large amounts of late quartz in small, irregular lenses that cut all of the earlier formed minerals and transect the zonal structure.

In some zones mineral proportions vary along strike and dip. In certain wall-zone mica deposits, for example, there are such variations in the book mica content that some parts of the zones repay mining and others do not. Definite shoots can be recognized within some zones and, if the shoots are large enough, the operator can take advantage of this by selective mining. Some shoots are irregular, but others are closely related to structural elements of a pegmatite. Shoots that are parallel to rolls of the wall, or are related to the keel or crest of a pegmatite, are known and are discussed in subsequent sections. Variation in the composition of a particular mineral may likewise be found within a zone, and ultimately all such variations must be studied if the structure and origin of pegmatites are to be understood. Where variations in mineral composition and mineral proportions are found, there is a subjective element in the location of zonal boundaries, but such variations have not ordinarily proved troublesome.

ORIGIN OF ZONES

The following generalizations may be made concerning the origin of the zones described in this report:

1. The spatial sequence of lithologic units is constant not only for a given pegmatite but for groups of pegmatites within small areas and for New England pegmatites in general. Units present in some pegmatites are absent in others, but, where found, the position of a unit with respect to other units is remarkably constant over the region. This feature the authors find difficult to explain if zones are due to successive hydrothermal replacements of massive pegmatite.
2. In most pegmatites studied, certain features suggest that the minerals of the inner zones were formed after the minerals of the outer zones. Where a quartz core, for example, is surrounded by a perthite or quartz-perthite core-margin zone, perthite crystals along the core-margin are euhedral against the quartz of the core. In a few pegmatites, quartz of the core extends outward into the perthite along fractures, whereas the reverse relationship has not been found. It seems clear that the cores in these pegmatites developed after the core-margin zones.

   It is noteworthy, moreover, that the general succession of mineral assemblages inward from the walls found in the present work corresponds to the paragenetic sequence of pegmatite minerals established by the work of many other investigators. An exception is plagioclase, which has usually been ascribed to late replacement. However, it has not been generally recognized that, where replacement effects are most strikingly indicated, two kinds of plagioclase are present. The replacing feldspar is commonly cleavelandite (An_{1-3}) where the zones contain either more calcic albite or oligoclase.
3. In some pegmatite bodies pseudomorphs and fracture-controlled replacement bodies are conspicuous, but such features are lacking in most zoned pegmatites or (if developed at all) are on a small scale and characterized by minerals other than those of the zones. Where present, replacement bodies are superimposed on the pattern of the zones, which are evidently earlier.
4. In most pegmatites, evidence that zones were formed by replacement of pegmatite has not been found.
5. Where replacement of pegmatite units has been recognized it has not, in general, developed concentric units of the zone type, but has obscured or obliterated existing zonal structure.

The authors are not in full agreement as to the interpretation of the evidence, but all feel that the possibility that most zones have developed by successive deposition inward from the walls, not by successive replacements of massive pegmatite, requires serious consideration. They are also agreed that further work on the problem of zone development is needed. It has been possible to test in some degree the methods that might be used in investigating the problem. It is believed that evidence should be furnished by work along the following lines:

1. Additional field and laboratory work on the plagioclase feldspar from different zones to establish the distribution of different kinds of plagioclase. Similar studies of variation in other common pegmatite minerals, such as tourmaline, muscovite, and beryl, should also be made.
2. Spectrographic determinations of the minor-element variations in minerals taken from successive zones. Muscovite, which contains relatively large amounts of Li, Cs, and Rb, is widespread, and occurs in almost every zone of many pegmatites. Stevens and Schaller (1942, p. 525-537) have indicated that minor element content is highest in muscovite developed late in the formation of California pegmatites.
3. If methods can be developed, alpha- and beta-quartz determinations should be made from carefully selected samples from well-zoned pegmatites. If the outer zones contain only beta-quartz (high-temperature quartz) and the inner zones only alpha-quartz (low-temperature quartz), successive deposition of the zones inward is indicated. Wright and Larsen (1909, pp. 421–447) concluded that some pegmatitic quartz is beta-quartz but that other quartz, particularly that in large masses, is alpha-quartz. Frondel (1945, pp. 447–460), however, has recently questioned the criteria used by Wright and Larsen for distinguishing the two types of quartz.
4. Detailed laboratory studies of the textural and structural relations of minerals in the various zones.
5. Careful mineral and chemical analyses to determine the bulk compositions of zones and of minerals within zones.

RELATIONS OF ZONES TO FRACTURE FILLINGS AND REPLACEMENT BODIES

In general, as shown in figure 7, fracture fillings and replacement bodies enter into structural patterns that are superimposed upon the structural pattern of the zones. In general, therefore, fracture fillings and replacement bodies represent the later stages of pegmatite development. In some pegmatites, however, zones and the other units overlap in age, for some fillings of fractures in outer zones are direct offshoots from inner zones, and the material forming an inner zone may likewise form replacement bodies in outer zones. The broad division of pegmatite units into two age groups, one consisting of zones, the other of replacement bodies and fracture fillings, is nevertheless useful provided that the existence of overlap is kept in mind.

CLASSIFICATION OF MINERAL DEPOSITS IN PEGMATITES

In classifying pegmatite mineral deposits, the mode of distribution of the mineral or minerals sought is the fundamental characteristic to be considered. Commonly the mineral will be found in marked concentration only in a certain lithologic unit in a pegmatite, or less commonly in two or even three of the units present. In the present report each unit in which a particular mineral is concentrated is regarded as a deposit of that mineral. The deposit is designated by the name of the structural type of unit involved—thus, wall-zone mica deposit, core-margin beryl deposit, fracture-controlled beryl deposit.

MINERALOGY OF THE PEGMATITES STUDIED

The minerals of the pegmatites studied identify them with the granitic group of rocks. The essential minerals in almost every pegmatite are quartz, perthite, plagioclase (albite or oligoclase, very rarely andesine), and muscovite. Certain minerals—biotite, black tourmaline, apatite, garnet, and beryl—are present as accessories in most pegmatites. The occurrence of the essential and the common accessory minerals is discussed in the preceding section on the internal structure of pegmatites.

The rarer accessory minerals have been given much attention by mineralogists and collectors. The bibliography included with this report (pp. 341–347) contains numerous references to the pegmatite minerals of Maine, from Black Mountain in Rumford, Newry, the Bennett quarry in Buckfield, the Harvard mine in Greenwood to mines and quarries in Poland, Auburn, Paris, Stoneham, and Topsham. In New Hampshire the Ruggles mine in Grafton, Parker Mountain in Strafford, the Palermo mine in Groton, and Beryl Mountain in Acworth are well known. The better known localities in Connecticut are the Branchville mine in Redding, the Gillette mine in East Hampton (Haddam Neck), the Strickland-Cramer mine in Portland, and the Roebling mine in New Milford.

The occurrence of the rarer accessory minerals at the better known New England localities is given in the table below. The list is incomplete and further work will reveal the presence of many minerals not included in the list. Many localities in Maine not visited by Survey parties have not been included.

The phosphates, especially those containing manganese and lithia, are probably the most distinctive accessory minerals in New England pegmatites. The Branchville mine in Connecticut is famous for its phosphate minerals. In the Grafton district of New Hampshire many pegmatites in the Littleton formation and some in the Kinsman quartz monzonite contain graftonite, triphylite, and their alteration minerals. Some of the pegmatites in the district contain these minerals in large masses.

Many localities in Maine, including Mount Mica, the Bennett quarry, Harvard quarry, and the Newry quarries, have yielded gem-quality tourmalines in the past. So far as is known none of the pegmatites in New England yielded more than a few specimens of gem-quality tourmaline during 1942–45. Small amounts of aquamarine of commercial quality were obtained from the Palermo and Pattuck mines in 1943. The total amount of gem stock obtained from both mines probably did not exceed 25 pounds.

The radioactive minerals (uraninite, uranophane, gummite, torbernite, and autunite) are found at the Ruggles mines in Grafton, New Hampshire, and have been found at other places in New Hampshire such as the Globe mine, in Springfield, Carpenter mine in Grafton, E. E. Smith mine in Alexandria, Palermo mines in Groton, and Parker Mountain mine in Strafford; and in Connecticut at the Strickland-Cramer mine in Portland and the Branchville mine in Redding.

MICA DEPOSITS

KINDS AND CHARACTERISTICS OF MICA

The generic name "mica" designates a division of minerals characterized by perfect basal cleavage along which the crystals split easily into thin laminae. Although the micas have a wide range of composition, all are essentially silicates of alumina with potash and hydroxyl. Iron, sodium, lithium, magnesium, fluorine, and sometimes other elements are present in various species. The mica division is divided into three groups: the mica group, including the micas proper; the clintonite group, known as the brittle micas; and the chlorite group.

The chief micas of commerce are muscovite (white mica or potash mica), phlogopite (amber mica), lepidolite (lithium mica), and zinnwaldite (lithium-iron mica). Muscovite, lepidolite, and zinnwaldite are mined almost exclusively from granite pegmatites. Small quantities of muscovite are recovered from mica-schists. Muscovite is by far the most abundant and most important of the micas in New England pegmatites. The other commercial mica occurring in these states is lepidolite, which is found only in a few pegmatites and commonly is present only in small quantities. Unless otherwise specified the term "mica" as used below refers only to muscovite.

PROPERTIES OF MUSCOVITE

Muscovite crystallizes in the monoclinic system but shows a close approach to rhombohedral symmetry. The crystals are rhombic or hexagonal in outline, and the angles defining the base are nearly 120 degrees. The precise formula of muscovite is still uncertain, although a close approximation is $2H_2O.K_2O.3Al_2O_3.6SiO_2$.

Mica crystals of all sizes and shapes are commonly termed "books." If crystal faces are absent, it is possible to orient a mica book by means of its percussion

Rare and accessory minerals in 20 New England pegmatites

[Magnetite, hematite, and goethite are common as inclusions in muscovite]

	Amblygonite	Arsenopyrite	Autunite	Beryllonite	Calcite	Cassiterite	Chalcedony	Chalcopyrite	Chrysoberyl	Columbite-tantalite	Cookeite	"Cymatolite"	Cyrtolite	Dahllite	Damourite	Dickinsonite	Dufrenite	Eosphorite	Eucryptite	Fairfieldite	Ferri-sicklerite
Connecticut																					
Anderson No. 1, E. Hampton																					
Branchville, Redding			X		X					X		X	X						X	X	
Gillette, E. Hampton																					
Spinelli, Glastonbury																					
Strickland-Cramer, Portland	X		X							X	X										
Toll Gate, Middletown										X											
Maine																					
Bennett, Buckfield	X		X			X				X	X			X		X		X		X	
Black Mountain, Rumford			X			X				X			X		X			X			
Harvard, Greenwood	X									X	X										
Newry, Newry	X		X	X		X	X			X	X							X			
New Hampshire																					
Chandler Station, Newport		X																			
DeMott, Grafton																					
Eight-ball, Rumney																					
Keyes, Orange																					
Palermo No. 1, Groton	X		X							X			X				X			X	X
Parker Mtn., Strafford	X		X			X					X						X	X		X	
Pattuck, Alexandria		X						X		X											
Ruggles, Grafton			X																		
Sargeant Mine, Claremont																					
Smith, Alexandria			X							X											
Weeks, Wakefield									X												

	Fluorite	Francolite	Gahnite	Graftonite	Gummite	Hatchettolite	Herderite	Heterosite	Lazulite	Lepidolite	Lithiophilite	Löllingite	Manganoan apatite	Manganite	Manganocolumbite	Manganotantalite	Marcasite	Montebrasite	Montmorillonite	Opal	Pollucite
Connecticut																					
Anderson No. 1, E. Hampton										X											
Branchville, Redding	X										X		X								
Gillette, E. Hampton	X									X											
Spinelli, Glastonbury																					
Strickland-Cramer, Portland	X									X	X		X								
Toll Gate, Middletown										X											
Maine																					
Bennett, Buckfield							X			X			X	X		X			X		X
Black Mountain, Rumford		X								X					X						
Harvard, Greenwood			X							X											
Newry, Newry		X			X	X	X			X	X							X		X	X
New Hampshire																					
Chandler Station, Newport																					
DeMott, Grafton				X								X									
Eight-ball, Rumney																					
Keyes, Orange				X													X				
Palermo No. 1, Groton	X			X	X			X	X	X		X		X							
Parker Mtn., Strafford				X				X		X		X									
Pattuck, Alexandria																					
Ruggles, Grafton					X														X		
Sargeant Mine, Claremont				X													X				
Smith, Alexandria										X		X									
Weeks, Wakefield																					

	Prochlore	Psilomelane	Purpurite	Pyrite	Pyrrhotite	Reddingite	Rhodochrosite	Samarskite	Siderite	Sphalerite	Spodumene	Topaz	Torbernite	Triphylite	Uraninite	Uranophane	Vivianite	Whitlockite	Zinnwaldite	Zircon
Connecticut																				
Anderson No. 1, E. Hampton																				
Branchville, Redding				X		X					X		X			X				
Gillette, E. Hampton			X																	
Spinelli, Glastonbury								X												
Strickland-Cramer, Portland				X							X				X	X				
Toll Gate, Middletown																				
Maine																				
Bennett, Buckfield		X				X	X				X	X		X						
Black Mountain, Rumford			X				X		X		X			X	X	X	X			X
Harvard, Greenwood											X									
Newry, Newry	X		X			X			X	X	X			X	X		X			X
New Hampshire																				
Chandler Station, Newport			X											X			X			
DeMott, Grafton														X			X			
Eight-ball, Rumney			X											X			X			
Keyes, Orange					X									X			X			
Palermo No. 1, Groton		X	X	X			X		X					X		X	X	X	X	
Parker Mtn., Strafford			X				X							X						
Pattuck, Alexandria					X									X			X			
Ruggles, Grafton				X									X		X	X	X			
Sargeant Mine, Claremont			X											X			X			X
Smith, Alexandria														X			X			
Weeks, Wakefield																				

figure. This is a six-rayed star of fractures that can be produced on a cleavage plate with a blow from a dull-pointed instrument. Two lines of the figures are nearly parallel to the prismatic edges and a third, the most strongly developed, is parallel to the plane of symmetry. Another less distinct six-sided star, the lines of which are nearly at right angles to those of the percussion figure, is called the pressure figure. It may be formed by pressure from a dull point while the cleavage plate is resting on an elastic surface.

Owing to its perfect basal cleavage, muscovite can be split into sheets less than one one-thousandth of an inch in thickness. The sheets have luster and are elastic, transparent, and flexible. Some mica is so flexible that, as in the manufacture of airplane spark plugs, a thin sheet can be rolled around a rod ⅛ inch in diameter without cracking, buckling, or any other impairment.

Most muscovite is colorless when split into sheets less than one thirty-second of an inch thick. Sheets 1/32-inch thick or thicker, may be colorless, gray, yellow, amber, red, brown or green. The terms most used in the mica trade for different colors are ruby, rum, green, white, and brown. Rum mica is brown and ruby is a reddish shade of brown. Colonial Mica Corp., in 1943-45, classified all mica other than green as "ruby." Some rum or ruby mica is color-banded, and has a cross-hatched, checkered, banded, or streaked appearance. This is caused by the presence of alternate lines or bands of rum or ruby and colorless material. Two sets of bands are present; one is parallel to the hexagonal sides of the book, the other is normal thereto. Some books of ruby mica are color-zoned; these contain wide bands of ruby color which are darkest near the outer margins of the book and are arranged in a hexagonal pattern. The hexagonal margins of other books are bordered by a green band. Most of the mica mined in New England is rum or ruby. Pale yellowish green, greenish white, and other shades are less common. There is no obvious correlation between wall rock and color of mica in New Hampshire and Maine. The pale rum mica mined in the Middletown district in Connecticut, however, occurs in pegmatites in the Bolton shist, whereas most mica from prospects within the Monson gneiss is green.

The hardness of muscovite on the Mohs scale is 2 to 2.5. This hardness is determined by the relative resistance of mica to abrasion as compared with a set of arbitrarily chosen minerals. In the mica industry, however, the term "hardness" is also used to describe the relative inflexibility or compactness of a mica sheet more than one thirty-second of an inch in thickness. This "hardness" can be tested easily by striking the sheet sharply with the knuckle of the index finger. A hard sheet will not "give" and a sharp sound will result, whereas a soft sheet will "give" more on being struck and will not emit as sharp a sound. Despite the relative inflexibility of a hard book, thin laminae peeled from the book possess the characteristic flexibility of muscovite. Hardness is a distinct asset; it is one of the factors that determine the quality of sheet-mica.

Mica is an excellent insulator against both heat and electric current and is the highest standard insulator used in electrical equipment. (See Wierum and others, 1938, p. 9.) There are more perfect insulators, but none that is also infusible, flexible, impervious to water, and obtainable in thin sheets.

STRUCTURAL IMPERFECTIONS

Structural imperfections of cleavage surfaces are present in muscovite from every pegmatite. Some pegmatites contain larger percentages of imperfect mica than others. The reasons for the imperfections are not always apparent, although in some cases the deformation of books is related to faults and shear zones. Imperfections decrease the size of flat, unmarred sheet mica that can be recovered from a book.

"Ruled" or "ribbon mica" has parallel sharp parting planes cutting the book at an angle of approximately 60° with the cleavage surface. These planes pass completely through some books, but extend only part way across the faces of others, or do not cut through their entire thickness. The trace of the ruling planes corresponds in direction to the rays of the pressure figure. In some books, two or three sets of ruling planes are present, their traces intersecting on a cleavage face at about 60°. This defect is very common in New England mica; almost every mica-bearing pegmatite in the region contains examples.

"Reeves" are crenulations, sharp folds, or discontinuities in the laminae of a book. They are commonly long and straight. In most books they have the same orientation as ruling planes.

"A" structure consists of two sets of reeves or partings that intersect on cleavage surfaces at approximately 60°. The arms of the "A" (actually a "V") are parallel to the ruling planes in most books.

The dielectric strength of mica (its ability to withstand high voltages without impairment or puncture) is unequaled by any other substance that is at the same time infusible, flexible, and nonabsorbent. (See Wierum, 1938, p. 9.) Muscovite is also resonant, a quality important in radio technology. It is practically incompressible, and is chemically stable.

In the varied attributes of mica are found (Wierum, p. 10) answers

> * * * to virtually every demand made by electrical engineers. Instead of becoming outmoded with the advance of science,

mica has become more and more necessary as higher temperatures and voltages are employed in generators; as radio and television are developed; as multitudes of small generators and motors serve us in automobiles; in airplanes, as they are gradually made safer; and as that imponderable unit, the electron, is studied, and slowly brought under control.

During World War II an intensive search for mica substitutes was made. Substitutes for mica in certain applications have been found but the extent to which the mica industry will be affected has not been fully revealed.

In "herringbone" or "fishtail" mica, there are three sets of reeves on cleavage surfaces. Two sets intersect a central, spinelike set at angles of approximately 60°. The defect is relatively uncommon in New England mica. It seems to occur most commonly in wedge mica.

In "tangle-sheet" mica perfect laminae may split well from one part of a book but may tear while being split from others. This imperfection, caused by intergrowth of parts of one sheet with another, may mar an apparently perfect book. The defect is fairly common in New England mica.

Fine cracks, nearly invisible to the unaided eye, sometimes occur in books of tanglesheet. These are often referred to as "hair cracks." Irregular cracks that cross cleavage sheets, from one ruling or reeving plane to another, are sometimes called "cross fractures."

The name "wedge mica" is applied to books that are thicker on one end than on the other. In some books the difference in thickness on opposite ends may exceed one inch in a book 5 inches long. Wedge mica commonly has "A" and herringbone imperfections, and is due to an unequal development in the width of the laminae. Some of the laminae extend across the entire width of the crystal, others do not. Where the short laminae are not matched by similar laminae extending from the opposite edge, the crystal is thicker on one side than on the other. Wedge-structure is a common defect in New England mica, particularly in books from intermediate-zone deposits. Photographs and detailed descriptions of many of the defects mentioned above are given by Sterrett (1923, p. 14–18).

Buckles, waves, and warping are terms used to describe deviations of a cleavage surface from perfect flatness. These imperfections are common in New England mica, especially in mica from wall zone deposits.

INCLUSIONS

Inclusions of foreign minerals in mica books are broadly referred to as "stains." In the trade, most formless inclusions are called "stains," while those with regular forms, apart from certain hematite and magnetite "stains," are usually called inclusions.

Inclusions in mica can be divided into: primary inclusions (those formed during or shortly after crystallization of the mica), and secondary inclusions (those formed between the cleavage planes chiefly through the action of circulating ground water). Some primary inclusions interrupt the continuity of one or more cleavage planes; and if such an inclusion is removed a hole (pinhole) remains in the main sheet. On the other hand, secondary inclusions and some primary inclusions are confined to the spaces between the sheets. By splitting the mica these inclusions can often be removed without damaging the adjoining cleavage surfaces. In some muscovite, secondary inclusions have formed only along a few opened cleavages, and for this reason mar fewer sheets than primary inclusions.

In New England, primary and secondary stains (and pinholes) seem to be most common in mica from wall-zone deposits, although stained mica is abundant in some other types of deposits.

The principal primary inclusions in New England mica are tourmaline, garnet, quartz, apatite, biotite, pyrite, and magnetite. "Clay stains," limonite, hematite, and manganese oxide are common secondary stains. Tourmaline and garnet occur in many books, in small flattened, subhedral crystals. In some pegmatites, tourmaline forms radial aggregates composed of long, narrow, needlelike crystals. Biotite is often intergrown with muscovite in (1) parallel blades, (2) alternating cleavage sheets, (3) in blades radiating from a common center, and (4) as hexagonal bands parallel to crystal outlines.

Clay stains are generally yellowish-brown or rust-colored films. Most clay stains are a mixture of limonite and small detrital grains of minerals derived from the surrounding rocks. Limonite and hematite stains are common and are deposited by circulating ground water that has removed iron from magnetite, pyrite, garnet, or other iron-bearing minerals. In general, secondary stains are absent below the level of oxidation. The depth at which this level is reached varies from one pegmatite to another and depends on many factors that include: (1) the degree to which the pegmatite and its wall rock have been fractured; (2) the amount of iron-rich minerals susceptible to oxidation, in the pegmatite or in the wall rock; (3) the topographic position of the pegmatite. In New England these stains are seldom found more than 50 feet below the surface.

Air stains are tiny bubbles of gas trapped between cleavage surfaces of mica books. Air stain is not common in New England muscovite.

Detailed information on the form and orientation of primary and secondary inclusions has been published by Frondel and Ashby (1936, p. 777–799; 1937, p. 104–121).

WARTIME CLASSIFICATION OF MICA

The marketing, grading, and quality-classification of mica are involved processes. Descriptions of the mica industry before World War II have been published elsewhere (Bowles, 1922; Chowdhury, 1941; de Schmid, 1912; Spence, 1929, 1937; Wierum and others, 1938). In the United States, Goverment subsidies met the urgent wartime need for high quality sheet mica from November 1942 to April 1945. During this period various changes in specifications and prices of strategic mica were announced by Colonial Mica Corp.[9] Definitions of terms used in this period and a general review of specifications and prices are given below.

Generalized review of specification and prices of mica purchased by Colonial Mica Corp., Nov. 1, 1942, to June 30, 1945

Period	Sheet				Punch (domestic) price	Remarks
	Grade (size) in inches	Trim	Quality classification (domestic)	Price per pound		
June 18, 1942–Nov. 1, 1942.	Various. From 1½ by 2 to 6 by 8.	½	1 and 2	$1.10 to $8.00	$0.22	
Nov. 1, 1942–May 24, 1943.	do	½	do	2.40 to 9.12	.30	
May 24, 1943–Dec. 31, 1943.	Sched. I: from 1 by 1 to 6 by 8.	½	No. 1	1.00 to 9.12	.30	Bonuses for ¾ or full trim; 2 tables with various price combinations offered in each schedule.
	Sched. II: 1 by 1 to 1½ by 2.	Full	1 and 2	5.00	.40	
	1½ by 2 and up	¾	do	5.00		
Jan. 1, 1944–Jan. 31, 1944.	Sched. II: 1 by 1 to 1½ by 2	Full	do	5.00	.40	Schedule 1 canceled.
	1½ by 2 and up	¾	do	5.00		
Feb. 1, 1944–Aug. 7, 1944.	Sched. II: 1 by 1 to 1½ by 2	Full	do	6.00	.40	
	1½ by 2 and up	¾	do	6.00		
Aug. 7, 1944–Dec. 31, 1944.	Sched. III: 1 by 1 to 1½ by 2	Full	do	6.00		
	1½ by 2 and up	Full	do	8.00	.40	
	Sched. II: 1½ by 2 and up	¾	do	6.00		
Jan. 1, 1945–Mar. 31, 1945.	2½ square inches with usable rectangle at least 1 inch wide.	Full	do	8.00	.30	Green mica and black-stained mica eliminated from purchases; ¾ trim sheet and sheet less than 1½ by 2 eliminated.
Apr. 1, 1945–June 30, 1945.	Table A: 1 square inch (with minimum width of ¾ inch) to 100 square inches (with minimum width of 4 inches.)	Full	1, 2, and 3	.25 to 38.65		Return to nonsubsidy basis; punch eliminated from purchases.
	Table B: 1 square inch (minimum width ¾ inch).	Full	1 and 2	2.25		

STRATEGIC MICA

The term "strategic mica" was used during World War II to designate various grades and qualities of mica required by war industry. As the term has been defined differently by various agencies, and definitions have varied from time to time, it has no fixed meaning in terms of grades (sizes) and qualities of mica. All definitions, however, are based on grades and qualities that are discussed fully below.

SHEET MICA

The term sheet mica has long been used for a wide range of grades (sizes) and qualities of mica. In the United States, before World War II, sheet mica was, in general, an area of mica, not less than 1½ by 2 inches, free from cracks, and other visible defects. Prices, in general, ranged from $1.10 to $8 per pound, depending on the size of the sheet. During World War II, Colonial Mica Corporation defined sheet in terms of specifications that were periodically revised. Acceptable grades of sheet were required at all times to have a rectangular area 1 by 1 inch or larger. Most of the sheet was purchased at $5 to $8 per pound, and most was required to be No. 2 inferior or better in quality. (Quality designations are defined below.) On April 1, 1945, the grades and prices of sheet were returned to a "sliding scale" similar to that which prevailed before the war, and the subsidy was withdrawn. (See table.)

PUNCH MICA

In the United States, before World War II, punch

[9] War Production Board Conservation Order M-101, effective December 1942, required all potential buyers of domestic mica to obtain authorization from the War Production Board to purchase domestic mica. The Colonial Mica Corp. was given authority to purchase domestic mica. On May 24, 1943, Colonial Mica Corp. issued its buying schedule under the high-subsidy one-price system. Colonial became the exclusive buyer of domestic sheet mica because the price named was considerably in excess of any price that could be offered by a private buyer.

mica was required to yield a circle 1¼ to 1½ inches in diameter. It was sometimes classified as sheet, although Colonial Mica Corp. has defined the two separately (in circular letters to mica producers, dated May 24 and Dec. 7, 1943, Sept. 27, 1944). Punch mica, as defined by Colonial must have a clear usable area, free from cracks, or other visible defects, of not less than 1 inch in diameter, and the total area of each piece must not be more than five times the usable area. Punch mica was purchased by Colonial from June 18, 1942, to March 31, 1945, at prices ranging from $0.22 to $0.40 per pound (see table).

QUALITY OF MICA

There are numerous quality designations for both foreign and domestic mica. The American Society for Testing Materials (A. S. T. M. Designation D351–38, adopted 1938) defined quality, in terms of the nomenclature used in the trade, as follows:

Designation	*Description*
Clear	Free of all mineral and vegetable inclusions, stains, air inclusions, waves, or buckles. Hard transparent sheets.
Clear and slightly stained	Free of all mineral and vegetable inclusions, cracks, waves, and buckles, but may contain slight stains and air inclusions
Fair stained	Free of mineral and vegetable inclusions and cracks. Hard. Contains slight air inclusions and is slightly wavy.
Good stained	Free of mineral inclusions and cracks, but contains air inclusions and some vegetable inclusions, and may be somewhat wavy.
Stained	Free of mineral inclusions and cracks, but may contain considerable clay and vegetable stains, and may be more wavy and softer than the better qualities.
Heavy stained	Free of mineral inclusions but contains more clay and vegetable stains than that of stained quality, and distinctly inferior as regards to rigidity and toughness.
Black stained or spotted	Apt to contain some mineral inclusions consisting of magnetite (black), specularite (red), and hydrous iron oxide (yellow). (In India this item is subdivided into three gradations, namely black spotted, black stained, and badly stained.)

During World War II domestic and Canadian mica was divided by Colonial Mica Corp. into three broad qualities: Nos. 1, 2, and 3. These arbitrary designations were based upon the presence of air inclusions, stains, hardness, and flatness. The A. S. T. M. and India designations with which Colonial Mica Corp.'s quality designations correspond are shown below.

Quality equivalents

[Modified from Colonial Mica Corporation, circular letter to mica producers, Feb. 21, 1945]

Domestic	*A. S. T. M. standard and India classifications*
No. 1	20 percent clear and slightly stained; 80 percent fair stained.
No. 2	Good stained.
No. 2 inferior	50 percent stained; 50 percent heavy stained.
No. 3	Black spotted; black stained.

TRIM

Sheet mica purchased by Colonial Mica Corp. was trimmed with bevelled edges, and the "total area of any piece must not be greater than 2½ times the area of the largest rectangle, free of cracks, reeves, or cross grain that can be cut from the piece." (Colonial Mica Corporation, May 24, 1943.) Half-trimmed mica is trimmed on two adjacent sides with no cracks extending from the trimmed sides. Three-quarter trimmed mica is cut on all sides with no cracks extending from two adjacent sides and no cracks extending into the pattern. Full trimmed mica must be trimmed on all sides and all cracks, reeves, and cross grain must be trimmed out. The minimum thickness of acceptable sheet mica was set at 0.007 inch.

PROCESSING OF MICA

Mica as recovered from pegmatites in mining operations is known as "crude mica" or "mine-run mica." At some mines, obvious scrap is separated from the crude mica, and the products of this separation are known as "mine-scrap," and "mine-cobbed," or "rough-cobbed mica." At the rifting and trimming shop, the mica received from the mine, either crude or rough cobbed mica, is dried, screened to separate grit and small mica flakes, and then is more carefully cobbed. Books containing sheet material are kept, and the rest is rejected as scrap. The books are given to rifters, who split the books into sheets thin enough to be cut with trimming knives. The rifters reject some mica as scrap, and the books, sometimes called "block mica," are passed on to the trimmers. The trimmers, equipped with sharp knives and trimming boards, cut the block-mica with beveled edges by holding the trimming knife at a low angle to the surface of the mica. Defective parts of the sheets are trimmed out and are discarded as "bench-scrap." Bench scrap commands a higher price than mine scrap, as it contains few adhering rock particles. The trimmers recover as large an area of clear sheet as possible, depending on whether half-, three-quarter-, or full-trim is desired. The trimmed sheet is then graded according to size, classified according to quality, packed in boxes, and shipped to the buyer often under the designation of "block mica."

TYPES OF MICA DEPOSITS

Five principal types of mica deposits have been found in New England: wall zones, intermediate-zones, pods, disseminated deposits, and fracture fillings. Two other types—cores and replacement deposits—are present but are not economically important. In general, the types are distinct, but gradations between them occur. Many pegmatites contain two or more of the basic types, and for these the term "complex deposit" was used in a previous paper. (Cameron and others, 1945, pp. 369–393). With the accumulation of more complete production data, the term has been abandoned because its use is no longer essential to the economic analysis of mica deposits. One mine in New Hampshire, the Nancy No. 1, was opened in a mica deposit that is unlike any other in New England and does not fit into the classification. The book mica occurred largely in wall rock.

WALL-ZONE DEPOSITS

In some pegmatites wall-zone mica deposits are present adjacent to the hanging wall only, but in others are present along both hanging wall and footwall. In a very few pegmatites the wall-zone mica deposit is confined to the footwall. Where the deposit is present along both walls the two portions commonly differ in persistence, quality of mica, and in content of recoverable sheet mica. Wall zones, especially their hanging wall parts, are more persistent and in general have been worked more extensively than any of the other types. The wall zone of the Victory-Gilsum pegmatite, Alstead, N. H., has been worked for 1,100 feet along strike and for 225 feet down dip. In the Strickland pegmatite the hanging-wall part of the wall zone has a strike length of at least 600 feet and has been explored for more than 180 feet down dip. The deposits range from one-half foot to 8 feet in thickness.

The extent of a wall-zone deposit may be directly related to pronounced structural features of the pegmatite walls. In the Ruggles pegmatite, for example, the wall zone is limited, in general, to the crest of the pegmatite. In the Strickland pegmatite, however, the wall zone is present along both walls and along the keel, but is absent from the crest. As suggested by this contrast, the structural relationships of wall-zone deposits must be ascertained for each pegmatite individually. Once determined for a particular pegmatite, however, the relationship is extremely useful as a guide to exploration and development.

Variations in thickness and richness of a wall-zone deposit in some pegmatites are systematically related to structural features of the walls. The hanging-wall part of the wall zone in the Strickland pegmatite is thickest and richest in an irregular belt or shoot that lies a short distance down dip from the crest of the pegmatite. The upper edge of the shoot coincides roughly with the upper edge of the wall zone. The yield of crude mica per ton of rock mined from the shoot has been two to three times the yield from other parts of the wall zone. In the upper E. E. Smith mine a wall zone is present along both flanks of the pegmatite but is thickest and richest along the keel. The thickness of the wall zone at the keel of the Strickland pegmatite, on the other hand, is slightly less than the average thickness of the zone elsewhere in the pegmatite. In the Blister pegmatite, the thickest part of the wall zone is associated with a roll in the hanging wall. In the Atwood mine, the mica content of the wall zone is highest in shoots parallel to rolls in the hanging wall.

Essential minerals in wall-zone deposits are commonly quartz, albite (rarely oligoclase), and muscovite. The general absence of potash feldspar and biotite is noteworthy. These minerals occur in many pegmatites that contain wall-zone deposits but are usually confined to inner zones. In the Blister mine, for example, both biotite and perthite are abundant in the pegmatite but do not occur in the wall zone. A few wall-zone deposits, however, contain subordinate or minor perthite.

INTERMEDIATE-ZONE DEPOSITS

The characteristics of an intermediate-zone deposit vary with its position in the pegmatite. Intermediate-zone deposits near the walls, such as the main productive deposit in the Gilsum-Victory pegmatite, have the structural and economic characteristics of wall-zone deposits. Deposits in zones near or adjacent to pegmatite cores, however, such as core-margin deposits, commonly contain less mica than wall-zone deposits and are less uniform in mica content. In many pegmatites, these inner intermediate-zone deposits are discontinuous. The presence of sizeable lean or barren parts may lead to abandonment of operations. Where an inner intermediate zone is present on both sides of ths core, the two parts commonly differ in thickness, mica content, or content of recoverable sheet. Most core-margin deposits occur in pegmatites with cores consisting predominantly of quartz. Cores in which perthite is predominant are seldom bordered by mica deposits, but the pegmatites of the Gilsum-Victory mine and the Pattuck mine are notable exceptions. Some cores, such as those of the Palermo No. 2 and No. 3 mines consist of quartz-rich parts alternating with feldspar-rich parts. Mica is abundant along the quartz-rich parts but is uncommon or absent adjacent to the feldspar-rich parts.

Essential minerals in the intermediate-zone deposits are commonly quartz, albite, and muscovite. Perthite is present in some deposits, especially inner intermediate-zone deposits adjacent to perthite-rich cores. Small amounts of tourmaline, beryl, columbite-tantalite, phosphates, and other minerals are also present in some deposits. Some inner intermediate-zone deposits contain only wedge or herringbone mica.

CORE DEPOSITS

Core deposits, so far as known, are restricted to pegmatites with narrow cores. In pegmatites with thick cores, mica books occur in a separate core-margin zone, and core deposits therefore are essentially telescoped core and core-margin zones. In examples studied in the Rice-Palermo area, the core contains coarse-grained anhedral quartz, subhedral plagioclase, perthite, and minor amounts of muscovite and tourmaline. The cores often occur in segments and are commonly absent where the pegmatites are narrowest. Although several core deposits have been prospected in the Rice-Palermo area, none was operated during World War II.

POD DEPOSITS

Concentrations of sheet-bearing mica books associated with pods are called pod deposits. Most pods with which book mica is associated are composed essentially of quartz, perthite, and plagioclase in various proportions. The mica books occur intergrown with coarse plagioclase and quartz along the pod margins, projecting into the pod, or are found within the pod itself. The Keyes No. 2 mine and the Ashley mine show examples of deposits of this type.

Pod deposits have not been important sources of sheet mica, because the pods are commonly small and sparsely distributed in the pegmatites that contain them. In a given pegmatite, the pods commonly differ in mica content and mica quality, and these features lend further uncertainty to mining operations.

FRACTURE FILLINGS

Many bodies formed along fractures contain sheet-bearing mica books. The simplest of these bodies are tabular fracture fillings that range from a few inches to a few feet in thickness and from 10 to 40 feet or more in length. Most are small and thin. Other bodies formed along fractures are similar to the tabular fracture fillings but appear to have formed partly by fracture-filling, partly by replacement of the fracture walls. These bodies represent a type transitional between simple fracture fillings and the replacement bodies discussed below. The most striking examples known in New England are in the Saunders and Ruby-Barney pegmatites, in the Grafton district, both of which have been worked for sheet mica. The deposit at the Saunders mine is 2 to 4 feet thick and has been traced for more than 120 feet; the deposit in the Ruby-Barney pegmatite ranges from 2 to 11 feet in thickness and has been traced 450 feet along strike.

Fracture fillings and related bodies consist essentially of quartz, plagioclase, perthite, and muscovite in various proportions. Most are too small, too thin, or too low in mica content to repay mining costs.

DISSEMINATED DEPOSITS

A pegmatite containing sheet-bearing mica books scattered without discernible system through the full width of the body is called a disseminated deposit. Actually such a pegmatite possesses two zones, a thin border zone and a core, and the sheet-bearing books are disseminated throughout the core. However, the border zone is only a few inches thick, whereas many cores are hundreds of times thicker, and the books occur practically throughout the full width of the pegmatite. However, no sharp line can be drawn between core and disseminated deposits. In small parts of disseminated deposits the mica may be concentrated along the walls or in the vicinity of pods, but clearly defined, persistent concentrations are lacking. The deposits are mixtures of quartz, plagioclase, perthite, and muscovite. The pegmatites of the Keyes No. 3 and No. 4 mines and the Charles Davis mine are examples.

MICA DEPOSITS IN WALL ROCK

At the Nancy No. 1 mine, Groton, N. H., a mica deposit has been formed in steeply dipping quartz-sillimanite schist that underlies a gently dipping pegmatite. The schist contains pegmatitic material, and many small irregular pegmatites and isolated crystals of mica were formed by replacement of the schist. The content of book mica in the schist was sufficient to repay operation costs in 1943. At the Keyes No. 3 mines, mica books have developed adjacent to a narrow pegmatite lens (in schist) that contains much pegmatitic material. The occurrence here is interesting, but the mica recovered came almost entirely from the pegmatite.

COMPARISON OF TYPES

The mica-bearing pegmatites studied during the present investigations are chiefly those that were prospected or mined during 1942–44. The following comparison of types, therefore, is based on information that covers only a small fraction of the many thousands of pegmatites present in the areas of crystalline rocks in New England. It is believed, however, that this selected group is representative of New England pegmatites that contain muscovite capable of yielding sheet mica.

Of the five principal types of mica deposits recognized, pod and fracture-controlled deposits are probably most common, although few have been mined. Wall zones, intermediate zones, and disseminated deposits are less numerous. Cores and replacement deposits are rare types in New England; no example of the core type was mined during World War II. Several pegmatites studied contain two types of deposits. The most common combination in operating mines consists of a wall-zone deposit and a core-margin deposit. Pod and disseminated types occur together in many pegmatites, however, that have not been mined or have only been prospected.

The table below shows production and yield data for the 5 major types of mica deposits in Connecticut, Maine, and New Hampshire during 1943 and 1944. The 87 deposits covered by the table yielded about 75 percent of the crude mica and 82 percent of the equivalent sheet mica produced in New England during the 2-year period. Of the basic types, wall-zone and outer intermediate-zone deposits were by far the most productive and have the best record for sustaining operations. This is due in part to their greater average richness but also in part to other factors. Such deposits on the average are larger and less variable in mica content than other deposits and present simpler problems of mining. Reserves can be predicted with more confidence than in other types because wall-zone and outer intermediate-zone deposits are commonly more persistent. The data show that the average mine working in such a deposit produced almost twice as much crude mica and more than twice as much equivalent sheet mica during 1943–44 as the average mine in an inner intermediate-zone deposit—the next most productive type.

In inner intermediate-zone deposits marked variations in mica content are common. Some core-margin deposits are difficult to follow, owing to irregularities of the core and variations in its composition. Irregularities may necessitate mining of much barren rock. Other inner intermediate-zone deposits are likewise more irregular in general than wall zones and some are likewise difficult to follow. For these reasons an operation on an inner intermediate-zone deposit is more expensive and difficult to maintain than one in a wall-zone deposit or a deposit in an outer intermediate zone.

The small size of the average fracture-filling deposit is commonly its chief drawback. Only two productive deposits of this type in New England are known, and only one was operated in 1943–44 (table below). In both, however, the relative ease with which the tabular bodies could be traced and the opportunity to employ selective mining were assets. Other deposits of this type were prospected in 1942–45, but were soon abandoned as unprofitable. No data on these operations are available.

Many pod-bearing pegmatites were prospected during the war, but the results have been disappointing, because the mica is virtually restricted to the pods or the pod margins. The content of book mica in some pods may be as high as 3 or 4 percent, and in the first stages of mining, returns per ton of rock moved have been high at some deposits. Once the pods in sight have been exhausted, however, the intervening pegmatite must be mined blindly in the hope of discovering more pods. In all but one of the mines operated during the war, the amount of barren rock between pods was so large that overall returns were exceedingly low, and operations were soon abandoned. Closely spaced pods appear to be present only in the Keyes No. 6 deposit. Another drawback is that the pods vary in crude mica content and in sheet content per ton of crude mica, even within a single pegmatite.

Yields of crude mica from operations in pod deposits show a considerable range, depending on whether operations were brief and restricted to individual pods ex-

Production, yields, and quality of sheet mica from Maine, New Hampshire, and Connecticut by type of mica deposits

[Data on sales of sheet and punch mica and on quality of sheet mica furnished by Colonial Mica Corp.]

Type of deposit	Production and yields, 1943 to 1944								Quality of sheet mica sold to Colonial Mica Corp., April 1944 to May 1945 (percentage of quality indicated)				Average number of months operated during 1943–44
	Number of deposits	Total output of crude mica (tons)	Average output of crude mica (tons)	Average percent of crude mica recovered from rock mined	Total output of equivalent sheet (pounds)	Average output of equivalent sheet (pounds)	Average recovery of equivalent sheet from crude (percent)	Number of mines	No. 1	No. 2	No. 2 inf.	No. 3	
Wall and outer intermediate zone	57	3,526.05	130.7	3.95	241,977.05	8,962	3.43	22	26.9	50.6	20.9	1.6	15.4
Inner intermediate zone	10	656.83	65.7	2.42	40,355.84	4,036	3.07	9	28.4	54.2	16.3	1.0	10.9
Disseminated	11	143.05	13.0	1.55	9,801.13	891	3.43	10	46.0	40.2	13.3	.5	5.8
Pod	8	16.60	2.1	1.02	852.73	104	2.56	7	28.5	48.5	22.7	.3	2.2
Fracture filling	1	36.00±		4.00±	2,682.39		3.72	1	25.8	60.1	13.6	.5	

posed at the surface or whether the whole pegmatite was mined. Most were restricted to individual pods, yet even so the average recovery of crude mica from rock mined from deposits of this class was only 1.02 percent.

In a previous section, the gradation of pod deposits into discontinuous core-margin deposits has been discussed. The distinction is important, for some core-margin deposits are productive. In the Nancy No. 2 pegmatite, Groton, N. H., for example, what appeared at first to be scattered pods proved to be segments of a discontinuous core, with an associated core-margin deposit that proved moderately productive.

Although the distribution of mica in disseminated deposits appears uniform to an observer, production records indicate that broad variations in their mica content occur. Large parts of some disseminated deposits are virtually barren. At the Enegren mine, for example, one end of a pegmatite lens yielded enough crude mica to justify operations. The other end of the lens, however, contained almost no recoverable crude mica, and was mined at a loss. Less striking variations in mica content are found in nearly all disseminated deposits. The chief disadvantage of deposits of this type is their relatively low average yield of crude mica. Only deposits of the pod type required the removal of larger amounts of waste rock. Disseminated deposits of sufficient size and of favorable attitude and topographic position, however, may be amenable to low-cost mining on an extensive scale.

Many factors must be considered in comparing yields of various types of deposits (table on p. 41), but three are of special economic importance: richness, expressed in terms of percentage of mine-run mica recovered, yield of salable sheet per ton of mine-run mica, and quality of mica.

On the average, the wall-zone and outer intermediate-zone deposits are far richer in mica than any other type. Inner intermediate-zone deposits are next, and disseminated deposits are a poor third. Adequate data on fracture-filling deposits are lacking, but most appear to be lean. Production statistics indicate that the inner intermediate-zone deposits have a lower yield of sheet than wall-zone deposits, but it is doubtful whether the production record is an accurate index of the way in which the two groups of deposits differ in sheet mica content. The yield of sheet from any given mine is strongly influenced by factors that have no connection with the original formation of the pegmatite: later deformation of the deposit due to earth movements, variations in mining technique, and variations in efficiency of the rifting and trimming processes. Any of these may markedly affect the amount of sheet recovered. A further complication is that production records have shown broad variations in the yield of strategic sheet from a single deposit. In some mines these variations can be correlated with faulting, shearing, or other geologic features, but in others the causes are obscure.

Available data indicate that the sheet mica from all classes of deposits was high in content of sheet of No. 1 and No. 2 qualities, and that disseminated deposits and inner intermediate-zone deposits yielded the largest percentages of high-quality mica. It must be remembered, however, that the data apply only to sheet mica prepared and sold in conformity with wartime specifications. Deposits containing large amounts of No. 3 mica were not mined, and mica from such deposits is therefore not represented in the tabulation. The quality data given in the table are valuable chiefly because they indicate that mica of high quality is not confined to one type of deposit.

APPLICATIONS OF STRUCTURAL ANALYSIS OF MICA DEPOSITS TO PROSPECTING AND MINING

RECOGNITION OF THE TYPE OF DEPOSIT

Production records indicate that in evaluating mica prospects it is important to recognize the type of deposit, as on this basis a forecast of the productivity can be made, within certain limits. Recognition of the type likewise affords a basis for mining and development, which must be governed primarily by the distribution of the mica within the deposit. In some deposits the relation of mica distribution to structural features has an important bearing on efficient exploration, and such relations are worthy of the same attention that is given them in developing other kinds of mineral deposits.

RECOGNITION OF PRODUCTIVE PEGMATITES

Studies so far have shown that no sharp distinction can be drawn between barren and productive pegmatites. Mica deposits are nowhere coextensive with the pegmatites in which they occur. It is evident that in prospecting for mica not only the right pegmatite, but the right part of it must be found, if mining is to be profitable. Generally, the best indication of a potentially productive pegmatite is the presence of a pronounced zonal structure. Well-zoned pegmatites deserve special attention from prospectors as they may contain the wall-zone or intermediate-zone deposits that have been the principal sources of sheet mica in New England in the past. In addition, accompanying zones may contain concentrations of other commercial minerals, especially feldspar, although rich deposits of both mica and feldspar do not commonly occur in the same pegmatite. The prospector should recognize in advance that pegmatites containing workable wall-zone or intermediate-zone deposits are exceptional occurrences and therefore constitute a very small proportion of known pegmatites.

Fragments of country rock that are completely surrounded by pegmatite are known as xenoliths. In some of the pegmatites that possess zonal structure, the border and wall zones are found around the xenoliths as well as adjacent to the walls of the pegmatite. If the prospector is fortunate enough to find a xenolith with respect to which the pegmatite is zoned and if the wall-zone around the xenolith contains sheet-bearing muscovite, then he may be reasonably certain that a similar zone is present somewhere along the walls of the pegmatite. Some pegmatites (Gotta-Walden mine, Portland, Conn., Toll Gate mine, Middletown, Conn.), in which mica-bearing wall zones are present almost exclusively along the hanging wall, contain xenoliths that are rimmed only on their lower surfaces by a mica-bearing wall zone. One pegmatite (Strickland pegmatite, Portland, Conn.) that possesses a mica-bearing zone along both walls, contains a xenolith bordered on both upper and lower surfaces by a similar mica-bearing zone. The limited evidence available suggests that the prospector may not only be able to recognize a wall-zone deposit, but may be able to direct his attention to one or both walls of the pegmatite, depending on whether the wall-zone is present adjacent to one or both surfaces of the xenolith examined.

MINERALOGICAL INDICATIONS

The presence of plagioclase-rich zones along the walls of a pegmatite, although by no means infallible, is the best indication yet known of the possible presence of a wall-zone deposit. The plagioclase is commonly blocky; that is, massive and equant or irregular. Cleavelandite is rare. The presence of much potash feldspar or biotite in a wall zone is an unfavorable indication for that zone, but an intermediate zone of such a pegmatite should be examined carefully. If a plagioclase-rich wall zone is found, prospecting of easily accessible parts of the zone is usually warranted. If this is done, however, the prospector should be cautioned against taking a small part of such a zone as a guide to the average productivity. In some wall zones there is a distinct concentration of mica into shoots that are separated by leaner pegmatite. Failure to explore a wall-zone deposit of this kind in advance of operations may lead either to over-optimism or discouragement, depending on whether the leaner or richer parts of the zone are mined first. In addition, opportunities for selective mining may be overlooked. The frequent occurrence of cores in bulges in a pegmatite mass is a clue to the location of core-margin and other inner intermediate-zone deposits. A core composed almost entirely of quartz or of quartz and perthite is more likely to be bordered by a mica-bearing zone than one consisting largely of perthite. The prospector should be aware of the variations that must be expected in the composition and shape of the cores, as these are likely to be accompanied by changes in the mica content of a zone in contact with it. A study of the core itself and of the composition of adjacent intermediate zones will assist materially in tracing a marginal mica-bearing zone. This is particularly true in places where the latter is lean and difficult to follow by mica content alone. Where inner zones are asymmetrically developed, the relationship of the productive mica zone to other intermediate zones and to the core likewise must be determined.

VERTICAL VARIATIONS IN MICA CONTENT AND QUALITY

Much effort and money have been expended in New England in prospecting pegmatites that are barren or virtually barren in outcrop, in the vague hope that these pegmatites would contain more mica at depth. It is scarcely surprising that scant success has attended such prospecting, which is based in part on misunderstanding of the origin of pegmatites. The fact that mica distribution and content were determined at the time of pegmatite formation, not by the much later process which sculptured the present topography, has not been generally recognized in the industry. In some cases, however, hope of a downward increase in mica content is justified by structural evidence. If mapping and study of a deposit indicate, for example, that a potentially productive zone lies below the surface, then downward increase in mica content becomes a reasonable possibility.

The widespread belief that mica quality always improves with depth is equally fallacious. In pegmatite outcrops, the mica books are often soft, water-soaked, and split by frost along cleavages. Only rarely do these effects extend more than a few feet downward in New England pegmatites. The same is true of secondary inclusions or stains. If, however, a pegmatite is badly fractured or if either pegmatite or wall rock contains much pyrite, secondary stains may extend 50 feet or more below the surface as a result of weathering and ground water circulation. Far more serious in their effects on content of sheet mica, however, are primary inclusions and structural imperfections of cleavage sheets. These defects were developed either at the time of pegmatite formation or as a result of later deep-seated earth movements, not as a result of atmospheric processes or of ground-water action. Except in the very few places where erosion has been guided by the same structural features (such as faults) that have affected the mica, the degree to which these defects are developed will have no relation to surface topography or to depth below the surface. As might be expected, production records show plainly that mica quality is as likely to become poorer downward as to improve.

ANALYSIS OF THE WARTIME MICA INDUSTRY OF NEW ENGLAND

COMPARISON OF MICA DISTRICTS

PRODUCTIVITY

Available data on the production of mica in New England, by districts is summarized in the table below. Records of crude mica output during 1942 and 1945 are fragmentary and are therefore omitted, but the output is known to have been far less than in 1943 and 1944, the peak years of the war period. Data for crude mica production during 1943–44 are complete except for some of the smaller mines. Total crude mica produced in New England during 1943–44, including small amounts produced in Massachusetts, is estimated at 5,600 tons.

Sales to Colonial Mica Corp. from January 1943 through May 25, 1945, are a nearly complete record of the production of sheet and punch mica for this period, as Colonial Mica Corp. was then purchasing virtually all the sheet mica produced in the region. In 1942, however, much mica was sold to private buyers, so that sales to the Corporation do not reveal total production.

The data indicate that the Keene district was the most productive of all the districts, the Grafton district second, and the Middletown district third. Production from the two districts in Maine was small. The drop in production in Maine from 1943 to 1944 is noteworthy. Operations in Maine in 1943 indicated that most of the deposits were uneconomic, and few mines were operated in 1944.

RECOVERY OF SHEET AND PUNCH MICA FROM CRUDE MICA

Production figures (see table) indicate that the crude mica from the two main districts of New Hampshire gave a considerably higher yield of sheet mica from mine-run mica in 1943–44 than crude mica from the Middletown district of Connecticut. The figures, however, should be taken only as approximations. Mica from some mines was processed into sheet, whereas mica from other mines was processed to yield punch mica plus sheet mica 1½ by 2 inches and larger. In order to arrive at the figures given in the table, it is therefore necessary to estimate the percentage of sheet mica that would be recovered by processing the punch. In line with practice accepted during the war, the probable recovery is taken as 10 percent, and the yield of any given mine is calculated on this basis in terms of "equivalent sheet," equal to the amount of sheet plus 10 percent of the amount of punch. Recent data furnished by Colonial Mica Corp. suggest that ultimate recovery may actually be higher. This would increase the percentages given but would not markedly affect the relative values for the different districts. Changes in specifications for trim from time to time during 1943–44 also introduce inaccuracies into the comparison, but probably do not significantly affect the relative standings of the districts.

Production of crude, sheet, and punch mica, in Maine, New Hampshire, and Connecticut, by districts

[Based on sales to Colonial Mica Corp.]

	1942 [1]			1943				1944				January–May 1945		
	Sheet mica (pounds)	Punch mica (pounds)	Value of sheet and punch	Crude mica (tons)	Sheet mica (pounds)	Punch mica (pounds)	Value of sheet and punch	Crude mica (tons)	Sheet mica (pounds)	Punch mica (pounds)	Value of sheet and punch	Sheet mica (pounds)	Punch mica (pounds)	Value of sheet and punch
Maine:														
Rumford district	41.44	443.00	$276.97	[2] 148	6,722.47	19,821.44	$36,165.61	50	4,549.96	6,647.00	$31,135.12	10.41	----------	$360.48
Topsham district	498.93	289.00	1,191.77	50	2,107.18	2,691.00	10,423.00	9	340.00	927.00	2,288.94	4.31	----------	34.48
Other	----------	----------	----------	----------	----------	----------	----------	----------	499.19	----------	2,869.02	----------	----------	----------
New Hampshire:														
Grafton district	11,787.07	12,172.75	36,560.29	735	42,092.92	15,087.00	189,017.45	692	59,665.28	4,512.56	335,346.01	4,897.37	7,205.56	35,732.25
Keene district	4,419.79	7,335.75	13,656.07	1,044	68,795.05	318,977.77	353,847.33	1,271	56,011.43	137,296.00	395,891.63	13,037.85	38,782.43	104,618.04
Other	----------	----------	----------	2	65.49	385.00	372.24	6	559.24	104.00	2,779.99	----------	----------	----------
Connecticut:														
Middletown district	5,582.50	8,735.00	13,096.51	562	21,692.04	121,686.50	127,618.46	544	27,854.97	12,106.00	172,557.31	812.49	1,714.00	5,783.88
Other	----------	----------	----------	[3] 27	669.43	----------	3,349.65	102	7,944.60	----------	48,160.70	645.06	----------	4,343.36
Totals [5]	22,329.73	28,975.50	64,781.61	[4] 2,568	[5] 142,144.58	[5] 478,648.71	[5] 720,793.74	[4] 2,674	[5] 157,424.67	[4] 161,592.56	[4] 991,028.72	19,407.49	47,701.99	150,782.49
Total, corrected to April 1945	26,666.86	33,317.50	82,437.45	----------	135,660.02	483,174.44	692,395.48	----------	158,727.27	158,236.56	1,023,904.15	----------	----------	----------

[1] Some mica produced in 1942 was sold to buyers other than Colonial Mica Corp., hence figures give only part of the production.

[2] Rough estimate based on figures furnished by Colonial Mica Corp.

[3] Includes small amounts from various prospects, part probably from Middletown district.

[4] See text.

[5] Compilation of sales of sheet and punch mica by districts is based on reports of sales by mines, furnished by Colonial Mica Corp., in early 1945. The figures for 1942, 1943, and 1944 were later corrected, but only totals for New England (except Massachusetts) are available. The discrepancies between the two sets of totals indicate that figures for the districts are only approximate.

Recovery of equivalent sheet from crude mica, by districts

	Number of mines	Mine-run mica produced (tons)	Equivalent sheet produced (pounds)	Average recovery of equivalent sheet (percent)
Grafton district, New Hampshire	38	1,292.4	97,579.70	3.77
Keene district, New Hampshire	12	2,243.5	172,696.80	3.84
Middletown district, Connecticut	14	1,076.4	59,286.25	2.76
Total	64	4,612.3	329,562.75	3.56

The 64 mines for which recovery data are available yielded nearly 92 percent of the total New England production, reckoned in terms of equivalent sheet.

QUALITY OF SHEET MICA

During the period April 1, 1944, to May 1945, consignments of sheet mica sold to Colonial Mica Corp. from each New England mine were sampled to determine the quality of the sheet. From each consignment 100 pieces of sheet were taken at random and divided according to quality into 4 groups: No. 1, No. 2, No. 2 inferior, and No. 3. The number of pieces of each quality present in the sample were taken as the percentage of sheet of that quality present in the entire consignment. The data obtained in this way and furnished by Colonial Mica Corp. have been used in compiling the table below, which shows by districts the percentage of sheet mica of each quality in consignments purchased.

Quality of sheet mica from New England mica districts

	Number of mines	Sheet mica produced [pounds]	Percent recovered, of quality indicated			
			No. 1	No. 2	No. 2 inf.	No. 3
Topsham and Paris-Rumford, Maine	7	3,739.57	36.3	50.7	12.0	1.0
Grafton, N. H	31	42,261.27	28.6	52.6	17.7	1.1
Keene, N. H	9	54,589.90	27.3	48.7	22.6	1.4
Middletown, Conn	6	20,931.56	27.4	48.2	21.8	2.6
All mines [1]	54	127,630.10	28.3	49.9	20.3	1.5

[1] Includes 1 mine that lies outside the principal districts.

The table covers about 94 percent of the mica sold to Colonial Mica Corporation during the period. The remaining 6 percent came from small mines and prospects.

Owing to the method of sampling, the figures are approximations, but they are the best available index to the quality of sheet mica produced from New England mica districts during the war. Because most of the sheet mica produced in New England was intended by the operators to be sold to Colonial Mica Corp., processing of the mica was adjusted to meet the Corporation's specifications. Therefore, the quality data given apply to practically the entire production for the period covered by the sampling. Nearly four-fifths of the production consisted of sheet of No. 1 and No. 2 qualities, those particularly needed for the war effort. The table suggests that mica from the Topsham and Paris-Rumford districts was appreciably higher in quality than that from other New England districts. Of the three major producing districts—Grafton, Keene, and Middletown—the Grafton district appears to have produced the greatest percentage of sheet of Nos. 1 and 2 qualities.

The table should not be taken to indicate the average quality of mica recoverable from New England pegmatites in general because pegmatites that would not yield crude mica containing large percentages of sheet of the higher qualities were not mined and are not included in the table. Thus, in the Middletown district only pegmatites in the Bolton schist were mined. Sheet-mica-bearing pegmatites occur in other rock formations in the district, but the mica in them is stained and not acceptable to Colonial Mica Corp.

PRODUCTION, COSTS, AND YIELDS OF MICA OPERATIONS DURING 1943–44

Production data for New England mica mines indicate that some mines were much more productive than others (see Bannerman and Cameron, 1946.) Comparison of costs and yields of the more productive mines with similar data for the less productive mines brings out features significant with regard both to wartime operations and to the future of the mica-mining industry of the region. For purposes of analysis, the more productive mines are taken as those which during the years 1943 and 1944 produced more than $40,000 worth of sheet and punch mica. In the table on page 46, the more productive class is represented by the 10 mines of group A, the less productive class by the mines of groups B and C. Group B consists of 15 less productive mines for which both cost and yield data are available. Group C consists of these same 15 mines plus an additional 30 less productive mines for which only data on yields are available. Group C therefore overlaps group B but is significant because the data given for it suggest that the 15 mines of group B represent fairly the entire group of less productive mines, a suggestion that is in harmony with the observations of Survey geologists who participated in the wartime investigations of pegmatites in New England.

Production, costs, and yields of mica from New England mica mines during 1943–44

	Group A (10 mines)	Group B (15 mines)	Group C (45 mines including the mines of group B)	Totals (groups A and C)
Production:				
Crude mica (mine-run mica)	2,893 tons	832 tons	1,398 tons	4,291 tons.
Crude mica, in percentage of total New England production [1]	51.6 percent	14.9 percent	25 percent	76.6 percent.
Sheet mica, in percentage of total New England production [2]	56.9 percent	14.2 percent	27.1 percent	84 percent.
Punch mica, in percentage of total New England production [2]	59.2 percent	7.9 percent	9.2 percent	68.4 percent.
Equivalent sheet, in percentage of total New England production [2 3]	57.4 percent	12.8 percent	22.9 percent	80.3 percent.
Value of sheet and punch, in percentage of total New England production	57.1 percent	13.6 percent	24.9 percent	82 percent.
Yields:				
Average yield of crude mica from rock mined [4]	4.59 percent	2.39 percent	2.14 percent	
Average yield of equivalent sheet per ton of rock mined [3]	3.3 pounds	1.34 pounds	1.21 pounds	
Average yield of equivalent sheet per ton of crude mica [5]	3.64 percent	2.81 percent	3 percent	
Average dollar yield per ton of crude mica [6]	$382	$323	$349	
Average dollar yield per ton of rock mined [7]	$17.52	$7.73	$7.46	
Costs (mining plus processing):				
Average cost per ton of crude mica [8]	$274	$316		
Average cost per ton of rock mined [9]	$12.52	$7.56		

[1] Recorded New England production for 1943–44 is 5,435 tons. Total production is estimated at 5,600 tons.
[2] Based on data furnished by Colonial Mica Corporation.
[3] Equivalent sheet equals pounds of sheet mica plus pounds of punch mica divided by 10.
[4] Average yield of crude mica from rock mined ranged from 0.12 percent to 12.0 percent.
[5] Average yield of equivalent sheet per ton of crude mica ranged from 0.22 percent to 6.6 percent.
[6] Average dollar yield per ton of crude mica ranged from $62 to $867.
[7] Average dollar yield per ton of rock mined ranged from $0.35 to $54.
[8] Average cost per ton of crude mica ranged from $106 to $826.
[9] Average cost per ton of rock mined ranged from $0.96 to $28.10.

Figures for yields are based on a broad range of data: production records furnished by mine operators, sales of sheet and punch mica to Colonial Mica Corp., and field work by the Geological Survey that included periodic measurements of rock moved in the various mines. Available data on costs, however, are more meager and are uneven in scope and accuracy. For some operations the figures include overhead, part or all of development and prospecting costs, and capital investment in mine and processing shop. For others, only direct operating costs are included, and these figures therefore do not cover the full expenses of operation. Furthermore, the data do not include subsidies in the form of governmental aid (such as technical geologic and mining advice), low rentals on equipment, provision of access roads, marketing facilities, and other items. The additions that should be made to the figures for unit costs to cover all these hidden items cannot be estimated accurately, and the averages given in the table are therefore minimal and approximate. Nevertheless, they are based upon the most complete set of data yet assembled for the New England mica industry.

Production.—The bulk of New England mica production in 1943 and 1944 came from relatively few mines, the remainder from a large number of very small operations. The 10 mines of group A alone accounted for about 52 percent of the output of crude mica and about 57 percent of the output of sheet mica during the 2-year period.

Yields of deposits.—In the table the dollar yield per ton of rock mined is given for each group of deposits. The average yield for group A was $17.52 compared to $7.73 for group B, and $7.46 for group C. The dollar yield per ton of rock mined depends mainly on two factors: the yield of crude mica per ton of rock mined and the yield of sheet and punch mica per ton of crude. The second factor is important because sheet and punch mica have been the chief source of income to the producer during the war. Processing of the crude mica yields other salable products (scrap, washer, etc.), but in general these have not been a major source of income.

The table indicates that the prime characteristic of the mines of group A is their relatively high yield of crude mica, more than twice the average yield for group B or C mines. The mines of group A are also characterized by a somewhat higher yield of sheet and punch mica per ton of crude mica (expressed as equivalent sheet). In general, this appears to be due to higher content of recoverable sheet in the crude mica, not to greater efficiency in processing. Analysis of the data indicates, however, that the yield of equivalent sheet has not been as important a factor in the higher ultimate yield of group A mines as the greater average content of crude mica in the rock mined. In individual mines, nevertheless, the percentage yield of sheet and punch mica has been very important. Some mines have been profitable under subsidy prices despite low yields of crude mica, because the mica yielded a high percentage of sheet and punch. Conversely other mines that showed high yields of crude mica have been financial failures because the content of sheet and punch mica was extremely low.

The highest average yield for any mine operated during the period 1943–44 was about 12 percent crude mica; the lowest average yield was approximately 0.12 percent. This is a wide range, and more than anything else it explains why some New England mica mines have been profitable, others extremely unprofitable. Under 1943–44 price scales, a mine in a pegmatite carrying only 0.12 percent crude mica is virtually an operation in barren rock, if the usual methods of New England mica mining are employed. The average yields from the mines are spread over the range between the two extremes. Thus, as in other mining industries, there is no sharp division between rich and lean mines. Barring a price scale so low that no mines can operate, prices cannot be set that will eliminate the problem of marginal mines, and every revision of price during the war brought a new group of mines into the marginal class.

Costs of mining and processing.—Average processing costs appear to be roughly the same for the mines of group A as for the less productive mines of group B, but mining costs per ton are appreciably higher for group A. This is chiefly because some of the mines of group A have been operated intermittently for many years and are now deeper and more difficult to operate than mines of group B. A contributing factor is that comparatively more time is consumed in the richer mines in sorting mica from muck and in handling it. Total costs (mining plus processing) per ton of rock mined are therefore higher for the more productive mines. However, the higher cost per ton of rock mined is more than offset by higher yields per ton; hence, the total cost per ton of crude mica is considerably lower than for the mines of group B.

Comparisons of costs and yields per ton of rock mined suggest that the highly productive mines, as a group, were profitable under 1943–44 conditions; whereas in general the mines of group B, and probably most other New England mica mines, have been marginal or unprofitable.

One of the mines for which cost figures are available is not included in either group A or B, for the reason that it featured mass mining of a large amount of low-grade ore and therefore was not a typical New England mica operation. In this mine the dollar yield per ton of rock mined was low, but costs were sufficiently reduced to enable operation at a profit.

Efficiency of operations.—The mica industry requires skilled labor both in mining and processing. Processing is an art, and the development of an efficient rifting and trimming procedure requires a combination of shrewd management and highly competent labor. Because the supply of labor skilled in mica work was very small at the beginning of the war and few operators had any experience either with mining or processing, efficiency varied widely from mine to mine. Undoubtedly, such variations are reflected in the high average costs per ton of rock mined (see table on p. 46).

Comparing mica mines as to efficiency of operation is not simple. New England mica mines are extremely varied in type of operation, so that a number of factors besides management (such as richness of deposits; geological characteristics of size, shape, and attitude; and accessibility, particularly in winter) contribute to the differences in costs per ton of rock mined. Nevertheless, after allowance is made for these factors, it seems clear that some operations have been more efficient than others, to the extent that costs at one mine have been twice to three times those of a corresponding one. Similar variations appear in processing efficiency. Effective processing requires a delicate balance between speed and care, and the degree to which this balance is achieved can mean the difference between profitable and unprofitable operation.

As most New England mining of the past has been opencut work, essentially quarrying, the pool of labor available at the beginning of the war included few men acquainted with underground work. During the war the transition from opencut mining to underground mining had to be made at many deposits, and the lack of experienced personnel has undoubtedly contributed to relatively high costs of mining.

Ordinarily, good mining practice calls for development work in advance of mining, to block out reserves and to open up new working faces concurrently with the mining of ore already developed. Exploratory work of this kind in New England mines, however, has been kept to a minimum or not done at all, owing to limited capital, short-term price guarantees, traditions of long standing in the mica industry, and other factors. Well-planned development and exploration, including basic geologic investigations, would increase efficiency of operation, but are not likely to be undertaken unless the industry can anticipate a profit over a reasonable period of time.

Reserves.—How much mica is still available in the deposits of New England can be estimated only in terms of the amount of mica that might be mined under a given set of economic conditions, for every revision of conditions changes the number of mines that can be operated profitably and therefore changes estimates of economically available reserves. Another difficulty in estimating reserves is that advance development and exploratory work have been done in very few mica mines; hence, there is no large amount of mica blocked out in advance of actual mining. Estimates of the extent and richness of known deposits can be made only on the basis of past production plus inferences drawn from geologic studies.

A conservative estimate indicates that with ratios of cost to sales prices comparable to those of 1943–44, minable reserves in known deposits would sustain operations for 4 years at the 1943–44 rate of about 2,550 tons of crude mica per year. Total reserves available under such conditions may be much greater.

Potential productivity of New England mica mines.—The productivity of the mines operated during the war was primarily a function of the richness of the deposits worked, although other factors entered heavily into individual operations. Certain mines were worked more intensively than others, but some of these fall in the more productive class, some in the less productive class. No mine was worked at full capacity, in terms of the type of operation employed, for as much as half the period from mid-1942 to mid-1945. Single-shift operation by a crew of 4 to 6 men was typical of both classes of mines. It follows that New England mica production during the war years was considerably below the maximum that could be achieved by concentrating effort on the richer and potentially more productive mines. Such a program might have been difficult to execute during the war period, for at the beginning of the emergency there was no satisfactory basis for evaluating mica deposits. However, if the data now at hand were properly applied, they would greatly facilitate achievement of a maximum rate of production should the present rearmament program or world conditions in general require it.

Outlook for the industry.—Under any set price schedule, the ultimate life of the industry of course depends not only on the size of reserves in known deposits, but also on the future rate of discovery of new deposits sufficiently rich to be worth mining. The discovery rate of the period 1942–44 was not encouraging. Most of the 1943–44 production came from previously known deposits, for despite intensive prospecting no new mica-producing districts have appeared, and few worthwhile new deposits have been discovered. Of the total output of crude mica during 1943 and 1944, only about 18 percent came from newly discovered deposits, and only 14 percent, at most, came from newly discovered deposits that might profitably be reopened even with a return to the conditions of 1943 and 1944. The reason is clear. Since the beginning of mica mining in New Hampshire in 1803, prospectors have relied almost entirely on surface exposures to indicate the mica content of pegmatite bodies. The pegmatites that showed books of mica in surface exposures have been sampled, while others have been ignored. This procedure has been repeated again and again through successive generations; hence, it seems likely that virtually all pegmatite bodies of promising appearance in surface exposures have been tested. Indeed, the coverage of the mica-bearing districts has been so thorough that the time seems past when prospecting on this basis can be expected to yield many new mines.

Further major discoveries, therefore, will depend to a large degree on the application of geologic data and modern methods of exploration to prospecting. The studies of the past few years have yielded much information on the occurrence of sheet mica deposits in pegmatite bodies. It is shown in this report that New England mica deposits can be divided into five major types (Cameron and others, 1945) and that these differ in size, persistence, distribution of mica, and productivity. Of the five types, wall-zone and intermediate-zone deposits have been far more productive than the rest, yielding about 93 percent of the total production from New England during 1943 and 1944. These two types of deposits are found only in well-zoned pegmatites. The information presented in this report concerning the composition, extent, and shapes of productive zones and their relations to structural features of the pegmatite walls is pertinent to problems of exploration, mining, and estimation of reserves, and has been applied to such problems during World War II. One instance of this is the diamond drilling of three New England mica pegmatites done by the U. S. Bureau of Mines in cooperation with the Geological Survey. The results indicate that where basic geologic data are at hand, core-drilling can be employed successfully in the exploration of mica deposits in well-zoned pegmatites.

Because pegmatite bodies are three dimensional, surface exposures rarely indicate fully the subsurface shape and internal structure. A pegmatite that is lean or barren at the surface may have minable portions underground, for the mica-bearing zones that have been so productive are not coextensive with the pegmatites that contain them. The character of the surface exposures of a pegmatite depends to a large extent on the manner in which the topographic surface intersects the pegmatite. New England pegmatites are mostly lenses, which structurally occur in a variety of patterns and at various levels with respect to the present erosion surface. Erosion has removed only the tops of some bodies while others have been partly or almost entirely removed (Bannerman, 1943, pp. 7–8). If only the crest of a lens is exposed, whereas the minable mica-bearing zone is developed only along the flanks or keel, the pegmatite will be barren in surface exposures. Such pegmatites have undoubtedly been avoided by prospectors in the past. A major problem is to develop additional criteria for distinguishing them from the host of others that are likely to be barren throughout their extent. If this can be done, the rate of discovery of new deposits may be improved. Prospecting can then be carried beyond the sampling of surface exposures and those parts of a pegmatite accessible by stripping shallow overburden.

The utilization of geologic data and modern exploratory techniques in prospecting pegmatites is likewise a matter of importance to the feldspar industry, which is faced with the need for continuing discovery of high-grade potash feldspar deposits and, like the mica industry, must deal with the problem of a declining discovery rate. Like mica deposits, high-grade feldspar deposits are virtually restricted to well-zoned pegmatites. Commonly the deposits form the cores of potash-rich bodies, but some pegmatites contain potash-rich cores enveloped in plagioclase-rich zones, one or more of which may be a productive mica deposit. Mica and feldspar, and other pegmatite mineral products as well, are therefore closely related aspects of a single problem, and anything that is done to assist the mica industry in prospecting will likewise aid all pegmatite mineral industries.

FELDSPAR DEPOSITS

Feldspar mining was the fourth most important prewar mining industry in Maine, New Hampshire, and Connecticut and was surpassed only by the stone quarrying, sand and gravel, and clay industries. Production during the war was large, and probably will be still greater during the postwar period. More efficient mining and sorting methods have been developed, and milling techniques are now known that will permit the separation of feldspar, micas, and quartz from material discarded during early work and from many pegmatites that could not be successfully mined for feldspar prior to 1943. New England has many pegmatites containing large tonnages of feldspar that might be recovered by milling.

KINDS AND GRADES OF FELDSPAR

Feldspar is the name given to a complex group of minerals that have certain characteristics in common. All feldspars are anhydrous silicates of aluminum, combined with potash, soda, or lime. The table gives the principal minerals of the feldspar group.

Minerals of the feldspar group

Name	Formula	Percent silica	Percent aluminum	Percent potash	Percent soda	Percent lime
Orthoclase	$KAlSi_3O_8$	64.7	18.4	16.9		
Microcline [1]	$KAlSi_3O_8$	64.7	18.4	16.9		
Albite [1]	$NaAlSi_3O_8$	68.7	19.5		11.8	
Oligoclase. [1,2]						
Andesine. [3]						
Labradorite. [4]						
Bytownite. [5]						
Anorthite	$CaAl_2Si_2O_8$	43.2	36.7			20.1

[1] Feldspars most abundant in pegmatites.
[2] Contains 10 to 30 percent anorthite.
[3] Contains 30 to 50 percent anorthite.
[4] Contains 50 to 70 percent anorthite.
[5] Contains 70 to 90 percent anorthite.

Orthoclase and microcline differ only in crystal form. Orthoclase is monoclinic, whereas microcline is triclinic. The potash feldspar obtained from pegmatite dikes in New England is mostly perthite, an intergrowth of microcline and albite. The albite occurs as thin parallel or subparallel lenses or lamellae in the microcline. The lamellae are usually distinguishable by the unaided eye, but in some specimens they are discernible only with the aid of a microscope. Perthite can usually be identified in the field by its glassy luster, blocky right-angle cleavage, streaks or fine lines caused by albite lamellae, cross-hatched (gridiron) polysynthetic twinning in the areas between the albite lamellae, and by the absence of plagioclase striations in the microcline component of the intergrowth.

The plagioclase feldspars, also known as soda-lime feldspar, form a continuous chemical series ranging from pure albite to pure anorthite. Most specimens can be distinguished from microcline by the thin parallel twinning striations found on their cleavage faces. Albite and oligoclase frequently termed "soda spar," are the plagioclase feldspars commonly found in New England pegmatites, but andesine occurs in some pegmatites. The members of the plagioclase group in general can be distinguished from one another only by use of the petrographic microscope or by other laboratory methods. Albite, however, can be identified visually when it occurs as the platy or lamellar crystals known as cleavelandite.

The percentages of potash, soda, and lime in a feldspar have an important bearing on its value for industrial purposes, as the fusion temperature is a function of chemical composition. Feldspars have no definite melting point but fuse over a range in temperature from 1,000° to 1,250° C. Albite fuses completely at a considerably lower temperature than microcline. In the manufacture of pottery, a glaze prepared with albite will become fluid and will run at a kiln temperature at which microcline remains more viscous and yields a good glaze.

The feldspar used in the ceramic industries serves as a bonding or coating agent that melts at a lower temperature than the material with which it is mixed or upon which it is applied. It is essential that feldspar of uniform composition be used for any particular ceramic purpose, for the color, translucency, thermal expansion, and softening range of a feldspar when fired depend on its composition. Feldspars of high potash content produce glasses of higher translucency than feldspars high in soda content. Impurities, particularly iron, detract from the value of the feldspar, because even small amounts affect the character of the resulting glass profoundly. Feldspar used in ceramic ware must be nearly free from biotite, tourmaline, garnet, or iron oxide stain.

Minerals Yearbook for 1944 (p. 143) gives the following as the consumption of ground feldspar sold by merchant mills in the United States by uses:

	Percent
Glass	64. 3
Pottery	31. 0
Enamel	2. 5
Other ceramic uses	. 2
Soaps and abrasives	1. 9
Other uses	. 1
	100. 0

In the United States, feldspar producers subdivide commercial feldspar into three grades that roughly designate the quality of their product. These grades are known as Nos. 1, 2, and 3. The table below shows the compositions of Nos. 1 and 3 grades, and the theoretical composition of pure microcline.

Analyses of potash feldspars [1]

	Pure microcline (theoretical)	No. 1 grade	No. 3 grade
Silica (SiO_2)	64. 7	65. 87	76. 37
Alumina (Al_2O_3)	18. 4	19. 10	13. 87
Ferric oxide (Fe_2O_3)			. 26
Lime (CaO)		. 20	
Magnesia (MgO)			
Potash (K_2O)	16. 9	12. 24	5. 24
Soda (Na_2O)		2. 56	3. 74
Water (H_2O)		. 64	. 30
Total	100. 00	100. 61	99. 78

[1] Theoretical composition of pure microcline from Bastin (1910, p. 9).
Sample for No. 1 grade from J. B. Richardson & Sons Quarry, Bedford, N. Y. Analysis by George Steiger, in laboratory of U. S. Geol. Survey.
Sample for No. 3 grade from Kinkle's quarry, Bedford, N. Y. Analysis by George Steiger, in laboratory of U. S. Geol. Survey.

Bastin (1910, p. 9) reports that the bulk of the No. 2 or "standard" feldspar is intermediate in its percentage of free quartz between Nos. 1 and 3 and that most of it contains between 15 and 25 percent quartz.

The three grades are usually separated at the quarry. No. 1 feldspar is selected from the feldspar-rich portions of the pegmatite and consists of perthite without visible impurities other than 6 percent or less of quartz. Number 2 feldspar is commonly graphic granite or "corduroy spar" but may contain in addition minor amounts of quartz-free perthite or albite. Free silica ranges between 15 and 25 percent; the minimum Al_2O_3 content is 17 percent; the maximum Fe_2O_3 content is 0.1 percent. Both the Nos. 1 and 2 grades must be free from biotite, tourmaline, garnet, and other iron-bearing minerals. Number 3 feldspar consists of albite, microcline, and quartz, with small amounts of iron-bearing and other impurities.

Before it is shipped to the ceramic manufacturer, the feldspar is ground until 98 percent passes through a 200-mesh screen. If the feldspar is to be sent to glass manufacturers it is ground to pass through 40-mesh screens. The product from a single quarry varies in chemical composition from place to place, particularly in the percentage of free silica, and the variations are even greater in feldspar produced from different districts. Such variations in the crude feldspar have a rather marked effect on the behavior of the fused ceramic product and necessitate constant checking in the manufacturing processes.

The Feldspar Grinders Institute was organized in 1929 to formulate standards for ground feldspar. This body, cooperating with the feldspar consumers, obtained the assistance of the Division of Trade Standards of the Bureau of Standards and a schedule of approved physical and chemical tests for feldspar was adopted in 1930. The schedule was not a purchase specification but established standards of classification for ground feldspar used in the manufacture of ceramic and glass products. The classification is based on particle size and chemical composition. Grinding mills commonly blend feldspars to produce a standard product or a product for a special purpose (Amberg, 1932; Burgess, 1930; Knight, 1928; and Parmelee and Amberg, 1931). Nepheline syenite has sometimes been added to the crude feldspar to increase the alumina content of the ground product. Spence (1932, p. 136) and Burgess (1937, p. 280) cite many references pertaining to the specifications, grinding, and utilization of feldspars.

The separation of feldspars and other minerals present in pegmatites and in granitic rocks in general by milling methods has been investigated by several feldspar companies and by the U. S. Bureau of Mines. Low-cost methods of separating feldspar from various rocks have been perfected, and much feldspar recovered by flotation processes is now being marketed, largely to the glass industry. Feldspar from this source has greatly diminished the need for recovery of feldspar by the methods traditionally employed in the pegmatite mining industry.

TYPES OF FELDSPAR DEPOSITS

All granitic pegmatites contain abundant feldspar. Until recently, pegmatitic material could be mined profitably for feldspar only if it contained a large proportion of perthite sufficiently coarse grained to be separated by hand. Such material is largely confined to well-zoned pegmatites, and these appear to have been the source of much of the feldspar mined in the past. The location of perthite-rich bodies in such pegmatites is related to zonal structures. The features of zoning significant with regard to feldspar deposits are: (1) zones conform, in general, to shape of pegmatite body; (2) quartz, biotite, and tourmaline (all injurious minerals) are most abundant in the zones near the walls; (3) coarse-grained perthite and quartz are most common in the central parts of a pegmatite body. Many of the unsuccessful feldspar operations of the past have been either in poorly zoned pegmatites or in those containing commercial feldspar only in pods or in quartz-feldspar cores too small to yield the necessary tonnages.

The feldspar-bearing pegmatites studied during this investigation can be divided into the following groups:

1. Well-zoned pegmatites, each containing a perthite core and an intermediate zone consisting of graphic granite or coarsely intergrown perthite and quartz.
2. Zoned pegmatites containing cores of perthite and quartz, graphically intergrown in part, and wall zones relatively rich in quartz and plagioclase.
3. Zoned pegmatites characterized by hood-shaped intermediate perthite zones at the top of quartz cores.
4. Zoned pegmatites containing small isolated pods of perthite and quartz surrounded by intermediate or wall zones of plagioclase, perthite, and quartz.
5. Poorly zoned pegmatites.

Pegmatites containing core and intermediate-zone deposits have been highly productive in the past. The type is exemplified by the Ruggles pegmatite in Grafton, New Hampshire (pls. 33–35). Its core consists of nearly pure perthite and very minor amounts of muscovite and quartz. Number 1 feldspar has been recovered from this unit. The main segment of the core is at least 400 feet long, 30 to 60 feet wide, and 50 feet high, and a smaller segment of the core was removed in mining from Pit 32. The core segments are completely surrounded by the "No. 2 feldspar zone," consisting of intergrown, very coarse perthite and quartz. A hood-shaped zone of perthite, quartz, biotite, and black tourmaline lies over the top and upper flanks of the No. 2 feldspar zone.

Feldspar-bearing pegmatites of the second type are illustrated by the Colony and Yuhas No. 2 pegmatites in Alstead, N. H. (pl. 14, and fig. 119). Each has a wall zone containing quartz, perthite, and plagioclase that grades into a core rich in potash feldspar. The zonal structure is not sharply defined. In less productive pegmatites the core consists of perthite, quartz, and plagioclase so intimately intergrown that hand separation is impractical; it is possible that feldspar may in the future be recovered from some of these pegmatites by milling.

In a few pegmatites, a perthite-rich hood overlies the crest of a quartz core and extends a short distance down the flank of the core. The northern opencut at the Palermo No. 1 mine was made in this type of a deposit. The Keyes No. 1 pegmatite is an example, and it seems likely that the feldspar obtained from the Branchville pegmatite during early work came from a perthite hood. Hoods are small and therefore do not contain large tonnages of feldspar. Some of the abandoned quarries in New England which produced feldspar in the past and which now have much quartz and little recoverable feldspar in them may also have had perthite hoods.

Pegmatites in the fourth group, showing small, discontinuous pods of perthite and quartz, have not been successfully exploited because only small tonnages of feldspar can be removed from them. The middle pegmatite at the Rogers prospect in Rumney (fig. 93) is an example, as are the Strain pegmatite in Orange and the Ashley pegmatite in Rumney, N. H. Few pods in these pegmatites are more than 40 feet long, 10 to 15 feet wide, and 10 to 40 feet deep. The pod at the Rogers pegmatite yielded only 70 tons of No. 1 feldspar.

APPLICATIONS OF STRUCTURAL ANALYSIS OF FELDSPAR DEPOSITS TO PROSPECTING

All relatively productive pegmatites studied in detail have well-developed zonal structures in which the perthite is segregated in zones or units large enough to sustain prolonged mining. Biotite, tourmaline, garnet, and quartz (adulterant minerals in commercial feldspars) are commonly limited to marginal zones near the walls of such pegmatites. Even with the development of milling techniques that enable producers to separate commercial feldspars from almost any large pegmatite, a zoned pegmatite still will command a premium, for it can furnish a higher grade mill-feed than most unzoned bodies. Also, until means can be derived for separating perthite from soda feldspar, such pegmatites will continue to be the principal source of high-grade potash feldspar.

The diagrams shown on figure 10 illustrate various types of feldspar deposits and the manner in which knowledge of the internal structure of zoned pegmatites may be used in prospecting and mining.

Figures *A*, *B*, and *C* show a typical pegmatite containing core and intermediate-zone deposits. The pegmatite is shown as it would appear after erosion to successive levels. Only the wall zone is exposed on the surface in *A*. Wall zones in many pegmatites contain little perthite, and a brief study of outcrops at this stage of erosion probably would not suggest that the pegmatite contained feldspar-rich zones beneath the surface. If the attitudes of the walls indicate that the pegmatite is thicker at depth, there is a possibility that the pegmatite has inner zones rich in perthite. When work was begun at the upper, main workings at the Ruggles mine in Grafton, the first pit was extended at least 15 feet through a perthite-quartz-biotite-tourmaline zone before commercial feldspar was struck in the No. 2 feldspar zone.

Figure *B* shows the pegmatite eroded to greater depth, revealing a small central area of quartz and perthite that appears to be the core of the pegmatite. The true core would be found only after erosion to the

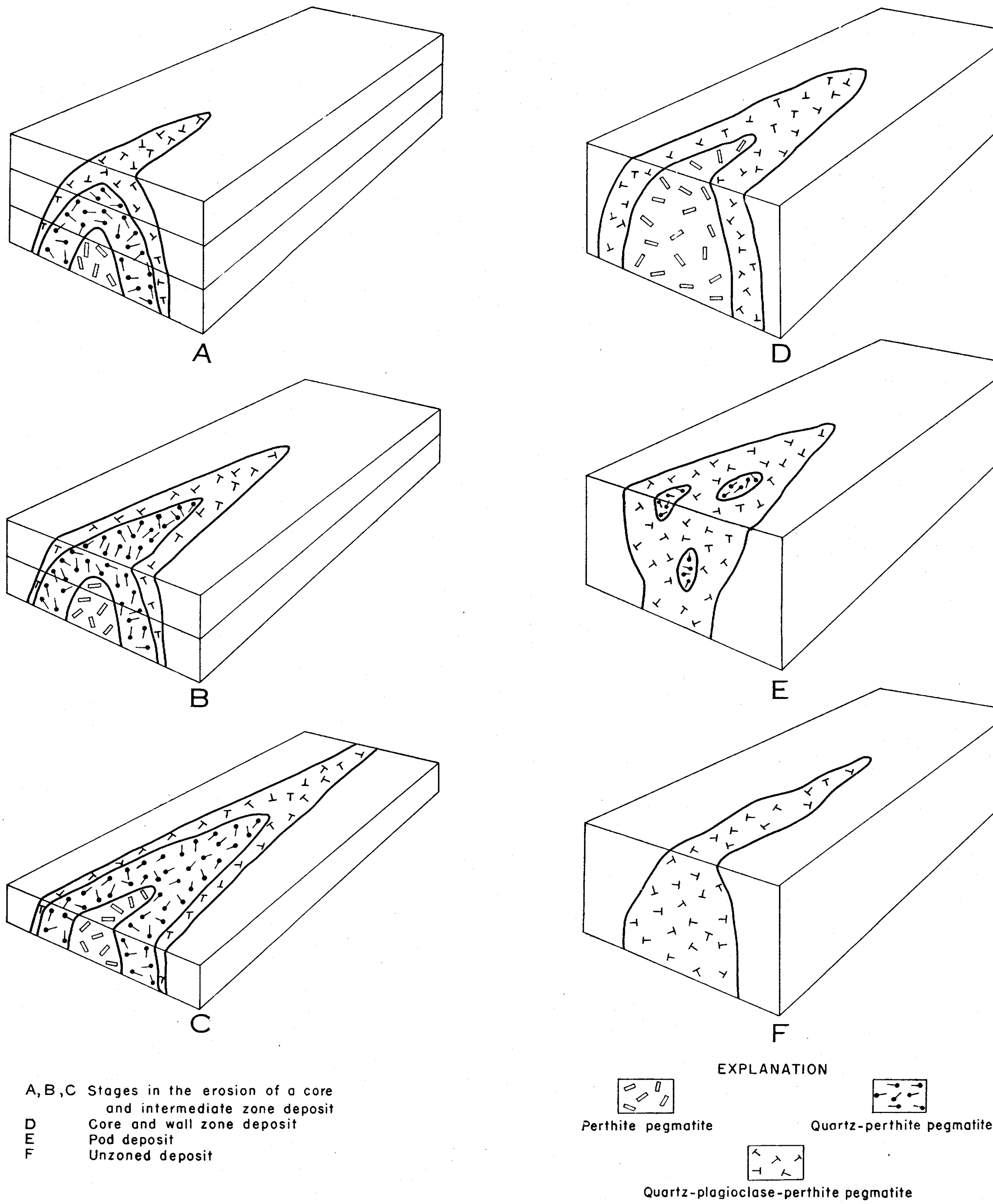


FIGURE 10.—Diagrams showing types of feldspar deposits. *A, B, C,* indicate stages in the erosion of a core and intermediate-zone deposit; *D,* core and wall-zone deposit; *E,* border deposit; *F,* unzoned pegmatite.

depth shown in figure *C*, or by exploratory work carried to this level. The depth to which the core extends down dip and its extent along strike could be determined by a combination of mapping, trenching or pitting, and diamond drilling.

Figure *D* represents a pegmatite containing feldspar deposits of the core and wall-zone types. Downward increase in the thickness of the small core exposed in the center of the pegmatite outcrop might be inferred from observations of the dip of the pegmatite contact. In the Colony pegmatite, Alstead, N. H., only a small part of the core was exposed when mining was started. It has subsequently been exploited over a length of 600 feet, a width of 120 feet, and a depth of at least 90 feet.

Figure *E* illustrates a pegmatite containing pods of quartz and perthite. If the pods are large enough, they may support small-scale quarrying operations, but pods commonly do not yield sufficient tonnages of feldspar to repay the costs of building access roads and moving in machinery.

Figure *F* illustrates a pegmatite showing no clearly developed zoning. This type of pegmatite generally shows a very gradual increase in the size and concentration of perthite toward the irregular center. It may contain isolated pods and irregular patches of quartz and perthite, but these will commonly be too small to justify mining.

BERYL DEPOSITS

BERYL

Beryl, currently the only commercial source of beryllium, occurs sparingly in many pegmatites. Most beryl is green or blue green (aquamarine), but some is pure white, yellowish white, golden, brown, pink, yellowish green, or emerald. Some crystals show color zoning. The cores of these are green or bluish green, the outer zones, golden or pink. Dana (1920, p. 407) gives the composition of beryl as $Be_3Al_2(SiO_3)6$ or $3BeO \cdot Al_2O_3 \cdot 6SiO_2$ (silica 67.0 percent, alumina 19.0 percent, beryllium oxide 14.0 percent), but potassium, sodium, caesium, rubidium, lithium, and iron may be present, and with increase in these elements the content of BeO may fall to 10 percent or less. New England beryl commonly contains 12 to 14 percent BeO (4 to 5 percent of the element beryllium).

Chemical analyses of beryl specimens from Maine pegmatites

[W. T. Schaller, analyst]

	Bennett, Buckfield	Standish	Greenwood	Warren Depot
SiO_2	64.57	64.25	63.18	63.98
BeO	12.55	12.40	11.88	11.70
Al_2O_3	18.47	18.79	18.22	18.17
Fe_2O	.01	.16	----------	.00
FeO	.30	.31	.14	.23
MgO	.00	.00	----------	.00
CaO	.00	.00	----------	.00
Li_2O	.56	.70	.86	.82
Na_2O	.96	1.02	.83	1.58
K_2O	.14	.08	.08	.06
Rb_2O	.00	.00	----------	.06
Cs_2O	.44	Trace	2.74	.76
H_2O [1]	2.12	2.32	1.94	2.46
TiO_2	.00	.00	Trace	.00
MnO	Trace	Trace	----------	Trace
BaO	.00	.00	----------	.00
	100.12	100.03	99.87	99.82

[1] Loss on ignition.

Beryl crystallizes in the hexagonal system and has an uneven or conchoidal fracture, which is pebbly in some crystals. Its hardness ranges from 7.5 to 8 on the Mohs scale, and its specific gravity is 2.63–2.80, commonly 2.69–2.70. The luster of beryl is vitreous or resinous. Crystals range from transparent to opaque and have a white streak. An imperfect and indistinct basal cleavage is common, and in some crystals from the Black Mountain quarries, and other localities, the cleavage is well developed. Crystals recovered from New England pegmatites range from ⅛ inch to 10 feet or more in length and from 1/32 inch to 3 feet or more in diameter.

Beryl is commonly recovered as a byproduct of operations for feldspar, lithium minerals, and mica. Under the low prices prevailing in former years ($35 per ton), only large crystals were recovered, but under wartime prices ($90 to $180 per ton), small crystals have been recovered and sold. The crystals in many pegmatites, however, are so small that hand cobbing is impractical. The beryl content of most pegmatites is so low that considerable quantities of rock must be mined and sorted in the recovery of the mineral. A pegmatite containing 1 percent beryl is unusually rich; most contain less than 0.1 percent of the mineral. For full recovery of the small beryl crystals occurring in these pegmatites, special methods of beneficiation and milling must be developed; some progress is reported to have been made in this direction by the U. S. Bureau of Mines (Jardine, 1945, p. 64).

PROPERTIES AND USES OF BERYLLIUM

The element beryllium has a specific gravity of 1.64, and a hardness between 6 and 7 on the Mohs scale. The atomic number is 4 and the atomic weight 9.1. Its melting point is about 1,285° C., and the boiling point is 1,530° C., at 5 mm pressure. At ordinary temperatures it is brittle, but at high temperatures can be forged, rolled, or polished. It is a better electrical conductor than copper but is inferior to silver. Some of the methods used in the extraction of beryllium from beryl have been described by Sawyer (1941b).

Beryllium is 17 times more permeable to X-rays than aluminum and is therefore used for windows in X-ray tubes. Ceramics containing beryllium oxide have a high thermal conductivity, low electrical conductivity, high strength, and resistance to thermal shock. Beryllium zinc silicate is used in the manufacture of fluorescent lamps, and beryllium products are used in cathode ray tubes and television equipment.

Many applications of beryllium involve the use of beryllium-copper alloys, most of which contain from about 0.3 to 2.5 percent beryllium. The value of beryllium-copper alloys lies in their superior hardness and in the retention of the electrical conductivity of copper. They are used in the manufacture of strong metal for electrical contacts, diaphragms, clips, small springs and other parts of special tools; in cast-setting diamond-drill bits, and reaming shells; as platings on various metals; and in pistons for airplane engines (Sawyer, 1941a, p. 37–39). Beryllium has also been alloyed with nickel, magnesium, and gold. Nighman (1945) mentions the recent development of a copper-manganese-nickel alloy which is said to have a greater hardening range and fatigue resistance than beryllium-copper. Because sources of supply are uncertain and beryllium is costly, it may be replaced for some uses by the substitute.

Wartime uses of the beryllium alloys included parts used in aircraft, ships, tanks, guns, shells, instruments, engines, motors, radio equipment, telephone and telegraph equipment, tools, and electrical control equipment for machinery and fire prevention systems (Anon., 1943).

TYPES OF BERYL DEPOSITS

Eight types of beryl deposits have been recognized in New England during the present investigation—border-zone, wall-zone, intermediate-zone (including core-margin), core, pod, disseminated, fracture-filling, and replacement deposits.

Border-zone deposits.—In some pegmatites small beryl crystals are concentrated within the border zone along one or both contacts of the pegmatite. The crystals may extend into the wallrock. Some quartz-rich or quartz-plagioclase-muscovite border zones are fluted, and have yellowish-green to blue-green beryl crystals parallel to the fluting and elongated in the surface of contact. Some crystals in these deposits are flattened, bent, and cut by quartz-filled fractures, and small groups of crystals are splayed or arranged in fan-shaped clusters. Examples of this type of deposit include the Burroughs prospect and the Big mine, both in Alstead, N. H. In some pegmatites, such as the Case deposits, Portland, Conn., beryl crystals in the border zones are arranged with long axes roughly perpendicular to contacts.

Wall-zone deposits.—In wall-zone deposits, the beryl crystals commonly are small and arranged with their long axes normal to the contact of the pegmatite. The beryl is commonly yellowish green, green, or blue green, although some is white or golden. In some pegmatites, such as the one at the Porter mine, the crystals are widely scattered through the outer part of the wall zone, and are associated with medium- to coarse-grained quartz, plagioclase, muscovite, biotite, and perthite. In others, such as the Case No. 2 prospect, crystals are evenly distributed through the full width of the zone. The beryl crystals show progressive increase in size from the outer to inner edges of the wall zones. Many crystals oriented normal to contacts are tapered, and these have their small ends next to the wall. The beryl deposit at Black Mountain is this type.

Intermediate-zone deposits.—Beryl crystals in intermediate zones, other than core-margin zones, are commonly small and oriented at random. The zones consist of quartz, plagioclase, perthite, biotite, muscovite, and apatite in various proportions. The beryl crystals are white, green, blue green, yellowish green, golden, or brown. Core-margin deposits consist of quartz, perthite, and beryl; of quartz, plagioclase, wedge muscovite, and beryl; or of quartz and beryl. Many of the largest crystals of beryl occur in core-margin deposits.

Core deposits.—In a few of the pegmatites studied, crystals of green, yellowish-green, or blue-green beryl occur within quartz or quartz-perthite cores. The crystals are as much as 6 feet long and 3 feet in diameter. The largest beryl crystals at the Bumpus Quarry occurred in the core and core-margin zones, and those at the Pattuck mine were in the core.

Pod deposits.—Pod deposits of beryl, similar to pod mica deposits, are found in many pegmatites. The beryl crystals are scattered along the margins of the pods or occur within the pods, which are commonly composed of quartz or quartz and perthite. Plagioclase and muscovite occur with the beryl crystals along the margins of pods.

Disseminated deposits.—Crystals of beryl are disseminated throughout some pegmatites, without relation to zones where such units are present. The crystals are commonly small or of medium size and oriented at random from one wall to the other. Most of the beryl is green or blue green, but some is yellow or golden. The crystals may be either evenly or unevenly disseminated. In the Gotta-Walden pegmatite, Portland, Conn., beryl is present in all zones, but is more abundant in the upper part of the body. In the Hale-Walker pegmatite, beryl is equally abundant in the border zone and the core. In both pegmatites, the beryl is directly associated with quartz and plagioclase, although perthite is present.

Fracture-filling deposits.—Most fracture-filling deposits are small. Some are thin lenses, as at the Britton mine, Alstead, N. H., others are veinlike fillings of cross-cutting fractures, as at the Gotta-Walden prospect, Portland, Conn. Beryl in such deposits is commonly associated with quartz, plagioclase, perthite, and muscovite in various proportions. Quartz and plagioclase are present in nearly all deposits.

Replacement deposits.—Replacement deposits containing beryl occur most commonly between quartz or quartz-perthite cores and the outer zones. The beryl is associated chiefly with quartz, wedge muscovite, and medium- to coarse-grained cleavelandite, in places containing open, angular cavities between the bladed crystals. Accessory minerals may include lithium minerals, phosphates, varicolored tourmaline crystals, cassiterite, and columbite.

Small- and medium-size crystals are more common than large ones, and in many deposits the crystals are intergrown with, or replaced in part by, quartz and cleavelandite. Crystals are oriented at random and are commonly white, green, blue, blue green, golden, or pink. The beryl-bearing quartz-cleavelandite bodies of the Strickland pegmatite are typical.

COMPARISON OF TYPES

Beryl recovered from the pegmatites of New England has consisted entirely of crystals that could be separated by hand, and for this reason the size of crystals obtainable from a deposit is important. In general, crystals large enough to be hand sorted are more abundant in inner intermediate-zone, core, pod, fracture-controlled, and replacement deposits than in outer intermediate-zone and wall-zone deposits. Beryl in border-zone deposits and most wall-zone deposits is too small to justify hand sorting.

Known wall-zone deposits are of low grade, commonly containing 0.3 percent of beryl, or less, and do not appear likely to become important sources of beryl even if milling techniques are developed. The Black Mountain deposit is an exception. Border-zone deposits likewise are low in grade and are so thin that they could not yield large tonnages. Inner intermediate-zone deposits, on the other hand, contain medium to coarse crystals of beryl and, because the zones are situated near the cores of pegmatites, the beryl in them is likely to be recovered as a by product if the cores are mined for feldspar. It is largely for this reason that most of the beryl produced from New England has come from inner intermediate zones and cores. Most of the rest has come from replacement deposits and wall zones worked for beryl together with perthite, cleavelandite, lepidolite, spodumene, scrap mica, and other minerals, in various proportions. In replacement deposits, however, beryl is commonly intergrown with other minerals.

Fracture fillings and pod deposits are common but have the same disadvantages as the corresponding types of mica deposits and are interesting chiefly as sources of cabinet specimens.

Few disseminated deposits of beryl examined during the present work contained 0.2 percent or more of beryl, but one, the Gotta-Walden prospect, is inferred to contain more beryl than any other deposit studied in New England, and its grade as indicated by crystal measurements is 0.84 percent beryl. It may be that further prospecting, particularly in Connecticut, would reveal similar deposits of comparable magnitude. Prospectors seem to have given less attention to disseminated deposits than to zonal and replacement deposits, which more commonly contain bodies of other commercial minerals that are minable by the methods of the past.

In no type of deposit is the content of beryl sufficient to justify operations for beryl alone, and this will probably hold true even if efficient milling methods for separating the constituents of pegmatities become available. The highest grade bodies of significant size known at present are the Black Mountain deposit, which is probably of the wall-zone type, and the Gotta-Walden deposit.

PRODUCTION

Beryl has been recovered from New England pegmatites since the early 1800's, and is represented in many museum and gem collections. However, production for commercial uses began after World War I. New England production was small as of the end of 1945, and chiefly from Maine and New Hampshire. Although no accurate records are available, the field evidence and available data suggest that the production from Maine probably has not exceeded 200–225 tons, that from New Hampshire, 100 tons, that from Connecticut 20 tons, and production from Massachusetts about 6 tons. Thus, New England pegmatites have yielded about 330 tons of beryl as of 1945.

The more productive New England pegmatites include the Bumpus and Black Mountain pegmatites in Maine, and the Palermo No. 1 pegmatite in New Hampshire. Other pegmatites have contributed a few tons each. During 1942–44, the Black Mountain and Palermo deposits each yielded about 33 tons. Well-known pegmatites that were not operated during the war period include the Bumpus, and Beryl Mountain, Acworth, N. H. During the period 1942–43, when beryl was in critical demand, joint studies by the Geological Survey and the U. S. Bureau of Mines were made at the Black Mountain pegmatite and at the Gotta-Walden, Bordonaro, and Case pegmatites in Connecticut, which in the aggregate contain considerable amounts of beryl. However, in the fall of 1943, before these properties could be put into production, the need for the mineral decreased, and plans for milling the beryl were abandoned. The Beryl Mountain pegmatite was studied and the old workings cleaned out by the Bureau of Mines, but the property was not operated. A few tons of the mineral was recovered from the muck in the old workings.

AMOUNTS OF BERYL IN KNOWN DEPOSITS

Amounts of beryl present in the individual pegmatites are given, so far as permissible, in the detailed reports on properties. The known deposits in Connecticut contain 835 tons indicated and 106 tons inferred beryl; those in Maine, about 250 tons indicated and 575 tons inferred; those in New Hampshire about 55 tons indicated and an additional 550 tons inferred; those in Massachusetts, a few tons inferred. The beryl in Connecticut deposits, and probably 50 percent of that reported for other states, will require milling. Total known beryl in New England is about 1,140 tons indicated and 1,231 tons inferred.

DESCRIPTIONS OF MINES AND PROSPECTS

MAINE

ANDROSCOGGIN COUNTY

BERRY FELDSPAR QUARRY

The Berry quarry is in the town of Poland, 1.5 miles S. 44° E. of the village of Minot (fig. 11). To reach it from this village, drive southwest 0.3 mile to a southeast fork, then follow this branch road 1.4 miles to the quarry, which is on the east side of the hill a short distance northeast of the road. Bertha M. and Thomas J. Bergeron, R. F. D. No. 2, Auburn, Maine, own the land. The quarry was visited in 1906 by Bastin (1911, p. 59–60) and the mine was mapped by L. R. Page and J. B. Hanley in May 1942.

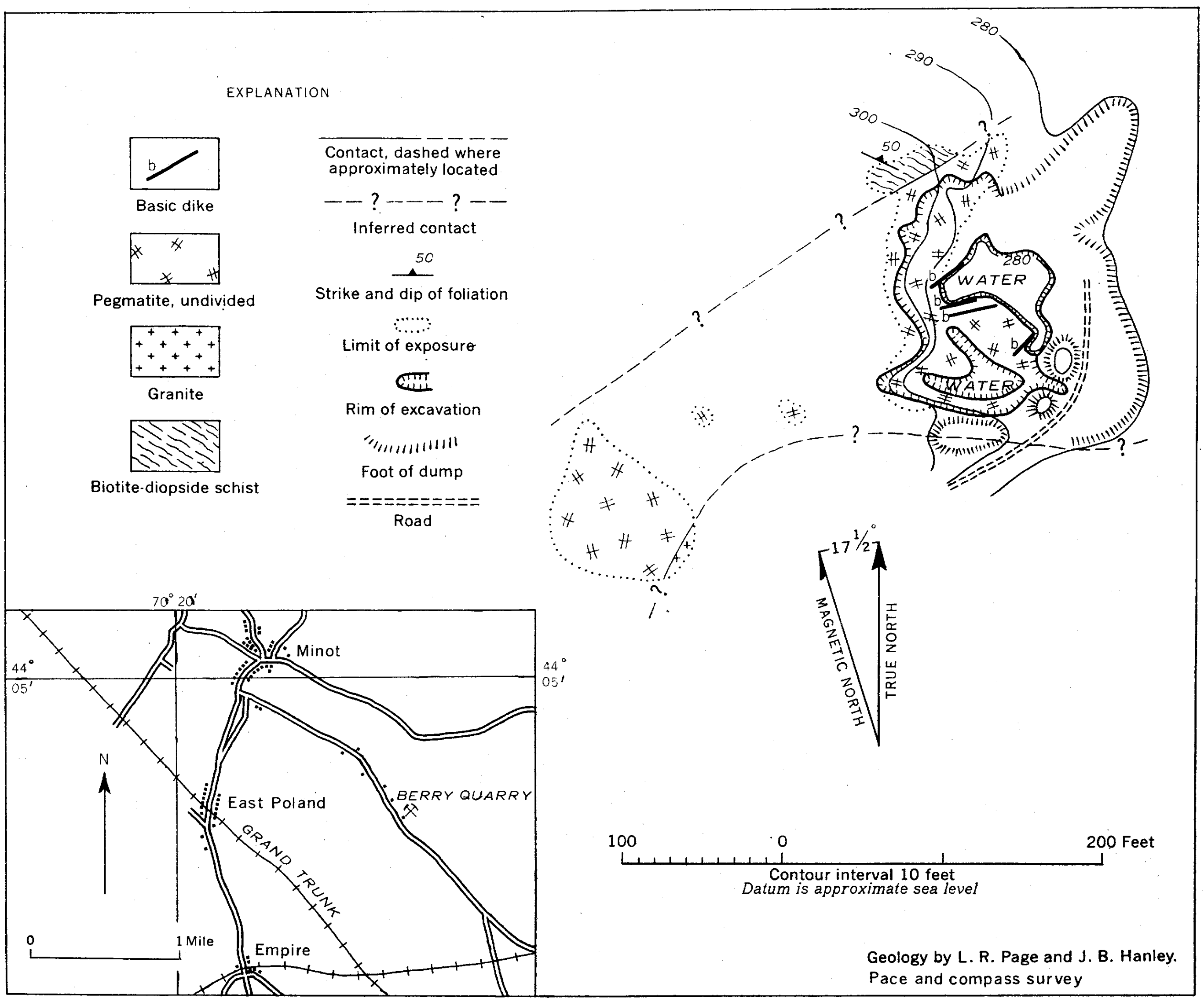


FIGURE 11.—Geologic map of the Berry feldspar quarry, Poland, Maine.

According to Bastin, the quarry was opened in 1900 and worked intermittently until 1906, when A. R. Berry, R. F. D. No. 7, Auburn, operated it for feldspar and gem minerals. In 1911, it was worked by F. S. Harvey for the Maine Feldspar Co., Littlefield Station, Maine. A small pit, flooded at the time of examination, had been made in a graphic-textured pegmatite that trends N. 60° E. The wall rocks are biotite granite and biotite-diopside schist. The foliation of the schist strikes northwest and dips 50° NE. The northwest contact of the pegmatite with schist is exposed a few feet north of the quarry. The southeast contact with granite lies about 200 feet southwest of the quarry.

The pegmatite is fine-grained at the margin but is predominantly graphic granite containing patches of perthite and graphic intergrowths of quartz and muscovite and quartz and tourmaline. Biotite blades are scattered irregularly throughout the graphic intergrowths. Pockets of albite and associated gem minerals were found during quarrying, but none was visible at the time of examination. The mineralogy of this pegmatite was described in detail by Berman (1930), who listed the following minerals: quartz, microcline, orthoclase, muscovite, biotite, albite, beryl, cassiterite, amblygonite, lepidolite, varicolored tourmaline, herderite, lavender apatite, caesium beryl, lithiophylite, rhodochrosite, eosphorite, reddingite, dickinsonite, fairfieldite, apatite, landesite, and manganese oxides. Of these, only quartz, microcline, muscovite, tourmaline, and biotite are found in abundance. Beryl was not observed in place, although it was found on the dumps.

Considerable feldspar might be produced from this pegmatite by careful hand-sorting, but it is doubtful that large quantities of beryl or sheet mica could be recovered.

CUMBERLAND COUNTY

LACHANCE MINES

The LaChance mines are in the town of Brunswick, 1.6 miles S. 12° W. of the village of Hillside. To reach them from Hillside, drive southwest 0.55 mile along the Maine Central Railroad, turn south across the tracks, and proceed 1.5 miles. The quarries are on the south side of a knoll about 0.2 mile west of the road. They are owned by Jeffrey LaChance, and were leased in 1943 by the Douglass Mining Co., Portland. The mines were visited in June 1942 by L. R. Page and J. B. Hanley, and were mapped by the Maine Geological Survey (Trefethen, 1943) in November 1943. J. J. Page examined the workings in November 1943, but the pegmatites being worked for mica were largely concealed by fill.

Three small open pits have been made on the property. LaChance opened the first pit in 1920 and operated it for a few months. It was then leased by the Maine Feldspar Co., who continued work until 1926 Messrs. Jeffrey, Moore, and F. Thomas LaChance worked the pits intermittently between 1926 and 1939. Clear quartz was produced and is reported to have been purchased by the General Electric Co., Schenectady, N. Y. In 1943 the mines were operated for mica by Jeffrey LaChance for the Douglass Mining Co.

A series of lens-shaped north-trending pegmatites cut feldspathic biotite schist and gneiss of the Pejepscot gneiss and a fine- to medium-grained biotite granite. The pegmatites are as much as 150 feet in exposed length and 75 feet in exposed width. The contacts between large pegmatites and schist are sharp, but those between small pegmatites and schist are gradational. Contacts between pegmatite and granite are gradational and irregular. The foliation of the schist strikes northeast, in general, and dips about 28° SE. A 12-inch, nearly vertical basic dike cuts pegmatite in one of the pits. It strikes about N. 3° E.

The margins of the pegmatites commonly have fine-grained border zones that grade inward into medium- to coarse-grained pegmatite containing quartz, microcline, plagioclase, biotite, muscovite, and tourmaline. Albite is present near some of the contacts. Scattered quartz pods lie in the medium- to coarse-grained pegmatite, and some are surrounded by a narrow border of albite, locally containing columbite. The pods consist chiefly of cloudy or milky quartz, but contain a small amount of clear quartz. This is cut by sheeting planes at intervals of from ½ to 1 inch. Muscovite books occur along the margins of some pods. Perthite crystals attaining a maximum diameter of 4 inches are present in the medium-grained pegmatite, but no large block feldspar was observed. Graphic intergrowths of garnet and black tourmaline with quartz are associated with aplite and small golden beryl crystals in the medium-grained pegmatite. Sheet-bearing muscovite books are said to have been found in a tabular unit 3 feet below the hanging wall of one of the pegmatites worked in 1943. This ruby mica is flat and clear. Many books were reeved, but a satisfactory percentage of sheet mica was recovered from it. The pegmatites mined in 1943 were narrow and short, and it is probable that reserves are small.

OXFORD COUNTY

BARRETT BERYL PROSPECT

The Barrett beryl prospect, on the southwest slope of Streaked Mountain, is in the town of Hebron 3.5 miles N. 17° W. of the village of Hebron. To reach the prospect from the village, drive north 0.8 mile to a fork; follow the northwest branch 3.1 miles, passing two crossroads, to the Barrett residence. The prospect is ⅛ mile east of the house, and is owned by James L. Barrett. Very little exploratory work has been done.

It was examined in August 1943 by D. M. Larrabee, L. Goldthwait, and W. M. Hoag.

The pegmatite is apparently a large sheetlike body. The top has been removed by erosion, but probably dipped about 30° SW. The pegmatite crops out continuously over an area 1 mile long and ½ mile wide on the southwest slope of the mountain. Many sheet joints, dipping nearly parallel to the outcrop surface, occur in the pegmatite. The body was injected into quartz-mica schist of the Sabattus formation, adjacent to its contact with the Androscoggin formation to the northeast.[10]

The pegmatite is chiefly fine- to medium-grained. Large patches of aplite and quartz-rich pegmatite of the border zone are scattered over the surface. In places the border zone contains small garnets and black tourmaline. Inward, the rock is medium-grained and consists of quartz, plagioclase, perthite, biotite, and books of muscovite that seldom exceed 1 inch in diameter. A few small beryl crystals occur in this part of the mass, and large black tourmaline crystals are common. Small, irregular, coarse-grained quartz-perthite lenses, in places containing beryl and rose quartz, are present in the medium-grained pegmatite. The texture of the mass is indicative of proximity to the top of the body.

Beryl is uncommon in most of the pegmatite examined, and only 10 crystals having a total surface area of 3 square inches were found. Feldspar-bearing pegmatite of minable grade does not occur in large quantities at the surface, but as the pegmatite is probably coarse-grained at depth, it is possible that minable concentrations are present. Good sheet-bearing muscovite was not observed, and there is no evidence that concealed parts of the pegmatite are richer in mica or beryl.

BENNETT FELDSPAR QUARRY

The Bennett quarry is in the town of Buckfield, 3 miles west of Buckfield village. To reach it from Buckfield, drive 0.5 mile northwest to a fork, and follow the northwest branch 0.9 mile to an intersection. Drive southwest 2.1 miles to the Bennett residence on a knoll east of the Basin Falls Brook and north of the road. Turn northwest at the house, and drive 0.5 mile through the Bennett farm to the quarry. The property is owned by Mrs. Blanche Bennett, from whom the mineral rights are leased by the United Feldspar & Minerals Co., West Paris. The mineralogy of the pegmatite was studied in 1923–24 by Landes (1925). During the spring of 1942 the pegmatite exposed above water in the pit was examined and mapped by L. R. Page and J. B. Hanley; later that year D. M. Larrabee and I. S. Fisher examined the property. In May 1945, the quarry was remapped by Larrabee and K. S. Adams (fig. 12).

The quarry, from which about 40,000 tons of rock has been removed, is an east-trending opencut 240 feet long, 20–80 feet wide, and 71 feet in maximum depth near the southeast corner. The cut was opened in 1920 by Paul Bennett, who worked it until 1923. It was operated under lease by the Maine Feldspar Co. until 1926, from 1926 to 1929 by Harold Perham, West Paris, and by the Whitehall Co. from 1929 until about 1933. The quarry was idle until November 1944, when the United Feldspar & Minerals Co. began operations.

The pegmatite crops out in places for a distance of about 1,000 feet beyond the east end of the cut and, according to Landes (1925, p. 361), is 650 feet wide at the crest of the hill east of the quarry. The walls are not exposed, but the body contains inclusions of strongly garnetized and tourmalinized biotite gneiss and schist containing much pegmatitic material. In general, the inclusions strike north and dip gently westward, although local variations are common. The attitude of these inclusions, many of which are thin screens, suggests that the body is a large sheetlike pegmatite dipping gently westward. Small lenses of aplite that grade into fine-grained aplitic biotite-bearing pegmatite and contain ¼-inch crystals of tourmaline and small kidney-shaped nests of biotite occur at the west end of the cut. These are probably inclusions of gneiss or fine-grained granite that have been converted to aplite by the action of the pegmatite.

The pegmatite contains an aplitic border zone ½ inch thick, in which garnet, apatite, biotite, and black tourmaline occur at the contacts with some of the gneiss inclusions. Inward from this marginal band, there is a zone composed of plagioclase-quartz-perthite pegmatite. This zone is perhaps 20 to 30 feet thick and medium- to coarse-grained. It contains much green apatite, scattered small books of rum muscovite, garnet, black tourmaline, green beryl, and silvery lepidolite books 2 to 3 inches wide. The lepidolite occurs in the south face, near the west end of the cut, whereas beryl is most abundant on the opposite face. This zone, from its relation to the inclusions, probably represents the wall zone of the pegmatite.

Inside the wall zone is a quartz-perthite intermediate zone containing small amounts of plagioclase, apatite, black tourmaline, garnet, and beryl. Tourmaline is most abundant in the floor at the northeast corner of the opencut. The quartz-perthite zone grades in texture and mineral composition outward into the wall zone, so that the two units are not sharply delimited.

[10] Hanley, J. B., Geology of the Poland quadrangle, Doctorate thesis, The Johns Hopkins University, 1939.

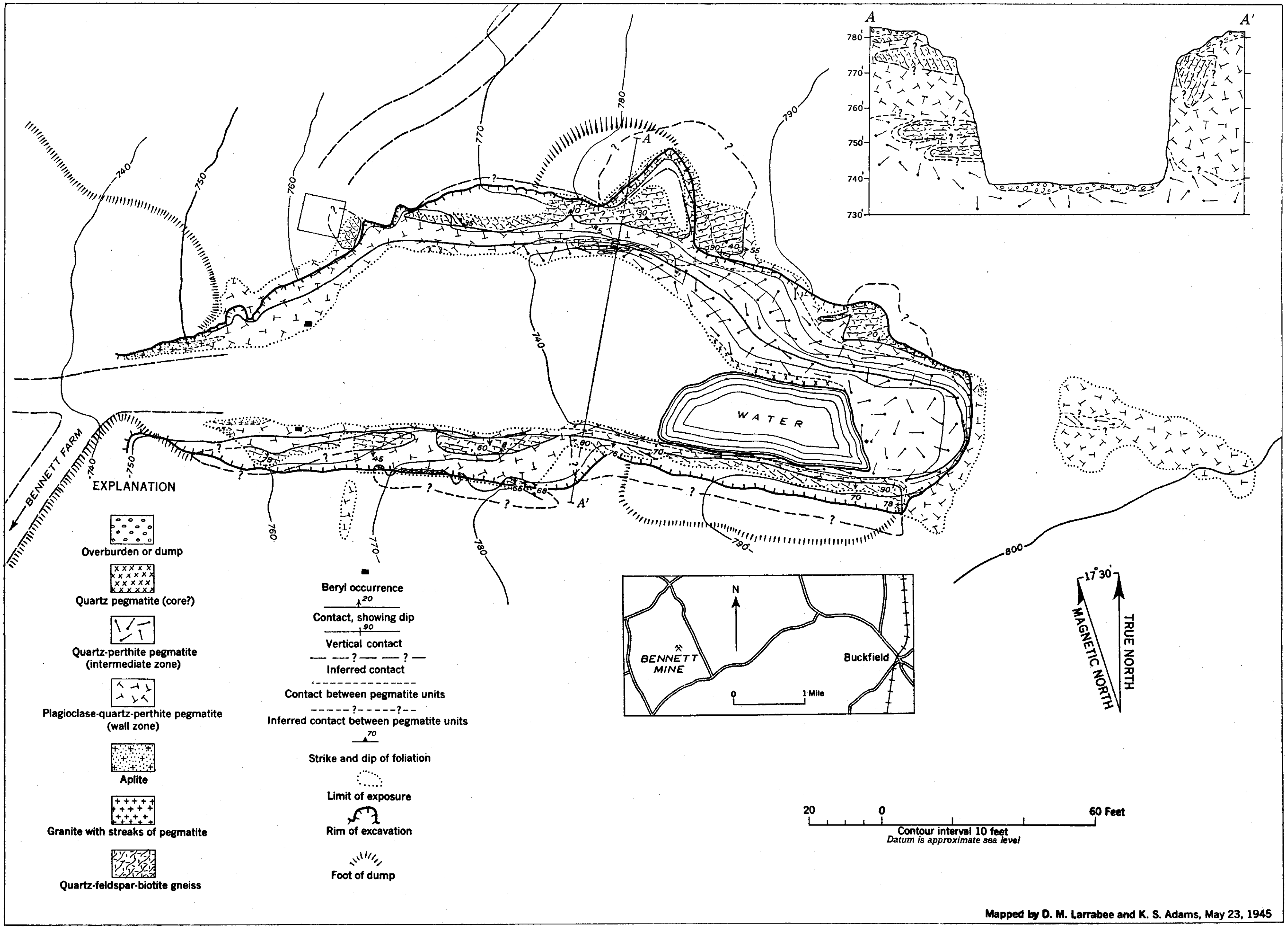


FIGURE 12.—Geologic map and section of the Bennett feldspar quarry, Buckfield, Maine.

Part of a quartz body is exposed in the north face near the east end of the cut. This unit trends east and dips approximately vertical. It is 40 feet long, probably pod-shaped, and may be the true core.

Replacement has occurred sporadically throughout the pegmatite, and small cavities due to solution are abundant along the north face in the western half of the opencut. Larger cavities have been reported near the south side of the pegmatite. Many minerals formed by replacement have been observed in and around cavities, and elsewhere in the pegmatite; occurrences are most common in the western half of the wall zone.

Landes, (1925, p. 367–398) who has carefully studied the several periods of mineralization, indicated five stages in the development of the pegmatite minerals. The first was a primary stage in which microcline, quartz, manganapatite, beryl, black tourmaline, muscovite, white lepidolite, biotite (from inclusions), garnet, arsenopyrite, and amblygonite developed. Succeeding stages were considered hydrothermal. The first period of activity resulted in the formation of quartz, lilac-colored lepidolite, cleavelandite, beryl, green tourmaline, spodumene, apatite, herderite, columbite, manganotantalite, cassiterite, pollucite, topaz, and two unknown phosphates. During the second phase of hydrothermal activity, amblygonite, lithiophylite, triphylite, rhodochrosite, eosphorite, fairfieldite, and reddingite were formed. The third period resulted in the deposition of lepidolite, rhodochrosite, cookeite, quartz, apatite, and herderite. Minerals, all alteration products, formed during the last period include kaolin, montmorillonite, psilomelane, manganite, red manganese phosphate, rhodochrosite, and dahllite.

A small outcrop of pegmatite about 400 feet north of the quarry has been prospected by means of an opencut. This pegmatite contains many inclusions of biotite gneiss and schist, and may be a part of the larger pegmatite to the south. At contacts with inclusions, the pegmatite contains a thin border zone, inside of which is a wall zone similar to that in the main body. There is a small irregular core consisting largely of quartz. Minute beryl crystals are present in the quartz and in the wall zone; 67 crystals have a surface area of 0.10 square foot.

During 1942, much interest was shown in these pegmatites as possible sources of beryl. In the faces and floor of the main cut, 45 crystals with a total surface area of 0.76 square foot were found. Most of these were in the western half of the cut, and occurred in 282 square feet of pegmatite where the mineral represented 0.3 percent of the body. However, careful study disclosed no evidence that the beryl-bearing unit continues in depth, and it appears unlikely that beryl extends eastward throughout the main body. The occurrence is small, and others of similar extent are to be expected in the cleavelandite-rich parts of the pegmatite. Larger crystals might be found in or marginal to the quartz-perthite core.

Several thousand tons of feldspar has been produced, and reserves amount to tens of thousands of tons. Much tourmaline and apatite occur with the perthite, but the satisfactory removal of these objectionable minerals is accomplished by magnetic separation.[11] Quartz, scrap mica, and small quantities of beryl, lepidolite, and columbite-tantalite can be recovered as byproducts.

BLACK MOUNTAIN AREA

The Black Mountain area (pl. 3) is in the towns of Rumford and Andover, about 5 miles northeast of the village of Rumford. It is accessible from Route 219 on the southwest, Route 120 on the northeast, and a connecting road extending from southwest to northeast, passing north of Howe Hill (1,441 feet, elevation), Whitecap (2,197 feet), Black (2,355 feet), and South Twin (2,156 feet) mountains, all of which, in addition to Farmers Hill, lie within the area. The area was surveyed by pace and compass during June–July 1943, by D. M. Larrabee, W. M. Hoag, W. H. Ashley, H. R, Morris, and L. Goldthwait (pl. 3). In May 1945. Larrabee and K. S. Adams examined additional outcrops along the north and southeast slopes of Whitecap Mountain.

Black Mountain and the southwest slope of South Twin Mountain were traversed at approximately 200-foot intervals. The bald slopes and summit of Whitecap Mountain, the south slope of Farmers Hill, and the southwest slope of Howe Hill were also searched for pegmatites, primarily those containing appreciable quantities of beryl or mica. The Black Mountain quarries and the Brown-Thurston beryl prospect, examined before traversing was undertaken, are described below.

More than 300 pegmatite outcrops in the Black Mountain-Whitecap area were examined for beryl and sheet mica, but no pegmatite mineralogically similar to those developed in the Black Mountain quarries or containing large quantities of beryl or sheet-bearing muscovite was found.

BLACK MOUNTAIN

The rocks on Black Mountain are quartz-mica schist, impure micaceous-quartzite, thin bedded pyritiferous quartzite with shale partings, and quartz monzonite. These enclose pegmatites that have various shapes, including lenticular pods, steeply dipping dikelike

[11] Rossell, H. A., superintendent, United Feldspar & Minerals Co., oral communication, May 23, 1945.

masses, and large gently-dipping sheets. These, with the exception of the Black Mountain quarry and Brown-Thurston pegmatites, are of similar mineralogy. In general, the border zones of the pegmatites consist of aplite or graphically intergrown quartz and muscovite. The wall zones are medium-grained and contain quartz, plagioclase, perthite, small muscovite books, garnet, tourmaline, and, in many places, heterosite or purpurite. Medium- to coarse-textured lenses of quartz and perthite occur in the centers of some bodies, but no large feldspar crystals were observed. Of the 224 pegmatite outcrops examined, 20 contain small quantities of beryl. This is in crystals that are rarely more than a few inches in diameter. There are two types of occurrences: green beryl commonly associated with small lenses of quartz or of quartz and perthite; and white beryl, which is most abundant in medium-grained wall zones. In most places, the white beryl is in pegmatites that also contain heterosite or purpurite. Minute crystals of golden beryl occur in the fine- to medium-grained wall zones of some pegmatites. No large concentrations of muscovite were seen.

SOUTH TWIN MOUNTAIN

Several west-dipping, sheetlike pegmatites occur on South Twin Mountain in wall rocks similar to those of Black Mountain. The pegmatites have border zones of aplite that commonly contain garnet and are banded parallel to the contacts. The wall zones consist of quartz, plagioclase, microcline, muscovite, heterosite or purpurite, black tourmaline, and green and white beryl, and contain lenses of coarsely crystalline quartz and microcline. Of the 57 pegmatite outcrops examined, 15 contain visible beryl. In general, the pegmatites on South Twin Mountain are of coarser texture than those on neighboring mountains, and contain larger quantities of plagioclase, heterosite or purpurite, and beryl.

WHITECAP MOUNTAIN

Whitecap Mountain is capped by a pegmatite that is probably sheetlike and is approximately 9,000 feet long and 6,000 feet wide. Beyond the margins of the main mass are many smaller pegmatites, some of which are tongues or fingers extending at right angles from the central mass. The country rocks are similar to those on Black Mountain. Inclusions are common near the margins of the main pegmatite and on its broad upper surface. The large pegmatite is broken by strong sheet joints parallel to the outcrop surface.

In general, the exposed surface of the pegmatite is fine- to medium-grained. Contact zones are fine-grained, garnetiferous, and aplitic, and remnants of thin aplite patches are scattered widely over the outcrop surface. These patches are mostly ¼ inch or less in thickness and are banded in some places, notably southeast of the peak. Thin patches of quartz and muscovite in graphic intergrowths occur on the outcrop surface. They lie upon a wall zone of fine- to medium-grained pegmatite containing quartz, plagioclase, muscovite, perthite, garnet, apatite, and tourmaline. Plumose aggregates of muscovite occur in this part of the mass, and are most abundant near the aplite. Small bodies of pale-rose quartz, and of quartz and perthite, occur within the wall zone and in places contain a few scattered, small crystals of green beryl. Some pegmatites satellitic to the main mass contain larger crystals of yellowish-green beryl. These commonly taper from one end to the other. Small quartz veins cut the pegmatites. The aplite patches, quartz-muscovite graphic intergrowths, plumose muscovite, and generally fine-grained texture, suggest proximity of the outcrop surface to the original hanging wall of the main pegmatite and coarser texture may reasonably be anticipated at depth.

HOWE AND FARMERS HILLS

The main ridge of Howe Hill contains several outcrops of pegmatite in impure quartzite and quartz-mica schist, which in general strike northeast and dip steeply southeast. The pegmatites commonly lie parallel to the bedding of the wall rock. They contain thin border zones of fine-grained rock consisting of plagioclase, quartz, garnet, and tourmaline. The marginal pegmatite grades inward into a medium-grained wall zone consisting of quartz, plagioclase, perthite, muscovite, black tourmaline, and pink garnet. Irregular lenses of coarsely crystalline quartz and perthite occur within the medium-grained parts.

Low Farmers Hill is composed of impure micaceous quartzite and quartz-mica schist containing sulfides. High Farmers Hill, to the west, is underlain by impure quartzite, quartz-mica schist, and andalusite schist that strike northwest and dip 60°–80° NE. The hill shows a number of outcrops of pegmatites having textures essentially similar to those on Howe Hill.

BLACK MOUNTAIN QUARRIES

These quarries, high on the northwest slope of Black Mountain, are in the town of Rumford, 5.7 miles N. 66° S. of the village of Rumford, Maine. To reach the workings from Rumford, drive about 8 miles northwest on Route 120, passing through Roxbury Notch. Turn south and drive 2.2 miles on a dirt road to a graveled access road leading southeast 1.1 miles up the mountain to the quarries. The United Feldspar and Minerals Company, West Paris, has the mineral rights, but property rights are owned by the Maine Products Co., New York City. The quarries were examined in 1906 by Bastin (1911, p. 95–97) and by Verrow in 1941

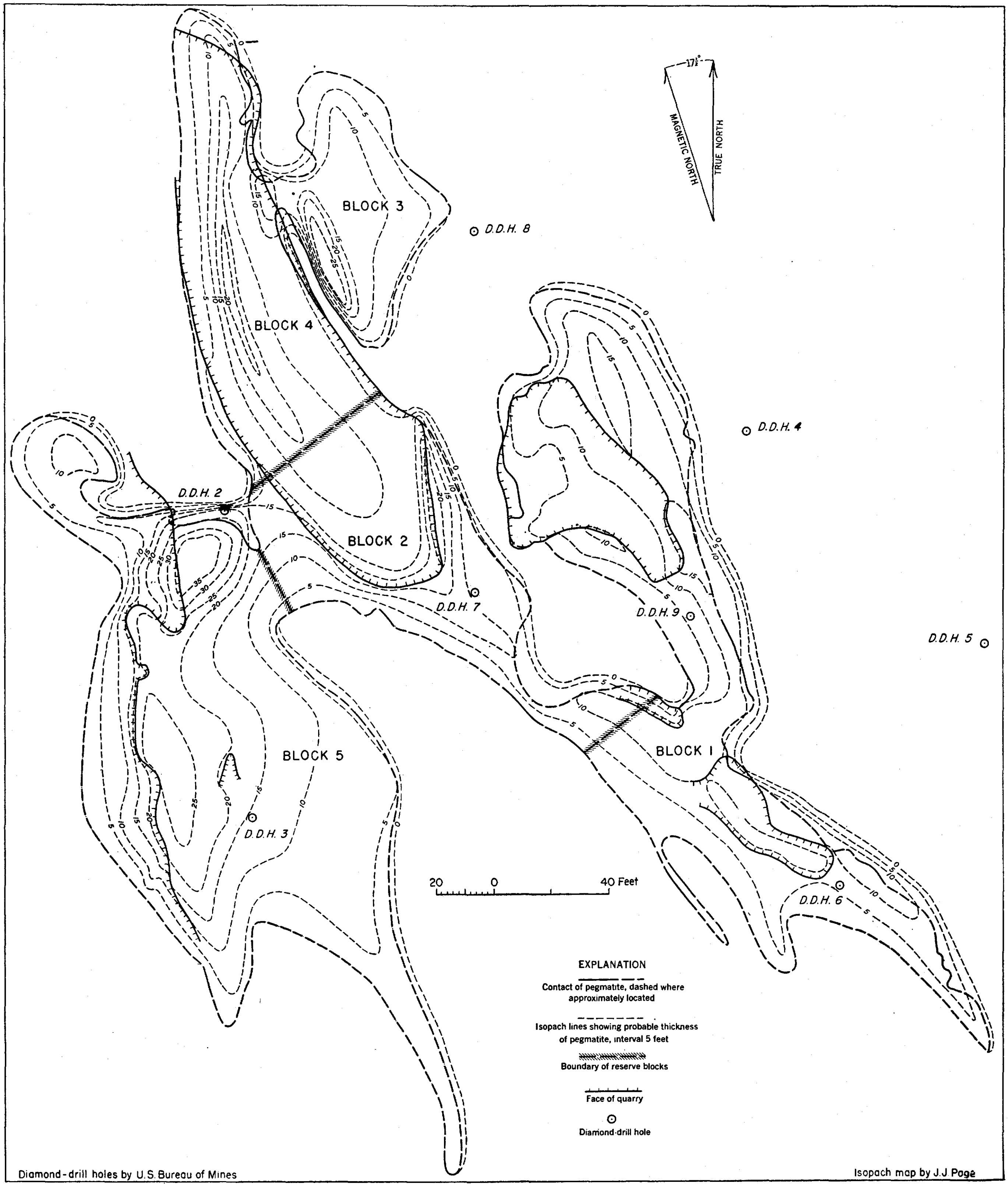


FIGURE 13.—Isopach map of beryl-bearing pegmatite at Black Mountain quarries, Rumford, Maine.

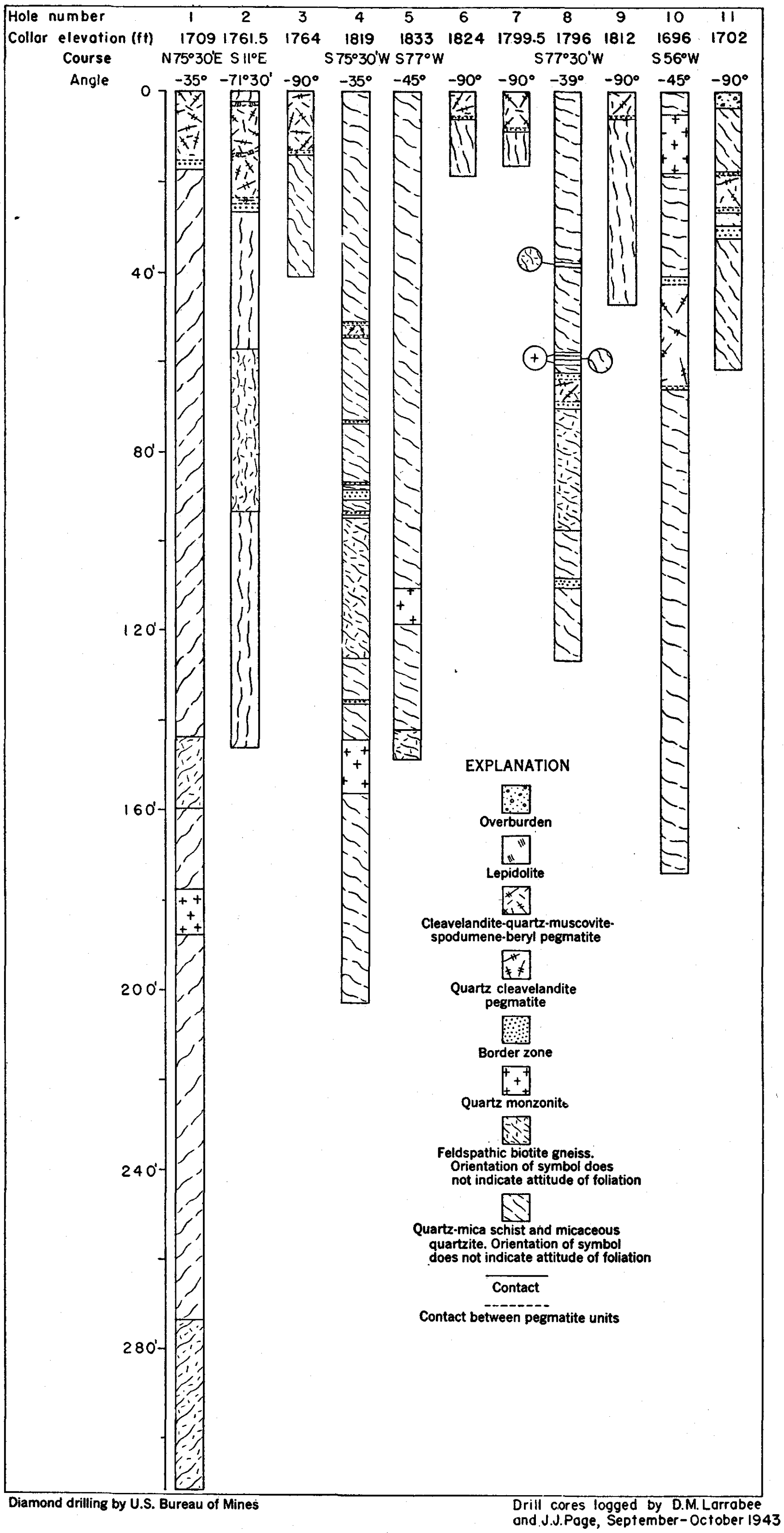


FIGURE 14.—Logs of diamond-drill cores, Black Mountain quarries, Rumford, Maine.

p. 119–120, 143). They were mapped in June 1942 by L. R. Page and J. B. Hanley. Further mapping was done in August 1942 by D. M. Larrabee and I. S. Fisher, in the fall of 1943 by Larrabee and J. J. Page, and in May 1945 by Larrabee and K. S. Adams (pl. 4; figs. 13, 14).

History.—According to Bastin (p. 97) the quarries were opened for scrap mica in 1901 by Oliver Gildersleeve, Gildersleeve, Conn., who worked them for four operating seasons. The dumps are reported to have been worked for scrap mica from 1931 until 1938 by S. I. Perham, West Paris, under an agreement with the Maine Products Company. The mineral rights were next leased by F. D. Pitts, Auburn, Mass., with whom an operating agreement was made by Caesari Trusiani, Brunswick, Maine. Trusiani recovered scrap mica, beryl, spodumene, lepidolite, and feldspar during summer operations from 1938 to 1942. In the fall of 1943, the mineral rights were leased by the United Feldspar & Minerals Co., and test samples for milling and separation were taken by this company and by the U. S. Bureau of Mines. During September and October 1943, the Geological Survey and the Bureau of Mines made a cooperative study of the pegmatites. E. E. Maillot, of the Bureau of Mines, supervised the diamond drilling. An access road to the quarries was built with the assistance of the Public Roads Administration during the latter part of 1943.

General description of the pegmatites and workings.—Five opencuts were made in two northwest-trending pegmatites during the early work at Black Mountain. The western pegmatite, 200 feet long and about 60 feet wide at the center, is lens-shaped. The contacts strike northwest, in general, and dip from 53° to 65° NE. The pegmatite was mined from an opencut that is 30 feet long, 20 feet wide, and has a maximum depth of about 10 feet. The eastern pegmatite, consisting of four connected pod-shaped bodies, represents the undulating bottom of a partly eroded sheetlike mass that strikes northwest and dips gently southwest. The individual pod-shaped bodies range in size from 100 feet long and 50 feet wide to 300 feet long and 100 feet wide. Each member of this group is connected to the adjacent pegmatite by a narrow neck of pegmatite 10 to 25 feet wide. The maximum thickness of the pod-shaped bodies ranges from 15 to 25 feet; the average thickness of all pegmatite is about 10 feet. Opencuts in the exposed bodies range from 20 feet long, 7 feet wide, and 5 feet deep to 200 feet long, 50 feet wide, and 40 feet deep. A third, small pegmatite between the east and west pegmatites was discovered by drilling; and several outcrops of one or more sheetlike pegmatites lie a few hundred feet east of the easternmost quarry. These eastern pegmatites are very different from those at the quarries, and probably are not parts of the same bodies. The dips of all the pegmatite contacts are extremely variable, and drilling has indicated sharp reversals of dip within a few feet of the surface.

Wall rock.—The wall rock is sulfide-bearing, interbedded quartz-mica schist and impure micaceous quartzite. These rocks strike northwest and dip steeply northeast. Near contacts with pegmatite, the wall rock contains brown tourmaline, and appears to have a higher content of pyrrhotite than elsewhere. Feldspathic biotite gneiss and fine-grained quartz monzonite were encountered in drill holes; the quartz monzonite was found in drill holes 1, 4, 5, and 10, and crops out along the road 25 feet north of drill hole 10.

Mineralogy and internal structure of the pegmatites.—The western pegmatite contains an aplitic border zone consisting of quartz, plagioclase (An_2), and muscovite. In places, 2 to 6 feet from the contact, it contains bands of garnet and large blue-black tourmaline crystals; the garnet bands lie between the tourmaline and wall rock. Inward from the border zone, a narrow medium-grained unit contains plagioclase (An_{2-3}), quartz, and muscovite. The central part of the exposed pegmatite consists chiefly of cleavelandite and quartz. Some of the cleavelandite is fetid when freshly broken. Small particles of cassiterite are scattered throughout the cleavelandite and in places are arranged in parallel, curving bands.

The small central pegmatite encountered in drill hole 2 contains a border zone of fine-grained quartz, muscovite, plagioclase, and black tourmaline. Inside the border zone, the pegmatite consists of coarse-grained cleavelandite, quartz, wedge muscovite, black tourmaline, green tourmaline in muscovite books, and pink garnet.

The irregular eastern pegmatite contains a border zone that locally is aplitic and consists of quartz, plagioclase, muscovite, garnet, and black tourmaline. In other places, the border zone consists of graphically intergrown quartz and muscovite, with little plagioclase. Small mottled brown and white patches in pegmatite at the wall rock contact near survey station 49 consist chiefly of brown tourmaline and biotite in feldspar. Bastin (p. 97) reported that these patches also contain green hornblende, quartz, labradorite, titanite, magnetite, and apatite with minute inclusions. The pegmatite inside the border zone consists chiefly of medium-grained plagioclase, coarse cleavelandite, quartz, and muscovite, with minor quantities of white beryl, black tourmaline, and apatite. The easternmost pegmatite body has a central core of quartz and perthite from 10 to 20 feet wide. Some spodumene appears to be in the center of a few pegmatite lenses.

Large quantities of quartz and cleavelandite have been formed by replacement of perthite and other minerals in the eastern pegmatite, and as a result part of the primary zoning has been obliterated. Wedge muscovite, spodumene, pink, blue, and green tourmaline, columbite-tantalite, cassiterite, books of silvery-lepidolite 2 to 3 inches broad, lilac and yellow lepidolite, triphylite, heterosite or purpurite, and eosphorite occur in the cleavelandite-rich parts of the pegmatite. The spodumene occurs in crystals from ½ inch to 5 feet long, the tourmaline in crystals from needle-size to 3 inches in diameter. Long needles of pale green tourmaline are intergrown with many wedge mica books. Columbite-tantalite is most abundant as thin plates in cleavelandite, and cassiterite occurs as small skeletal crystals in the cleavelandite. The large books of silvery lepidolite were found only on the dump from the opencut at the end of the access road. A narrow vein of fine-grained, purple lepidolite cuts the cleavelandite pegmatite in the easternmost pit, and large, irregular veins are present in the spodumene-rich parts of the body west of drill hole 2. Small veinlets occur elsewhere in the pegmatite, and are commonly associated with pink tourmaline. The phosphates are most abundant in the easternmost body. In addition to the above minerals, Verrow (1941, p. 119–121, 143) listed amblygonite, autunite, cyrtolite, damourite, francolite, mangano-columbite, rhodochrosite, siderite, uraninite, uranophane, vivianite, and zircon.

Beryl.—Because beryl was of prime wartime interest, it received special attention. The beryl is associated with cleavelandite, quartz, and yellowish wedge muscovite; the cleavelandite and quartz have partly replaced the beryl, which is commonly surrounded by whorls of muscovite books. Apparently, beryl is concentrated nearer to the walls than to the center of the pegmatite bodies. Crystals range in size from ⅛ to 24 inches in diameter, and some taper sharply from one end to the other. All visible beryl crystals were counted and measured; the total was 1,025 crystals having a total surface area of 111.31 square feet. These were exposed in 13,784 square feet of pegmatite, the beryl content of which is therefore 0.81 percent. An isopach map (fig. 13) was prepared in order to estimate tonnage in the remaining parts of the eastern pegmatite. The western pegmatite, which contains no visible beryl, was not considered in the computations.

Estimated tonnages of beryl and pegmatite are as follows:

Block	Beryl surface (square feet)	Pegmatite surface (square feet)	Beryl (percent)
1	66.27	5,640	1.18
2	28.03	1,600	1.75
3	8.05	832	1.02
4	1.84	860	.22
5	7.12	4,852	.15
Total	111.31	13,784	
Average			.81

Block	Pegmatite (square feet)	Average thickness	Pegmatite (cubic feet)	Pegmatite (tons)	Beryl (tons)
1	10,372	7.2	75,612	6,300	74.3
2	5,812	10.6	61,665	5,140	89.9
3	3,136	10.2	32,175	2,681	27.3
4	5,556	8.9	49,680	4,140	9.1
5	14,052	11.3	158,928	13,244	19.8
Total	38,928		378,060	31,505	220.6

The dump below the easternmost pit probably contains about 12 tons of beryl, but the other dumps probably contain little. Estimated reserves of other minerals include 2,500 to 3,000 tons of scrap mica in place, with an additional 50 tons on the dumps; 20 to 25 tons of lepidolite in place and an additional 18 to 20 tons on the dumps; 1,000 to 1,500 tons of spodumene in place and possibly an equal amount on the dumps; 20 tons of perthite stockpiled and 500 tons in place. A few thousand tons each of cleavelandite and quartz remain in place, and there are similar amounts on the dumps. Reserves of columbite-tantalite and cassiterite are probably not more than 10 and 25 tons, respectively.

BROWN-THURSTON BERYL PROSPECT

The Brown-Thurston prospect is in the town of Rumford on top of a knoll 0.2 mile east of the summit of Black Mountain. It is 5.2 miles N. 64° W. of the Rumford business district. To reach it from Rumford, follow Route 120 northwest 8 miles through Roxbury Notch. After passing through the Notch, follow the road turning south from Route 120 for 1.5 miles to a southeast fork; proceed 0.6 mile along this road to the farmhouse of E. F. Swain, at the northeast end of Swains Notch. A trail leads southward along Swains Brook about 4,000 feet to a saddle on the ridge extending north from the east peak of Black Mountain. From this saddle, follow a true bearing of S. 10° W. about 2,500 feet to the knoll. The prospect is in Lots 83 and 84: Lot 83 is owned by Mrs. Tom Brown, Bethel, and Lee Thurston, Rumford Center; Lot 84 belongs to Arthur Stowell, Dixfield, Maine, and Charles Bartlett, Hanover, Maine. The pegmatites crop out

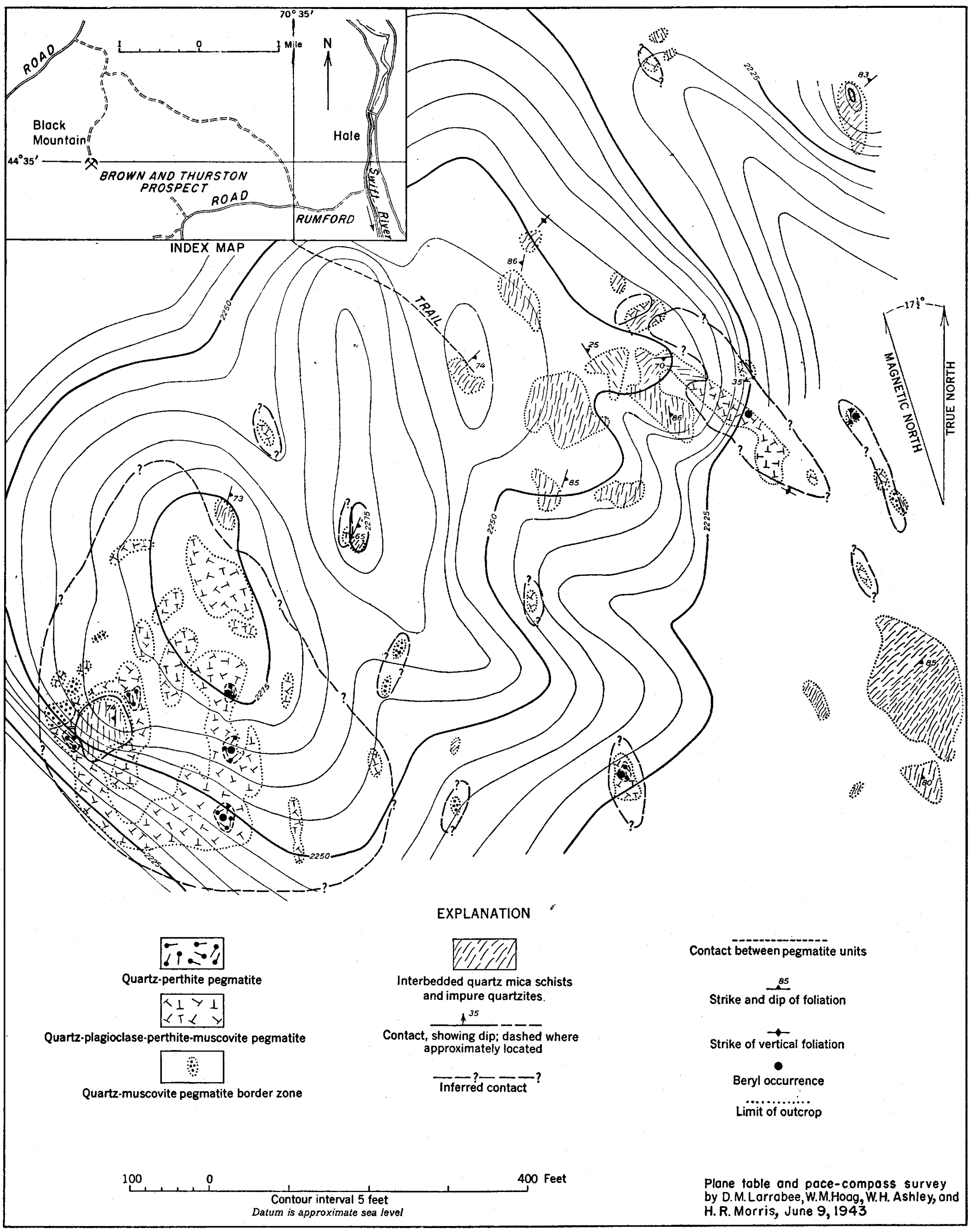


FIGURE 15.—Geologic map of the Brown-Thurston beryl prospect, Rumford, Maine.

along the property line separating these two lots, about 500 feet northeast of the corner post of Lots 66, 67, 83, and 84. The prospect is undeveloped. It was mapped in June 1943 by D. M. Larrabee, W. M. Hoag, W. H. Ashley, and H. R. Morris (fig. 15).

The prospect contains many pegmatite outcrops; these may be parts of two or more sheetlike bodies. The largest pegmatite is probably about 500 feet long and 350 feet wide. The pegmatites were injected into interbedded quartz-mica schist and impure, micaceous quartzite. Variations in the trend of the wall-rock foliation are found from place to place, but the strike in general ranges from N. 15° E. to N. 40° E., and the dip from 74° W. to 85° E.

In some places, the pegmatites are aplitic at the contacts, where they contain small red garnets and black tourmaline crystals, but in others the border zone contains graphic intergrowths of quartz and small mica books. Isolated patches of the border zone material and flat inclusions of wall rock on the surface of the outcrops suggest that the exposures are near the tops of the pegmatite bodies. The inner parts of the bodies consist of fine- to medium-grained quartz, plagioclase, perthite, and small books of wedge muscovite. Cleavelandite occurs adjacent to and near small perthite lenses; small irregular masses of heterosite or purpurite in places are associated with cleavelandite. Small golden, green, and white beryl crystals also occur in the cleavelandite rich parts, although the green beryl is more common in quartz-perthite lenses.

The golden beryl is commonly in crystals ⅛ inch across, oriented with the long axis normal to the surface of the outcrops; some crystals reach diameters of ¼ inch. The white and green beryl occur in slightly larger crystals, as much as 4 inches long and 1.5 inches across. Some larger crystals have been removed by collectors. Six beryl-bearing lenses were examined, but the small golden and white beryl crystals are inconspicuous and may occur elsewhere in the pegmatites. Eighty-five crystals having a total surface of 21 square inches were observed in 59 square feet of lenses, indicating a beryl content of 0.2 percent. The average beryl content for all exposed pegmatites is about 0.004 percent. The difficulties of mining, transportation, and milling, together with the small quantity of visible and indicated beryl, were not conducive to operation under 1942–44 conditions.

BUMPUS FELDSPAR QUARRY

The Bumpus quarry, 6.4 miles S. 6° E. of Bethel, is in the town of Albany, 1.2 miles S. 31° W. of the village of Town House. To reach the quarry from Bethel, drive 0.25 mile west from the Bethel Inn to the Pine Hill crossroad, turn south on the Songo Pond road, and proceed 6 miles to the Town House crossroad. Turn southwest and drive 1.2 miles to the Bumpus residence east of the road. The quarry is 0.1 mile southeast of the house. Harry E. Bumpus, Auburn, owns the mineral rights, but property rights are said to be owned by the United Feldspar & Minerals Co., West Paris. The quarry, flooded at the time, was mapped in May 1942 by L. R. Page and J. B. Hanley, and the area surrounding the quarry was mapped in August 1942 by D. M. Larrabee and Irving S. Fisher. In May 1945, after it was drained, the quarry was remapped by Larrabee and Karl S. Adams (pl. 5).

The quarry is reported to have been opened for feldspar in 1930 by Bumpus, who worked the open pit intermittently until 1940. In that year operations ceased because of legal difficulties. In April 1945, the Douglass Mining Co., Portland, made an operating agreement with Bumpus, and contracted with the C. C. Smith Co., Cambridge, Mass., to pump and clean the pit, and to remove the beryl, scrap mica, and feldspar. The work began late in April. The open pit is 270 feet long, 40 to 60 feet wide, and 20 to 60 feet deep. An estimated 39,000 tons of rock has been removed from it.

The pegmatite is a tabular body that strikes N. 60° E., dips about 50° SE, and appears to plunge gently southwest. It extends beneath the swamp northeast of the cut. A small prospect trench extending south from the main pit is in overburden, and no rock was visible in the prospect trench south of the center of the open pit. The wall rock is fine-grained, gneissic biotite granite with inclusions of biotite schist. Plagioclase in the granite has a composition of An_{16}. The foliation of the granite in general strikes north and dips 45° W. Small inclusions or irregularities in the footwall of the pegmatite are visible in the northwest face of the pit.

The pegmatite contains four well-defined units. The fine-grained aplitic border zone, ¼ to ½ inch thick, contains plagioclase (An_{10-11}). It grades inward into a wall zone of coarsely crystalline blocky plagioclase (An_3), cleavelandite, quartz, and perthite. The wall zone contains minor amounts of garnet, apatite, black tourmaline, and a little biotite commonly intergrown with nests of small wedge-muscovite books. A few beryl crystals 1 to 10 inches long and ¼ to 2 inches in diameter occur with plagioclase (An_3) in this zone on the northwest face of the cut. Small patches of graphically intergrown quartz and muscovite are present in the plagioclase-rich parts of the zone. Plagioclase in contact with the inclusion or roll in the footwall mentioned above has an anorthite content of 10 percent.

Inside the wall zone are two units—a perthite-quartz body occupying all of the central part of the pegmatite and a body, composed largely of rose quartz, that lies between the perthite-quartz body and the hanging wall part of the wall zone. The perthite crystals are largest in the northeast end and southeast face of the pit, where they attain lengths of 12 to 14 feet. Those in the northwest face are smaller and are associated with more interstitial quartz and some cleavelandite. Some bodies of graphic granite are present in this unit. The quartz body contains green beryl, small quantities of plagioclase, and large whorls of wedge muscovite. Minute crystals of the plagioclase are widely scattered in the quartz. The relationships of these two units enclosed in the wall zone are not known. The perthite-quartz body occupies a central position, but comparison with other pegmatites suggests that the quartz body may be the true core, and that the perthite-quartz body may be an asymmetrically developed intermediate zone. However, no evidence for this has been revealed.

In addition to the isolated crystals of green beryl in the rose quartz bodies, beryl crystals are present at the contact between rose quartz and blocky perthite in the southeast wall of the pit; several crystals occur with large nests of wedge mica in the quartz. Beryl occurs in the rose quartz of some parts of the southeast face in series of three or more over-lapping prisms; the crystals range from 2 to more than 10 feet long and from 6 to 48 inches in diameter. The longest crystal is exposed for 10 feet and ranges from 8 inches to 2 feet in diameter. Thirty-four crystals have a total exposed surface of 80 square feet, or approximately 7 tons per foot of depth. According to Stanley I. Perham, oral communication, May 20, 1945, one crystal 18 feet long and 4 feet in diameter was sent to the American Museum some years ago, and 17 fairly large crystals have been removed since 1930. He also stated that small golden beryl was intergrown with some of the large green beryl crystals.

High-grade feldspar has been produced from the quarry, and some remains in the southeast wall, in the northeast end, and in the floor. Considerable rum-colored scrap and punch mica has been produced, but in general, the muscovite is marred by wedge structure and intense ruling and no sheet of high quality can be recovered from the mica in sight. The ruling is most intense near the southwest end of the pit. Much rose and colorless quartz has been produced, and a considerable quantity remains in the southeast wall. Additional large crystals of beryl probably occur in the quartz mass in the southeast face and in the floor below the face, and others might be found in the rose quartz in the northeast end of the pit.

DONAHUE MICA PROSPECT

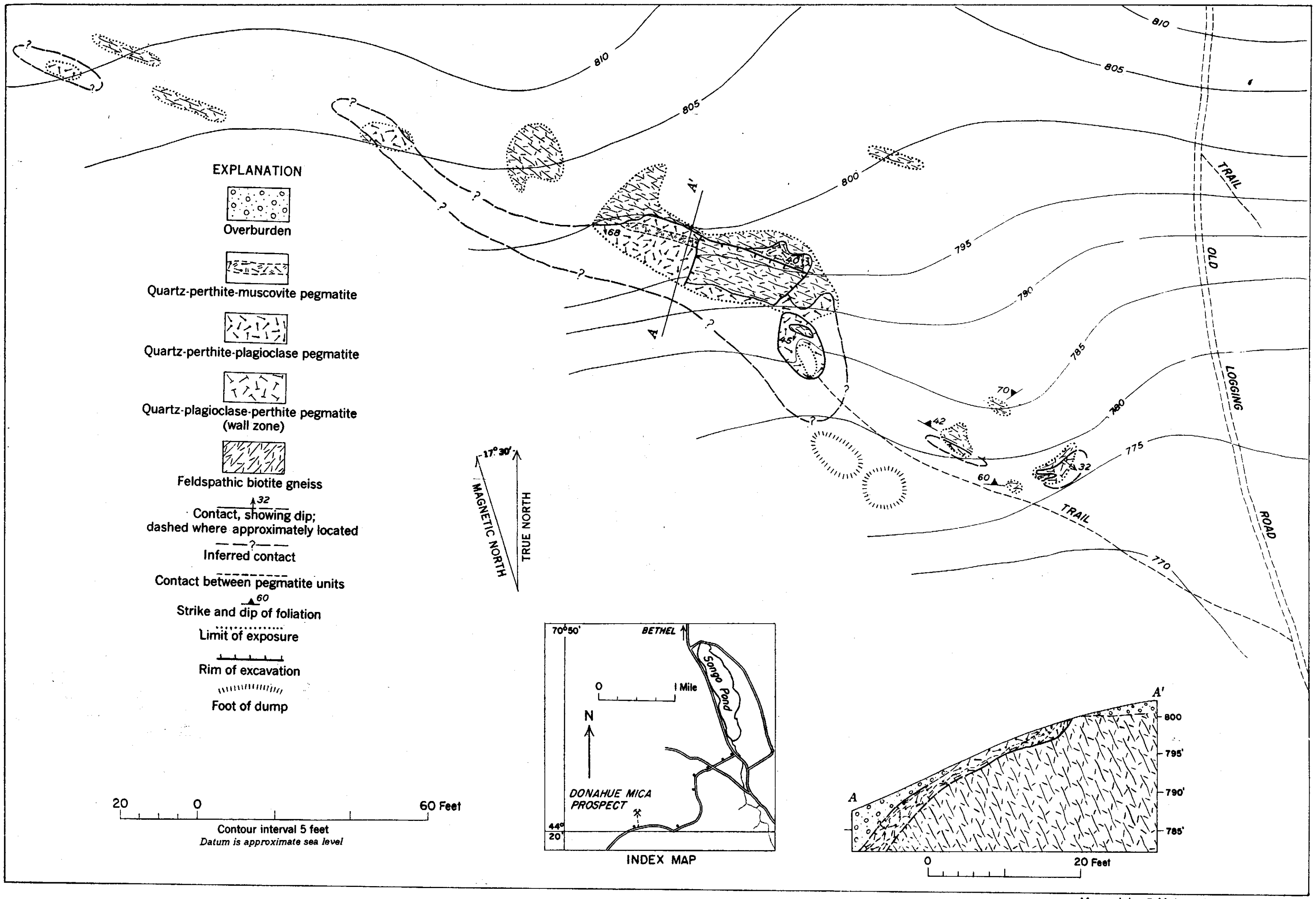
The Donahue prospect is in the town of Albany 5.1 miles S. 13° W. of the south end of Songo Pond. To reach it from Bethel, follow the Songo Pond road west from the Bethel Inn 0.3 mile to the Pine Hill crossroads, turn south and proceed 4 miles to a west fork. Follow this branch 0.35 mile to a crossroad, and continue 1.8 miles to a truck trail leading north. Follow this 0.2 mile to the prospect. This is on land formerly owned by E. O. Donahue, Bethel, and reported to be owned now by Ralph Kimball, Portland. The deposit was opened for feldspar and mica in July 1942 by Arthur Kimball, Bethel, who operated it for a short time. It was leased and operated by the Douglass Mining Co., Portland, Maine, in 1943. The prospect was mapped by the Maine Geological Survey in 1943 (Trefethen, 1945, p. 29–30), and was mapped July 26, 1943 by D. M. Larrabee, L. Goldthwait, and W. M. Hoag. The map was revised in August 1943 upon the completion of prospecting by the Douglass Mining Co. (fig. 16).

The prospect pit is in a southward-dipping pegmatite injected discordantly into feldspathic biotite gneiss. The foliation of the gneiss strikes northeast to southeast, and dips 70° NW. to 42° NE. The main pegmatite, well exposed in the workings, strikes N. 70° W. and dips 20°–68° S. Erosion has removed both the gneiss originally forming the hanging wall and the upper part of the pegmatite, exposing a narrow lens of quartz, perthite, and muscovite lying upon a thin layer of quartz-plagioclase-perthite pegmatite that is separated from the footwall gneiss by a thin layer of aplite. The wall zone of quartz-plagioclase-perthite pegmatite ranges in thickness from 1 to 3 feet, and has an average thickness of about 1.5 feet. It contains scattered books of wedge and "A" mica, black tourmaline, garnet, and a few small green beryl crystals. The narrow, podlike unit 50 feet long and from 6 to 12 inches thick is composed chiefly of quartz, perthite, and wedge and "A" mica. It strikes N. 70° W. across the outcrop at the prospect cut. This unit, near the footwall and generally parallel thereto, pinches out downward against a slight roll in the wall. The center of the pegmatite consists chiefly of quartz and perthite. Small outcrops of pegmatite to the southeast show medium-grained aggregates of quartz, plagioclase, perthite, and small books of muscovite surrounded by a narrow border zone of fine-grained, quartz-rich pegmatite.

Mica from the podlike unit in the main outcrop and from that 60 feet N. 70° W. is ruby and in books having an average diameter of 3 inches. Nearly all is "A" and wedge mica; some is ruled and warped. A very small amount was obtained, but the quality was such that none was rifted, and most was never removed from the muck. Recovery of feldspar has also been unsatisfactory.

GEORGE ELLIOT MICA MINE

The Elliot mine is near the northeast end of Mount Dimmock in the town of Rumford 2.5 miles N. 30° W. of the village of Rumford Point. To reach it from this village, drive 0.6 miles northwest on Route 2 and turn north on Route 5 west of Ellis River. Follow Route 5 north 2.1 miles to the Elliot farm one-half mile beyond Davis Pond. The trail to the mine leaves the highway 0.15 mile south of the farmhouse. Follow this trail three-quarters of a mile up the steep slope to the mine on the ridge. It is on land owned by George Elliot, Rumford Point, and was mapped in August 1943 by D. M. Larrabee, L. Goldthwait, and W. M. Hoag (fig. 17). It was further examined in June 1944 by E. N. Cameron.



Mapped by D.M. Larrabee, L. Goldthwait, and W.M. Hoag, July 25, 1943

FIGURE 16.—Geologic map and section of the Donahue mica prospect, Albany, Maine.

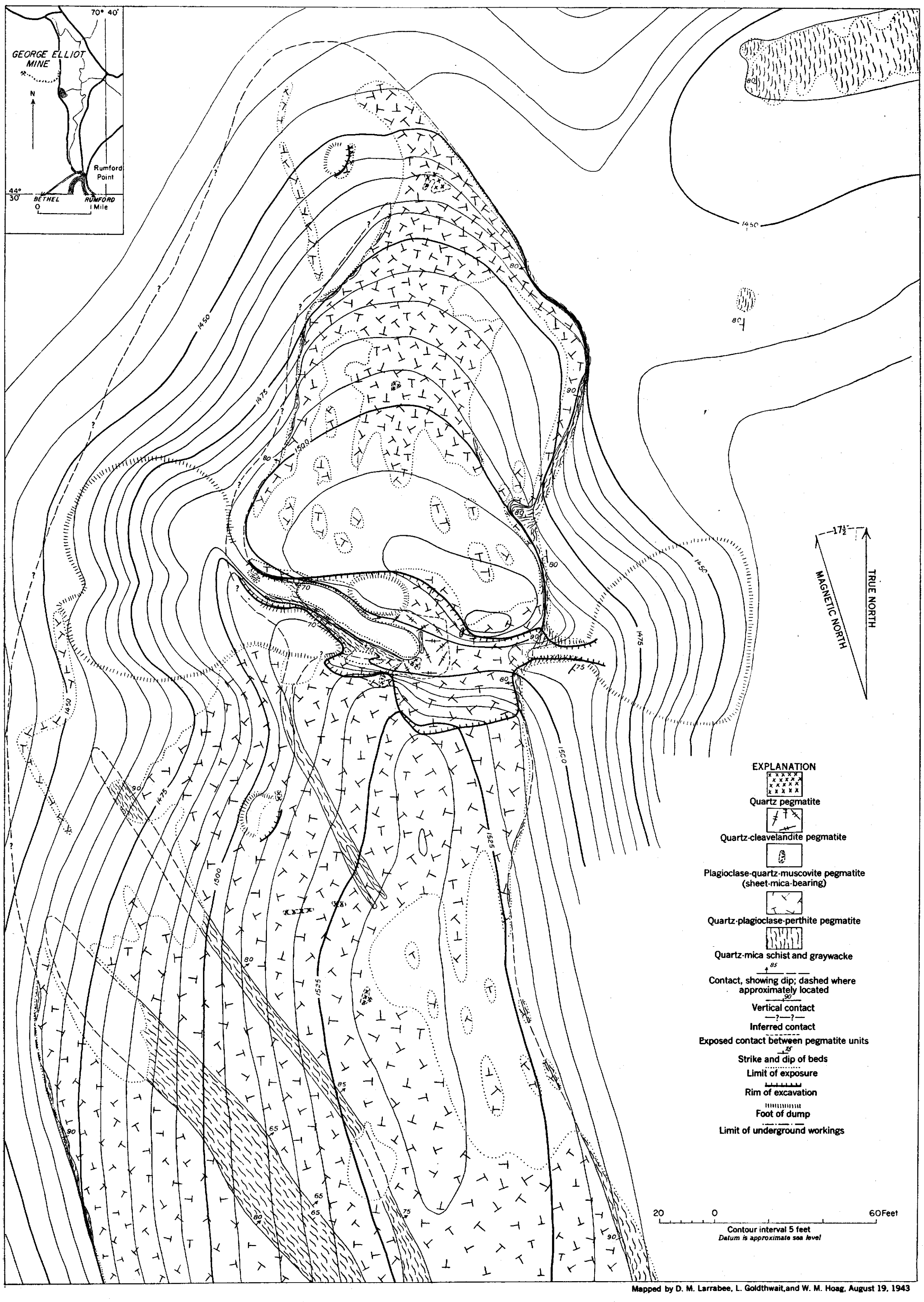


FIGURE 17.—Geologic map of the George Elliot mica mine, Rumford, Maine.

The mine was opened for mica in 1898 by a Mr. Robinson, Hartford, Maine, and is reported to have been worked in 1900 by the Consolidated Mining Co., Rumford. In 1942 it was leased by William Bryant, Rumford Point, and Fred L. Foster, Lynn, Mass., who mined mica until the fall of 1943. An open-cut 20 feet long, 10 to 40 feet wide, and as much as 35 feet deep, and two small prospect pits on the west side of the ridge have been made. About 3,000 tons of rock has been mined.

The mine is in a north-trending nearly vertical pegmatite that is 200 feet wide and extends at least 1,000 feet south of the area mapped. It probably plunges northward under interbedded quartz-mica schist and impure gray quartzite forming the wall rock. The bedding of the wall rock strikes north in general, and dips 82° W. to 75° E. Several large inclusions of schist trend northwest and dip 75° NE. to vertically. Inclusions and walls are strongly garnetized and tourmalinized; the tourmaline crystals are alined roughly parallel to the axes of minor crenulations in the schist. Pyrite is present in the impure quartzite.

The pegmatite is aplitic at its contacts and contains garnet and black tourmaline. Inside this border one is rock composed of medium-grained quartz, plagioclase, perthite, biotite, and muscovite, with subordinate black tourmaline and green apatite. This material incloses small bodies of quartz, perthite, and wedge muscovite. Pegmatite in the opencut consists of medium- to coarse-grained quartz, green, gray, and white plagioclase, perthite, biotite, and muscovite. A large quartz pod which may be the core is reported to have been mined in the floor of the western half of the cut, now muck-covered: only a small part of the pod is exposed. The pegmatite in part of the cut contains abundant cleavelandite and a few soft, altered beryl crystals; this material is shown separately on the map. Muscovite occurs in disseminated books within the coarse-grained pegmatite near the center of the body and in a poorly developed zone (not shown) of quartz, plagioclase, and perthite along the lower side of a large inclusion in the cut. A nearly vertical, tabular deposit of plagioclase, quartz, and muscovite, developed along a fracture, is exposed in the south wall of the cut; this is 5 feet wide at floor level and pinches out upward below the rim of the cut. It does not extend north of the inclusion or south of the small stope. A narrow cross-vein extends a few feet laterally east and west from this tabular unit.

The mica is rum to ruby. Much of it is warped, ruled, clay stained, wedge shaped, and has "A" structure. Books as large as 10 inches in diameter and 3 inches thick have been recovered, but most are much smaller. Apatite, quartz, tourmaline, and garnet are common inclusions, and thin plates of quartz occur along the cleavage planes of some books. Although green mica has been reported from this mine, it was observed in only one book, in which a pale-green band outlined the margins of a ruby crystal. Pegmatite in the cut contained an average of 1 percent mica; that in the richer parts near the inclusion and in the unit along the fracture contained about 5 percent. The yield of trimmed sheet was not sufficient for profitable mining during 1942–44. Reserves of book mica in sight or reasonably inferable are small.

GOGAN MICA PROSPECT

The Gogan prospect is in the town of Mexico, ¼-mile east of Hale village, and 3.0 miles N. 24° W. of the business center of Rumford. To reach the prospect from Mexico, follow Route 17 northwest 2.5 miles to the highway bridge across Swift River. Go downstream by trail 0.1 mile, across the grade of the abandoned branch of the Maine Central Railroad. The prospect is adjacent to the east abutment at the river, and is reported to be on the land of Morris J. Gogan, Rumford.

Mineral rights were leased by the Douglas Mining Co., Portland, in the summer of 1943, and two small openings were made in the largest pegmatite. The prospect was mapped by D. M. Larrabee, L. Goldthwait, and W. M. Hoag in July 1943 (fig. 18).

Several irregular podlike pegmatites crop out along the banks of the river and as islands in it. They were injected discordantly into interbedded quartz-mica schist and impure quartzite that are contorted near the intrusives. The largest pegmatite is about 100 feet long and 25 feet wide. It strikes northwest and dips 45°–50° NE. It has an aplitic border zone that contains black tourmaline and green apatite. Inside the border zone, the pegmatite consists of fine- to medium-grained quartz, plagioclase, perthite, and subordinate muscovite and biotite, enclosing a coarsely crystalline central unit of quartz and perthite with long narrow, laths of intergrown muscovite and biotite. The smaller pegmatites are medium-grained and contain discontinuous quartz pods bordered by books of wedge mica.

The ruby mica occurs as narrow books, most of which are 2 to 4 inches long and ⅛- to ¼-inch thick. A few are 18 inches long and ¾-inch thick. Many are intergrown with biotite. All are soft, warped, and ruled, and many have "A" structure. Prospecting in 1943 did not yield enough good mica to encourage further work. Rifting tests were not made on the mica recovered, but it seemed clear that the prospect could not be operated successfully. The pegmatite extends only 5 feet above lowest river level, so that the recovery of even small amounts of feldspar and quartz was impossible.

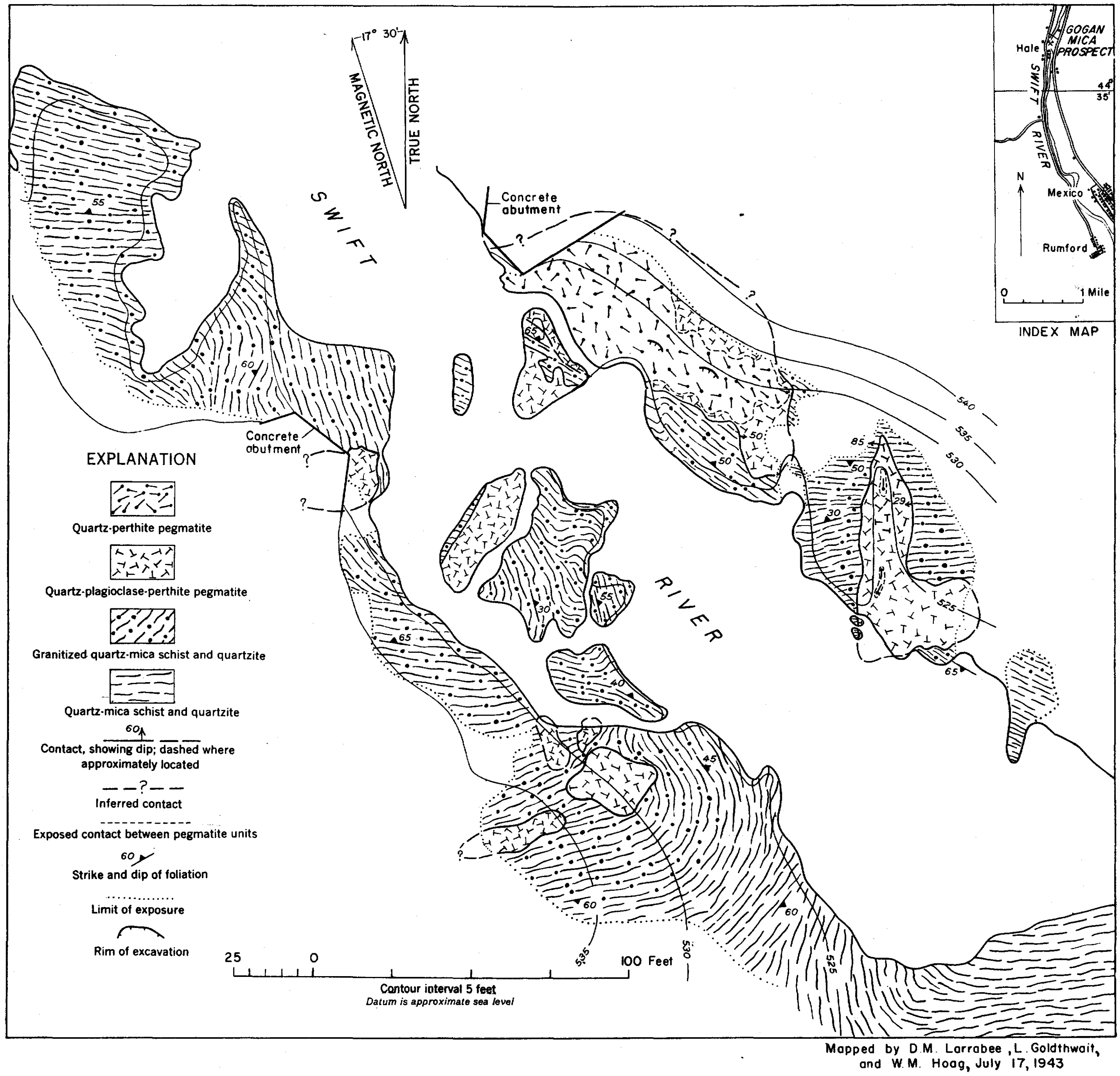


FIGURE 18.—Geologic map of the Gogan mica prospect, Mexico, Maine.

HARVARD QUARRY

The Harvard (Noyes Mountain) quarry, on the steep west slope of Noyes Mountain, is in the town of Greenwood, 0.4 mile east of Mud Pond and 2.1 miles N. 22° W. of the village of Nobles Corner, Maine. To reach the quarry from Nobles Corner, drive 2 miles northwest to a crossroad, turn east, and drive 0.15 mile to a sharp bend in the road; follow an old logging trail north 0.5 mile to the quarry. The land is owned by Lyndon Philbrook, Greenwood, Maine, and the mineral rights are held jointly by William Bryant, Rumford Point, Maine, and Fred L. Foster, Lynn Mass. The pegmatite was studied in 1923–24 by K. K. Landes (1925, pp. 335–411) and Charles Palache, and was examined in July 1943 by the Maine Geological Survey (Trefethen, 1945, p. 45). It was mapped in August 1943 by D. M. Larrabee, L. Goldthwait, and W. M. Hoag. The map was revised in May 1945 by Larrabee and K. S. Adams (fig. 19) to include development during the war period.

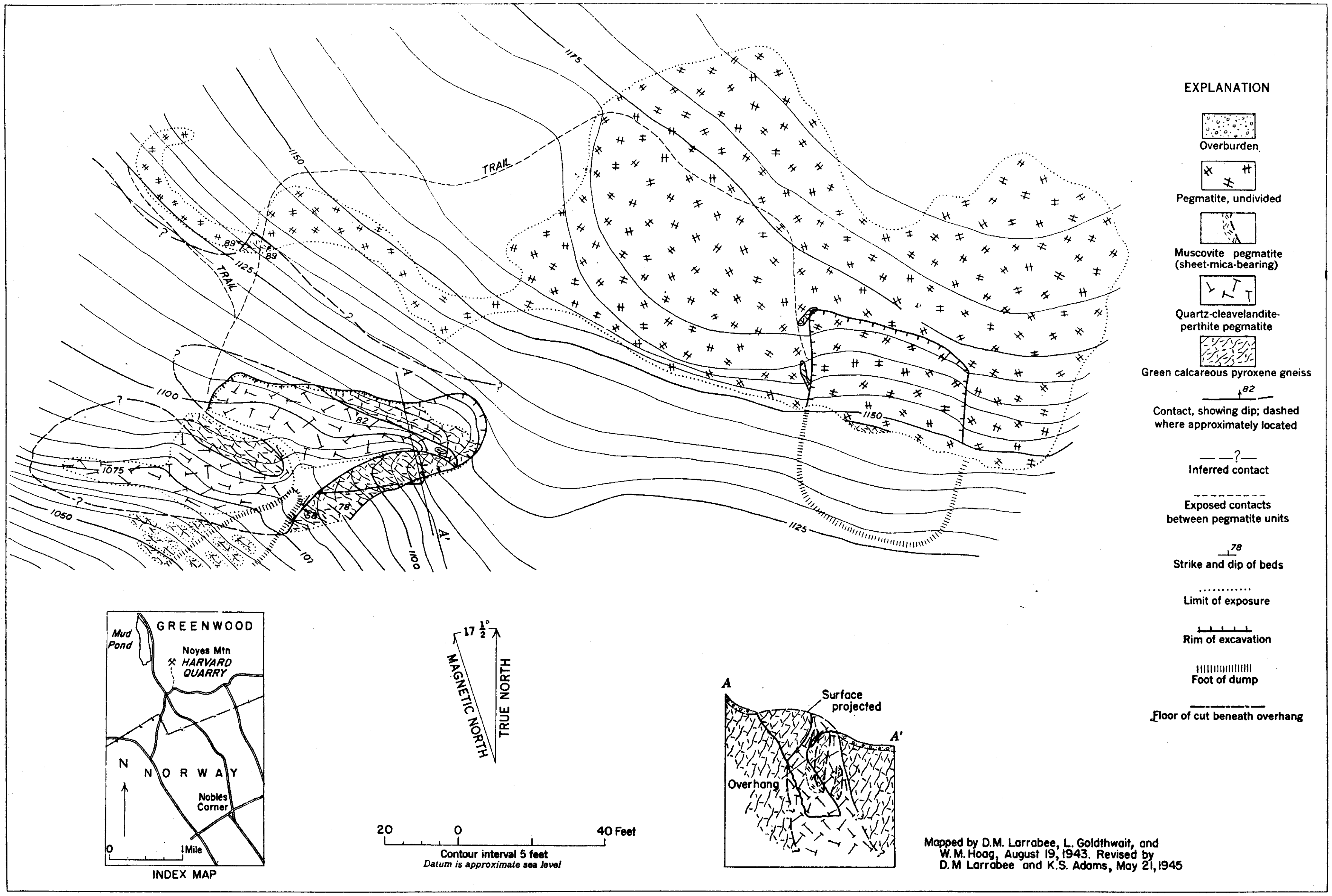


FIGURE 19.—Geologic map and section of the Harvard quarry, Greenwood, Maine.

According to Arthur Valley of Paris Hill, the quarry was opened for quartz crystals in the late 1800's by Isaac P. Noyes, Norway, and was operated by George Noyes and Tim Heath in the early 1900's. In 1917 the mineral rights were obtained by the Harvard Museum, and in 1923-24 quarrying was done for the Harvard Mineralogical Department by Loren B. Merrill, Paris, and Arthur Valley. In 1926 the mineral rights were sold to L. B. Merrill, who later disposed of them to Arthur Merrill and Abbey Valley. The rights passed in turn to Arthur Valley, who in 1943 sold them to Bryant and Foster. These men operated the quarry for mica during the fall and winter of 1943. The main working is an opencut that trends N. 80° E. It is 75 feet long, 20 to 30 feet wide at the top, and has a maximum depth of 45 feet.

Apparently, two pegmatites occur in the quarry area. They are in biotite schist and greenish gneiss, composed of alternate bands of calcareous and siliceous material and containing much pyroxene. Vesuvianite is abundant in some places near the southeast contact. The gneiss strikes northwest and dips 78° NE. In the quarry, the southeast contact between one of the pegmatites and wall rock strikes N. 80° E. and dips 58° S., the dip steepening upward to the surface; the north contact, below the upper rim of the cut, strikes N. 65° W. and dips 82° SW. This pegmatite probably pinches eastward and fingers upward above the end of the pit. The exposures of pegmatite on the slope north and northeast of the quarry are probably part of a large sheetlike mass. A shallow opencut 40 feet long was made in the southern edge of the upper outcrops shortly after 1900 and was enlarged slightly in 1943.

The pegmatite quarried is poorly zoned but contains a border zone that is one-half inch thick and consists of fine-grained quartz, plagioclase, and muscovite, interbanded with layers of garnet, black tourmaline, and apatite. The inner part of the pegmatite consists chiefly of coarsely crystalline quartz and cleavelandite, with minor quantities of perthite. Near the footwall contact, the texture is less coarse and more closely knit than near the hanging wall, where cavities occur between cleavelandite blades. Pegmatite near the footwall contact contains much garnet, green apatite, and black tourmaline. The hanging wall part is marked by the presence of slender green tourmaline crystals, books of white lepidolite 3 to 6 inches broad, and rum to ruby muscovite constituting 6 percent of the pegmatite in a layer 2 feet thick along part of the hanging wall. The muscovite was removed during 1943. Muscovite also occurs beneath an inclusion in the east end of the pit, where the pegmatite fingers out upward. Large cavities that yielded many fine mineral specimens were found in the center of the pegmatite during early operations, and in 1945 parts of several small cavities were visible in both sides of the cut. These contained heulandite (Landes, p. 406) in places incrusted by quartz, and pink cookeite, purple apatite, small, friable, green tourmaline crystals with quartz centers, and purple lepidolite. Specimens of pink beryl, green beryl, white and pale-lilac spodumene, and apatite intergrown with black tourmaline occur in small cavities in specimens found on the dump. Graphic intergrowths of quartz and muscovite, and of quartz and black tourmaline were also found on the dump.

The mineralogy and paragenesis of this pegmatite have been discussed by Landes, who recognized two phases of hydrothermal activity following a first stage of magmatic crystallization. He grouped the minerals of the pegmatite as follows: (1) Primary, or magmatic—white and pink microcline, quartz, muscovite, green beryl, black tourmaline, dark-green manganapatite, red garnet, and arsenopyrite; (2) first hydrothermal stage—quartz, cleavelandite, lilac-colored lepidolite, green tourmaline, spodumene, amblygonite, cassiterite, pale-green to colorless beryl, green gahnite or zinc spinel, columbite, herderite, bertrandite, and hamlinite; (3) second hydrothermal phase—quartz, cookeite, and purple apatite. Supergene mineralization produced kaolin from feldspar and amblygonite, and montmorillonite from the feldspars.

The upper pegmatite, mapped as pegmatite-undivided, is similar in general to that in the Harvard quarry, but contains less cleavelandite and more perthite. Some books of rum to ruby mica were recovered from the margins of quartz-perthite lenses in the shallow opencut. The texture of the main pegmatite mass is medium- to coarse-grained, and the body contains irregular patches of graphic granite.

Much of the muscovite from both pegmatites has "A" structure, inclusions of garnet, apatite, tourmaline, and quartz, which, when removed, leaves pin-holes. Other defects are warping and ruling. Some good small sheet mica was recovered, but the mica mined in 1943 did not yield sufficient sheet to encourage operation in 1944.

HIBBS FELDSPAR QUARRY

The Hibbs quarry is in the town of Hebron, 1.25 miles N. 17° E. of Hebron village. To reach it from this village, drive north 0.8 mile to a fork and follow the northeast branch 0.5 mile. The quarry is a short distance northwest of the road. The property, formerly owned by Alton Hibbs, Bath, Maine, is said to have been purchased in 1943 by persons from Philadelphia, Pa. Bastin (1911, p. 72) visited the quarry in 1906, and the Maine Geological Survey mapped it in 1943 (Trefethen, 1945, p. 47). The quarry was mapped

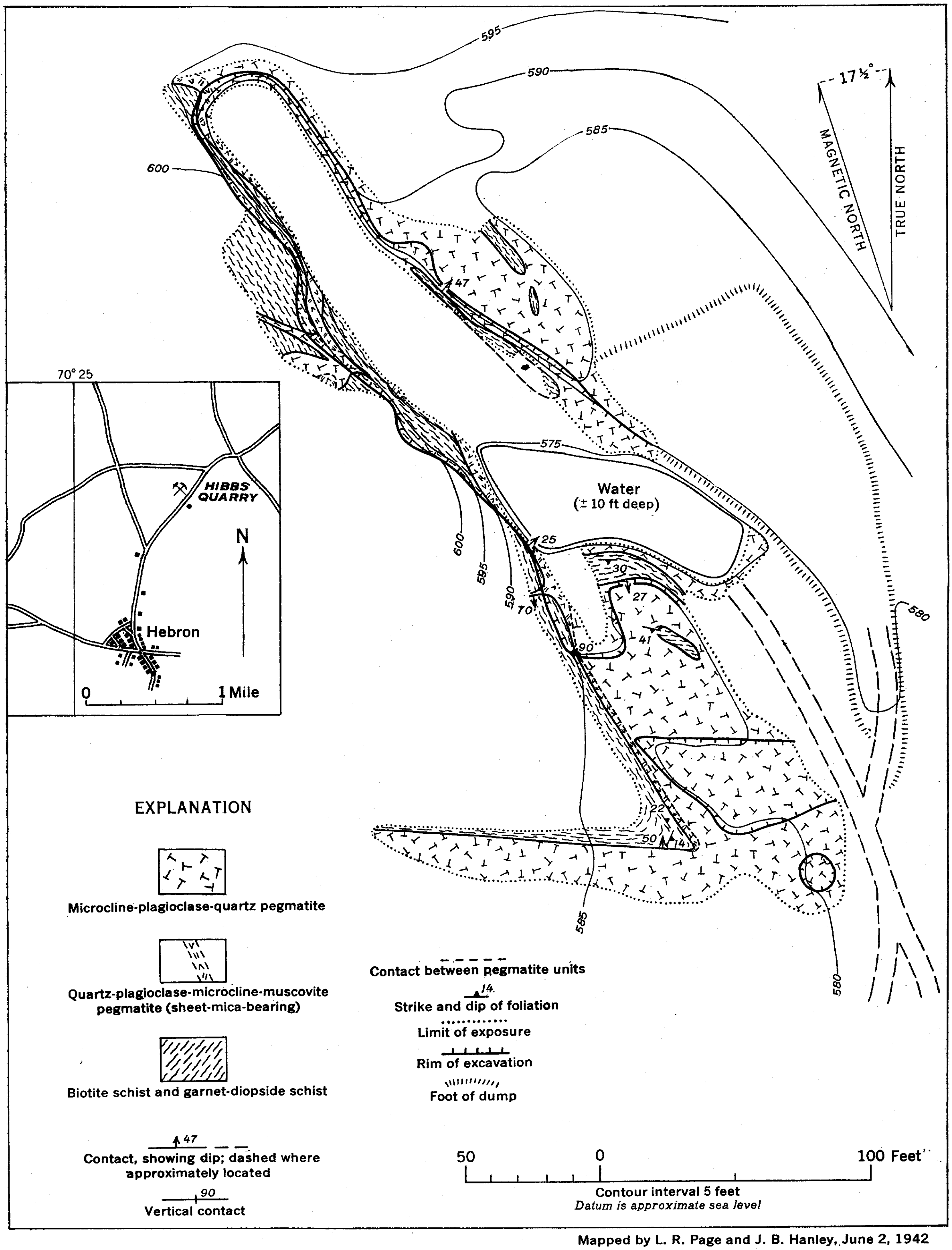


FIGURE 20.—Geologic map of the Hibbs feldspar quarry, Hebron, Maine.

for the Geological Survey in June 1942 by L. R. Page and J. B. Hanley (fig. 20), and was examined briefly in April 1944 by E. N. Cameron.

The quarry is a northwest-trending opencut about 325 feet long, 30 to 75 feet wide, and 15 to 25 feet deep; the central part is flooded. Bastin (1911, p. 72) stated that J. A. Gerry, Mechanic Falls, and W. Scott Robinson operated the quarry during 1906–07. Harold Perham is reported (Stanley Perham, West Paris, oral communication, June 1942) to have operated the deposit about 1930 for feldspar, and he also recovered some mica and beryl.

The pegmatite is exposed for about 375 feet northwest along its strike and in places dips 30°–40° NE. It is in coarse-grained biotite schist and garnet-diopside schist; the wall rocks generally strike northwest, dip 30°–40° NE., and are locally transected by the pegmatite.

The pegmatite has an aplitic border zone. Inside this is a fine- to coarse-grained wall zone of quartz, plagioclase, perthite, large black tourmaline crystals, garnet, biotite laths, and muscovite. This zone is 2–5 feet thick, and is exposed for 250 feet along the southwest side of the quarry. The apparent core is composed chiefly of coarse-grained plagioclase, perthite, and quartz and contains small bodies of graphic granite and scattered muscovite books. Radial intergrowths of quartz and muscovite occur near the graphic granite. The core contains less tourmaline and biotite than the wall zone. Apparently, the largest perthite crystals were recovered from the flooded part of the quarry, although blocks 2 by 3 feet are present in the north end of the pit (Trefethen, 1945, p. 47). A few cassiterite and columbite grains were found in the broken rock in the bottom of the quarry, and beryl fragments were seen on the dumps.

Most of the rum-colored mica is ruled, crumpled, and damaged by wedge and "A" structure. A few books are 5 inches by 8 inches, but most of those seen are smaller. No mining was done at this deposit in 1942–44, but the wall zone may contain sufficient sheet mica to justify mining under economic conditions comparable to those of the war period. The deposit is one of the few promising mica prospects in Maine. Some high-grade feldspar can be recovered from this quarry. Beryl seems to be rare.

GUY JOHNSON MICA MINE

The Guy Johnson mine lies in the town of Albany 1.2 miles S. 52° E. of the village of Hunts Corner. To reach it from Hunts Corner, travel 1.6 miles southeastward in Sweet Brook valley to a fork. Follow the easterly fork 0.25 mile to the farmhouse of Hugh Stearn. A poorly graded dirt road leads from the house 0.5 mile to the mine.

Owners of the property are the heirs of Guy Johnson, formerly of Snowville, N. H. Johnson began operations by working the pegmatite for feldspar about 1938. The property was later leased to the Douglass Mining Co., Portland, which is said to have operated it for several months in 1943. L. A. Anderson of East Stoneham worked the mine intermittently in 1944. Workings in October 1944 consisted of an opencut 55 feet long, 25 feet wide, and 18 feet deep. The mine was mapped in July 1943 by D. M. Larrabee, L. Goldthwait, and W. M. Hoag. Further mapping was done by V. E. Shainin and K. S. Adams in June 1944 (fig. 21), and the mine was visited by Shainin and A. H. McNair in October 1944.

The form and attitude of the pegmatite are unknown. Its outcrop is 170 feet long and 100 feet wide. In the southern part of the workings the body dips discordantly beneath country rock. The contact here strikes east-west and dips 45° S. The country rock is a medium-grained feldspathic biotite gneiss locally impregnated by pegmatite.

A fault that strikes N. 77° W. and dips 20°–25° SW. cuts pegmatite in the walls of the cut. Its displacement could not be determined, but from the operator's description it appeared to be a normal fault with a displacement of about 5 feet. The fault coincides with the contact locally in the southern face of the cut. The shear zone along the fault varies from ¼ inch to 8 inches thick and contains both gouge and clay, the latter introduced from the surface. The gouge is composed of crushed pegmatite.

Four units can be recognized in the pegmatite. The border zone, 1 to 3 inches thick, consists of muscovite, quartz, and plagioclase, plus garnet and black tourmaline. The plagioclase-quartz unit, the form of which is unknown, is exposed in the northern face of the cut. It consists predominantly of plagioclase, with much quartz, subordinate perthite and muscovite, and accessory biotite, beryl, black tourmaline, garnet, apatite, autunite, and torbernite. Weathered pegmatite in outcrops north of the quarry appears to belong to this unit. The unit passes southward into quartz-perthite pegmatite beneath backfill in the floor of the cut.

A quartz-perthite unit in the southern portion of the cut is so poorly exposed that its form cannot be determined. The unit consists of coarse-grained quartz and perthite, and accessory muscovite, plagioclase, beryl, and black tourmaline.

The fourth unit is a tabular body of muscovite and quartz, probably deposited along a fracture. It is about

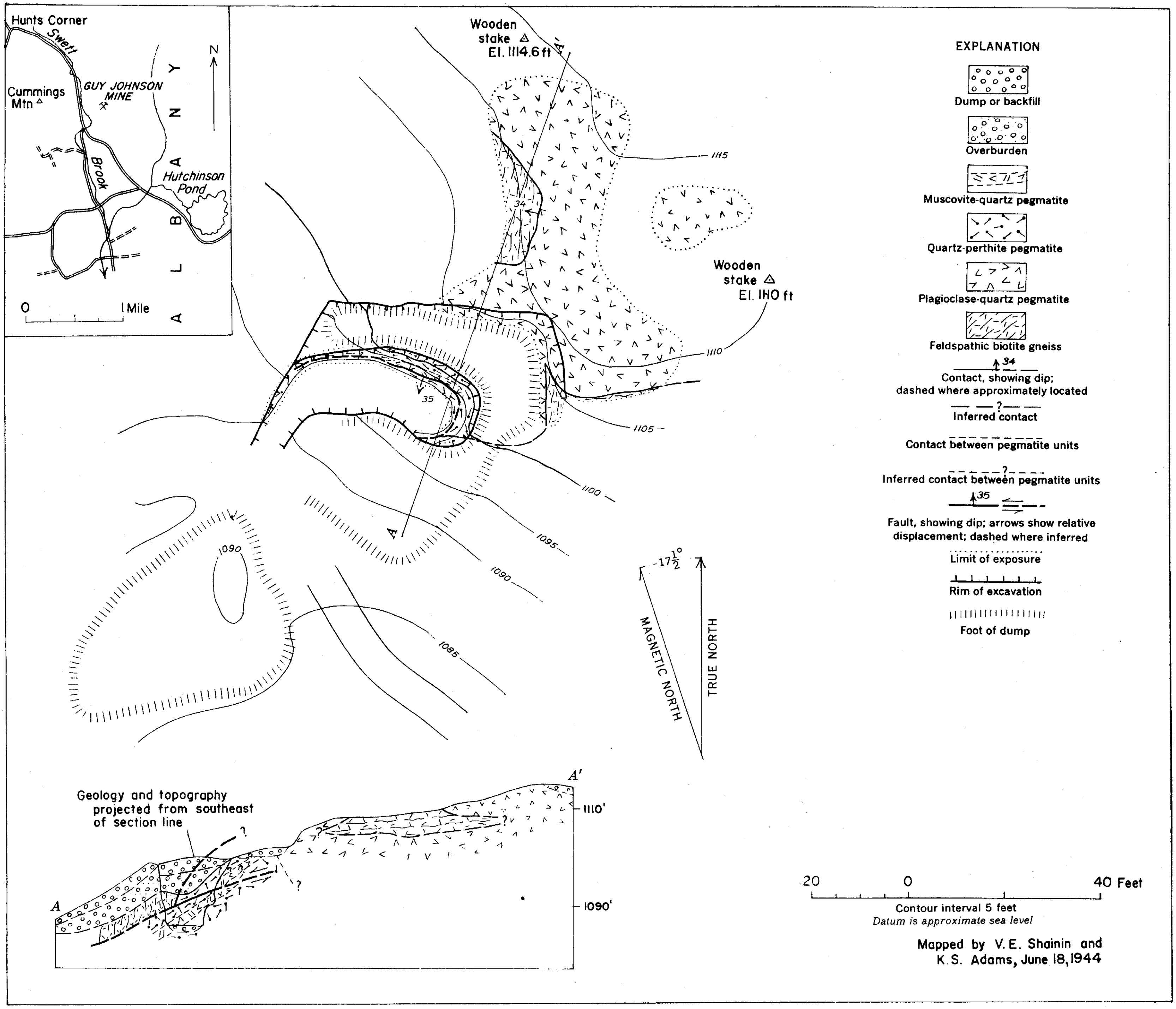


FIGURE 21.—Geologic map and section of the Guy Johnson mica mine, Albany, Maine.

2 feet thick, strikes N. 70° W. and dips 30° to 35° SW. The deposit lies in the quartz-perthite unit and consists of muscovite and quartz, with subordinate plagioclase and accessory black tourmaline. The mica books average 3 inches in diameter, but some are 10 inches broad. In 1943, before the last quarrying operation had begun, the trace of this body was mapped on the outcrop surface. At the time of resurveying, much of it had been mined out and it was visible only in the lower part of the southernmost workings. Although the junction of the fault with the tabular deposit is nowhere exposed, the operator reports that the body was noticeably offset where it was intersected by the more gently dipping fault (fig. 21, sec. A–A′).

Rum-colored muscovite, in books about 3 inches across, is also disseminated throughout the plagioclase-quartz unit. Most of the books are wedge-shaped, warped, and ruled, and many exhibit "A" structure. The content of sheet in mine-run mica appears to be low.

Beryl occurs in scattered green crystals associated chiefly with quartz in the plagioclase-quartz unit. The crystals average 1 to 2 inches long, but some exceed 1 foot in length and 9 inches in diameter. It is estimated that the visible pegmatite contains less than 0.3 percent beryl.

There is no indication that recovery of sheet mica from mine-run mica would improve with further mining. The tabular deposit of mica probably intersects the more steeply dipping wall-rock contact not far below the floor of the present working, and probably terminates there.

LITTLE SINGEPOLE FELDSPAR QUARRIES

These quarries, on top of the eastern peak of Little Singepole Mountain, are in the town of Paris 1.8 miles N. 21° E. of the village of Hebron. To reach them from Hebron, drive north 0.8 mile to a fork; follow the left branch 1.85 miles to a left fork, passing a crossroad at 0.6 mile. Follow this fork 0.6 mile southwest to a road turning east 0.1 mile to a house. An old trail leads southeast about 0.5 mile to the quarries. These were mapped and studied briefly in May 1942 by L. R. Page and J. B. Hanley (fig. 22).

Some small open pits are indicated on the map as three groups referred to points A, B, and C. All the pits are in a large possibly sheetlike pegmatite about 0.25 mile wide and 0.5 mile long, which is enclosed in the mica schist. The pegmatite is characterized by graphic texture. It contains small patches of quartz and muscovite 6 to 8 inches broad, graphic intergrowths of quartz and tourmaline, biotite-rich parts, and coarse-textured lenses of quartz and perthite, but the relationships of these units have not been fully determined. A vertical basic dike cuts the pegmatite.

The pegmatite exposed in the six workings in the vicinity of point A is chiefly a graphic intergrowth of quartz and perthite containing a northwest-trending lens of coarse quartz, perthite, albite, muscovite, and beryl. Green and yellowish-white beryl crystals occur in a band along the southwest side of the pits. These crystals average ½-inch in diameter, but are as much as 1.5 inches across and 6 inches long. The beryl is associated with albite and blocky perthite, some of which is fetid when freshly broken. Biotite and tourmaline are sparingly distributed in the beryl-bearing unit. To the northeast, patches of graphic intergrowths of quartz and tourmaline (not shown on fig. 22) occur in the pegmatite. Graphic pegmatite crops out 220 feet east of the pits, and good outcrops extend 100 feet to the west, and to the southeast as far as the two prospect pits mapped.

The three pits northwest of point B are in graphic granite pegmatite. A northwest-trending band, 6 to 12 inches thick and containing 50 percent black tourmaline, is bordered by rock that contains biotite and scrap muscovite and grades outward into the graphic granite. Biotite seems to be most abundant in the upper 5 to 10 feet of the outcrops and occurs at, and parallel to, the contact with schist in the surrounding area.

The two pits north of point C, also in graphic granite, are separated by a vertical, 4-foot basic dike that strikes N. 65° W. The southern pit bottomed in graphic-textured quartz and perthite is separated from biotite-rich graphic granite by a 6- to 12-inch band of tourmaline and apatite.

The pits southwest of point C are in coarsely crystalline graphic-textured perthite and quartz that contain thin sheets and radial aggregates of muscovite. Several tabular crystals of columbite, ¾ inch long and ⅛ inch thick, are enclosed in garnet.

These quarries were not operated for sheet mica or beryl during 1942–44. Although beryl occurs, chiefly in the workings at point A, its recovery would involve the mining and milling of considerable rock, for the crystals are not large enough to be hand cobbed. Very little sheet mica was seen. Only a small quantity of block feldspar is present, but the reserves of graphic granite are considerable.

LOBIKIS MICA MINE

The Lobikis mine lies in the town of Peru 2.7 miles S. 34° W. of the village of West Peru. It may be approached from West Peru by traveling 2.7 miles southwestward on a paved road to the schoolhouse at Dickvale hamlet. From this point a road leads 1 mile northwestward to the mine.

The property is owned by John Lobikis of West

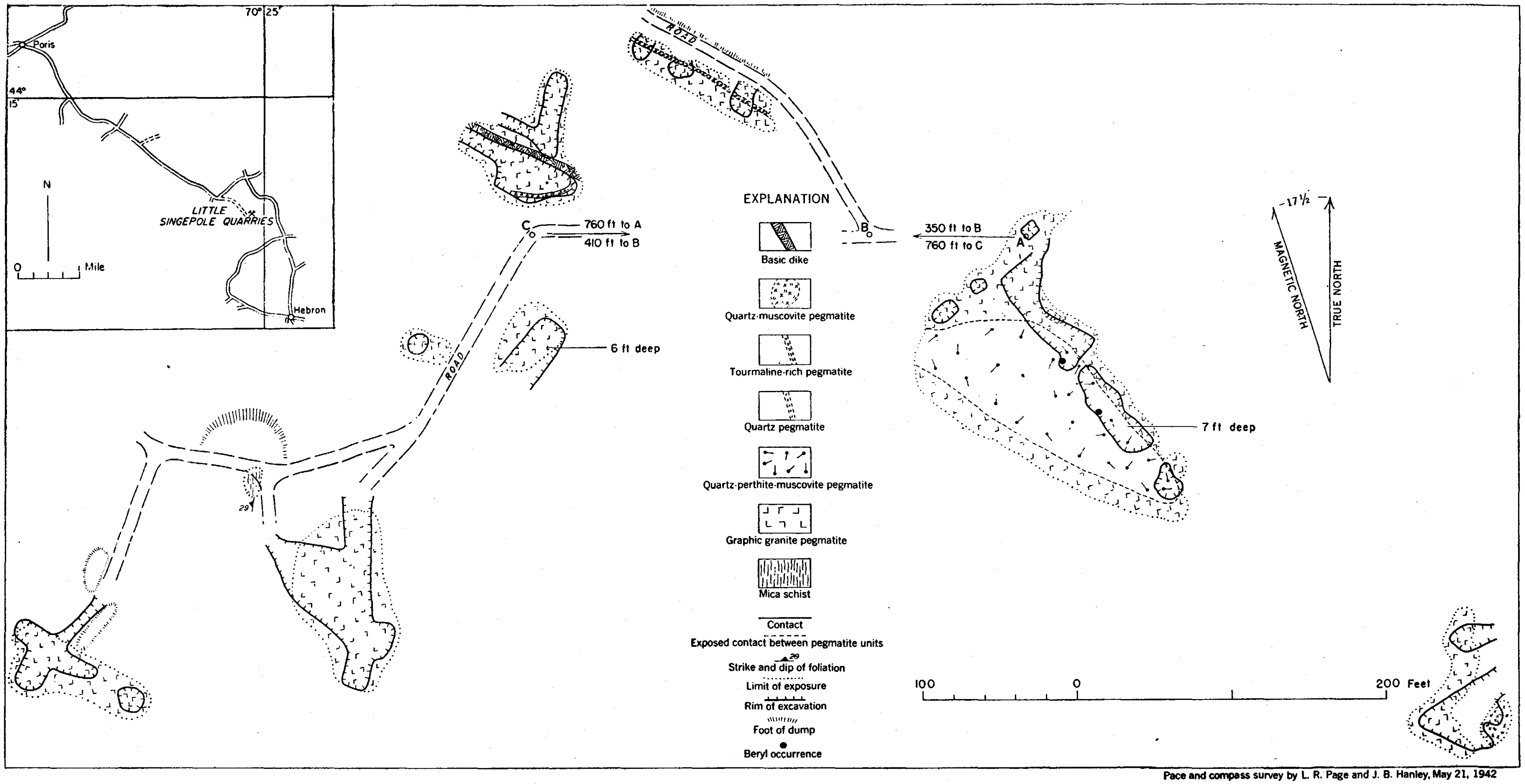


FIGURE 22.—Geologic map of the Little Singepole feldspar quarries, Paris, Maine.

Peru. The Douglass Mining Co. of Portland, Maine, began operations in May 1943, and worked the mine intermittently until July 1944.

The mine is an open pit 60 feet long, 40 feet wide and averages 10 feet in depth. Three prospect faces have been blasted in the flanks of a dome-shaped knoll north of the pit. The largest face is 40 feet long and 6 feet high. The rock mined prior to January 1944 yielded about 1 percent mine-run mica.

D. M. Larrabee, L. Goldthwait, and W. M. Hoag mapped the mine in August 1943. Opencut operations necessitated a resurvey in June 1944 by V. E. Shainin and K. S. Adams (fig. 23). The mine was also examined by Shainin and A. H. McNair in October 1944.

The pegmatite is intruded discordantly into medium-grained biotite gneiss. The exposed portion of the pegmatite appears to be dome-shaped, but outcrops are insufficient to show the true form and attitude of the pegmatite. The body has a maximum outcrop length of 130 feet. A capping of gneiss, extremely varied in thickness, is preserved in places on the knoll north of the pit. North of the quarry the contact between gneiss and pegmatite dips 45° to 50° N. South of the cut the contact dips southward, probably at a more gentle angle. Gneiss overlain by pegmatite is exposed on the western flank of the knoll. The gneiss there may be either an inclusion within pegmatite or part of its footwall. Several small xenoliths of gneiss occur in the pegmatite.

Exposures of the pegmatite show two zones. The fine-grained border zone, 2 inches to 3 feet thick, is a discontinuous layer adjacent to the gneiss contact. It consists of quartz and muscovite with subordinate amounts of perthite, apatite, and garnet. The apparent core consists of quartz, perthite, and plagioclase. Accessory minerals are muscovite, biotite, apatite, beryl, garnet, tourmaline, triphylite, vivianite, and pyrrhotite. Graphic granite is common and large perthite crystals occur in places. Quartz occurs in abundant irregular pods 2 inches to 2 feet in diameter or as larger masses. One quartz body, 6 by 6 by 20 feet, had been mined out when the mine was remapped.

The operators report that large books of mica occurred within the larger quartz body as well as along its margins but that most of the sheet mica recovered came from books along the margins of the smaller pods. Not all of the mica books are associated with pods. Book mica, associated chiefly with plagioclase, also occurs disseminated throughout the pegmatite.

Biotite (in long, narrow blades) and apatite are associated with the quartz pods in many places. Many of the large muscovite books are intergrown with biotite, although most of the biotite occurs separately. Beryl is found in or near quartz pods and occurs in crystals 1 to 10 inches long. It is roughly estimated that the pegmatite contains less than 0.1 percent beryl.

Triphylite, vivianite, pyrrhotite, and garnet are intimately associated with the quartz pods. Scattered, irregular bodies of garnet-rich aplite are found within 5 feet of the contact with gneiss.

The pegmatite contains both pod deposits and disseminated mica. At the time of remapping, the only large muscovite books adjacent to the wall were those associated with the quartz pods mentioned above. These books did not appear to be part of a wall zone. The sheet mica recovered was rum to ruby, fairly hard, and flat. "A" structure was common. Ruling was uncommon and cross fracturing rare. Very few wedge-shaped books were seen.

Future mining operations for mica would probably involve the removal of large quantities of waste rock because of the extremely irregular capping of gneiss and the widely dispersed occurrence of mica. Probably recovery of about 1 percent crude mica from the pegmatite mined could be anticipated.

NEWRY MINES

The Newry (Dunton) mines, including the old gem mine on top of the hill and the United Feldspar & Minerals Co. mine nearby, are in the town of Newry, 3.9 miles N. 40° W. of the village of Rumford Point, Maine. To reach the mines from Rumford Point, drive 0.6 mile northwest on Route 2, crossing the Ellis River, and turn north on Route 5. Drive 4.1 miles north to a quarry road that turns off to the southwest. Walk along this road 1 mile up the steep slope to the old gem mine, passing the feldspar mine at about 0.9 mile. The gem mine is well known to mineral collectors and a number of articles have been written on its minerals and their paragenesis. (See Bastin, 1911, p. 76–78; Palache and Shannon, 1928, p. 393–396; Fairbanks, 1928, p. 24; Fraser 1930, p. 349–364; Shaub, 1940 p. 673–688; and Verroe, 1940, p. 51.) L. R. Page and J. B. Hanley mapped and briefly studied the pegmatites at the quarries in May 1942 (fig. 24).

Several pegmatites crop out on and near the hilltop, and the largest was worked by Edmund Bailey, Andover, Maine, prior to 1900. In 1903–04, H. C. Dunton, Rumford Falls, Maine, operated the mine for gem tourmaline (Bastin, p. 76), and in 1926–27, W. D. Nevel, Andover, was in charge of the General Electric Co.'s operations for pollucite. In 1935 Nevel reworked the dumps for amblygonite, spodumene, and plagioclase and in 1936 he opened the lower workings. These were operated continuously when weather permitted until 1945 by the United Feldspar and Minerals Company, West Paris. The old gem mine consists of two shallow opencuts 100 to 150 feet long and 25 to 125

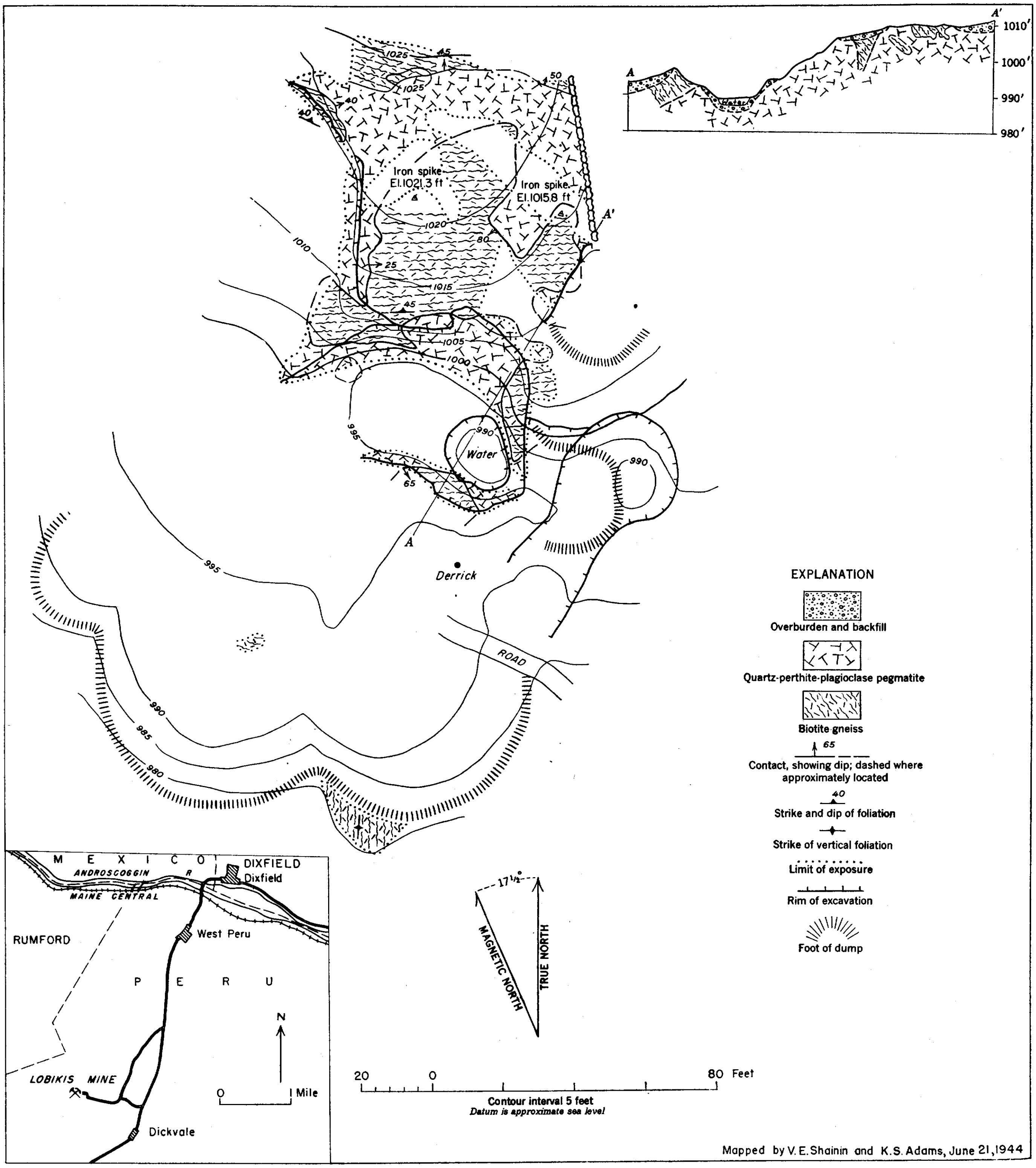
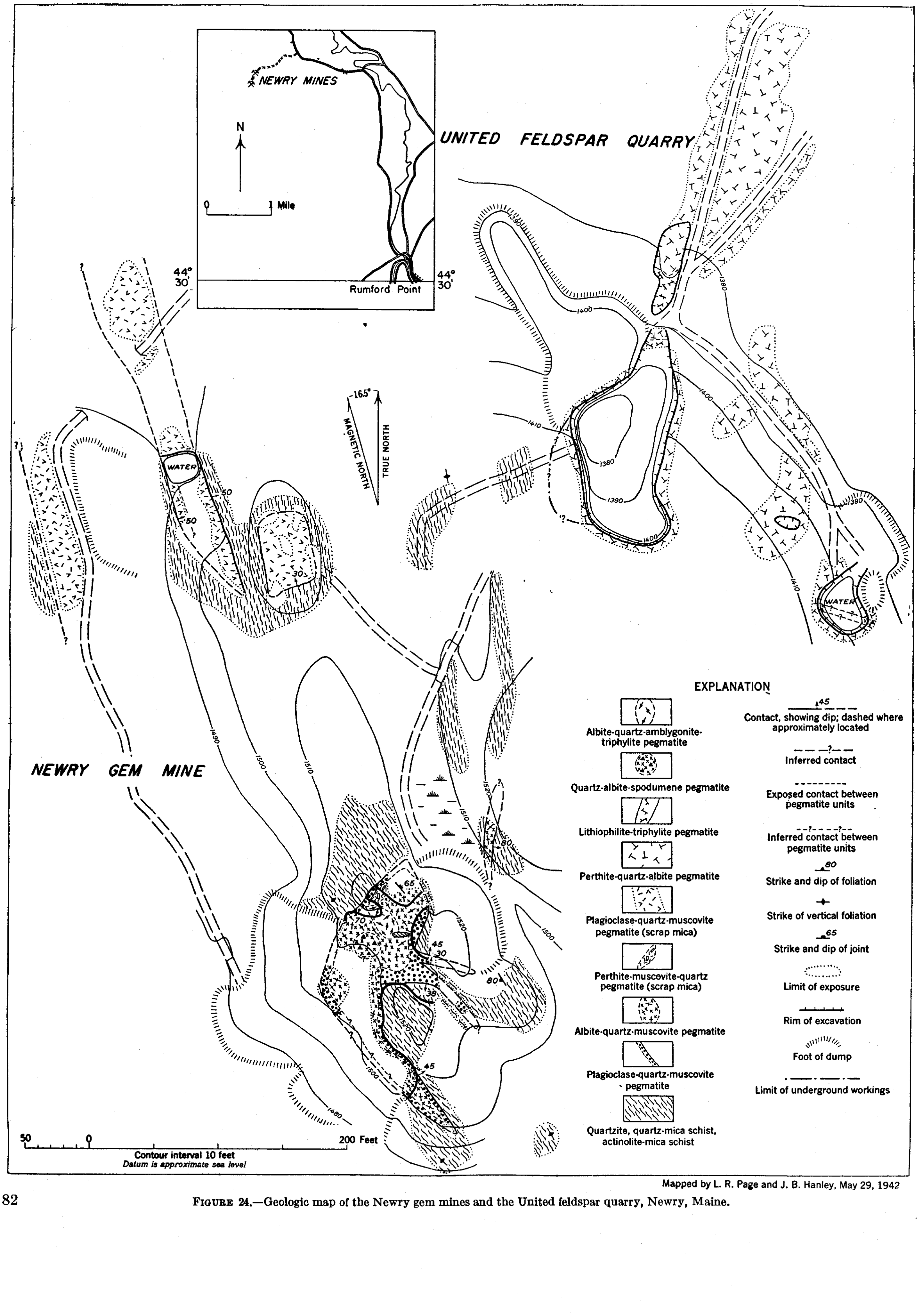


FIGURE 23.—Geologic map and section of the Lobikis mica mine, Peru, Maine.



Mapped by L. R. Page and J. B. Hanley, May 29, 1942

FIGURE 24.—Geologic map of the Newry gem mines and the United feldspar quarry, Newry, Maine.

feet wide. The United Feldspar workings are three pits ranging from 50 to 150 feet long, 25 to 75 feet wide, and 5 to 40 feet deep.

Most of the wall rock is interbedded quartzite and quartz-mica schist. At the Newry gem mine the wall rock is a massive greenish actinolite-mica schist that contains abundant tourmaline crystals near the pegmatite contacts. The quartzite and schist strike generally north and northwest and dip nearly vertically. The northwest-trending pegmatite on the hilltop containing the gem mine is irregular. It pinches out abruptly to the north and fingers out into three offshoots to the southeast. In the southern part of the same pegmatite, the east wall strikes N. 35° W. and dips 40°–55° NE. At the northwest edge of the quarry, the contact strikes about N. 35° E. and dips 70° SE. The east wall in the northern part of the quarry strikes about N. 20° E. and dips 60° NW. The northernmost offshoot to the southeast strikes S. 75° E. and lenses out downward. The central offshoot has a variable strike and appears to widen with depth.

The pegmatite consists of a number of different units. These are described briefly below, but their relationships to each other and to the form of the pegmatite body as a whole await more detailed study. The wall zone, 2 to 10 feet thick, is fine grained, consists of plagioclase, muscovite, and quartz, and has bands distinguished by differences in the proportions of individual minerals. Discontinuous lenses of cleavelandite lie parallel to the bands in some places, but in others they cut across the bands.

The inner part of the pegmatite consists largely of radial groups of cleavelandite, quartz, and muscovite, with disseminated columbite-tantalite, cassiterite, and tourmaline. A narrow lens-shaped body, 25 feet long, composed of perthite, muscovite books, and quartz is present at the north face of the quarry, where it lies between the border zone and the inner cleavelandite-quartz-muscovite pegmatite. Few of the perthite crystals exceed 12 inches in diameter. In one place in the inner part of the pegmatite there is a round body of pegmatite, about 20 feet in diameter, that contains spodumene crystals 1 to 2 feet long, 8 inches wide, and 3 inches thick. With these are associated small quantities of tantalite, cassiterite(?), purpurite, and lepidolite. In the same part of the pegmatite is an elliptical body of amblygonite approximately 25 feet long and 15 feet wide. The amblygonite occurs as rounded nodules, 6 to 8 inches in diameter. It is stained with manganese oxides, and is associated with small amounts of triphylite, lithiophylite, pink, blue, and green tourmaline, muscovite, albite, and quartz.

In addition to these minerals the following have been listed by Fraser (1930, p. 352): pyrite, beryl, apatite, microcline, pollucite, montebrasite, several varieties of lepidolite, beryllonite, rose quartz crystals, cookeite, siderite, eosphorite, francolite, herderite, reddingite, a red manganese phosphate, autunite, sphalerite, gummite, pitchblende, chalcedony, and opal. Shaub (1940, p. 683) has added zircon to the list and Verrow (1940, p. 51) mentions hatchettolite, prochlore, and vivianite.

Another pegmatite has been quarried about 250 feet northwest of the hilltop. This pegmatite, 25 feet wide, strikes N. 25° W. and dips 50° NE. It lenses out at the southeast end of the pit, but crops out for at least 200 feet to the northwest. It is poorly exposed, but appears to consist chiefly of plagioclase, quartz, and muscovite, with irregularly distributed spodumene and cleavelandite crystals near its center. Cleavelandite-cassiterite-tantalite pegmatite forms a 6-foot layer along the footwall, and a 5-foot layer of fine-grained plagioclase, quartz, and muscovite occurs below the hanging wall.

The United Feldspar & Minerals Co. operated three pits northeast of the hilltop. The largest quarry is in block perthite. Near the top of this quarry a scrap muscovite zone, as much as 10 feet thick in places, is exposed in the south and west walls. Blue and gray lithiophylite and triphylite occur in a unit below the muscovite zone. Nests of well-formed cleavelandite crystals are interstitial to the perthite. A large crystal of snow-white beryl was mined from the perthite-rich pegmatite. The small pit north of the main quarry is in perthite-quartz-albite pegmatite, and contains phosphates that may be an extension of the phosphate body in the main pit. The third pit, about 200 feet southeast of the large working, is in perthite-quartz-albite pegmatite containing a spodumene layer at least 5 feet thick. About 40 percent of this layer is splintery spodumene, weathered green to brown. The average size of the crystals is 10 by 4 by 2 inches, but larger crystals are present. Columbite occurs with black quartz in the south wall. The pegmatite exposed in the prospect trench to the west contains amblygonite, spodumene, columbite, muscovite, and perthite.

The old gem mine on top of the hill has yielded hundreds of interesting mineral specimens, and the United Feldspar quarries have been the source of a large tonnage of high grade feldspar and considerable spodumene. Scrap mica, beryl, and amblygonite have been recovered as byproducts. Reserves of these minerals in the pegmatites appeared large in 1942.

PEABODY MOUNTAIN FELDSPAR QUARRY

This quarry, on the west side of the northeast shoulder of Peabody Mountain, is in the town of Batchelders Grant, 4.3 miles S. 66° W. of the village of West Bethel. To reach it from West Bethel, drive 4.25 miles west on Route 2, crossing Peabody (Bog) Brook at 3.8

miles. Turn south on a quarry road, passable to cars of high clearance, and drive 1.1 miles to an old loading chute. Here three trails begin: Both the center and left hand trails lead to the quarry, but the center trail has the better grade. Follow this trail about 3,000 feet south to the opencut, which is on the land of the Forest Service, U. S. Department of Agriculture. Floyd Mason, West Bethel, owns the mineral rights to the quarry area. The entire pegmatite was mapped in August 1943 by D. M. Larrabee and I. S. Fisher, and a special detailed map of the northwest part was made in May 1945 by Larrabee and K. S. Adams (fig. 25).

Mason discovered the pegmatite in 1928, and obtained the mineral rights in 1937. He opened the quarry in 1938, operating it intermittently until the fall of 1940. It has been idle since. The quarry face, extending northeast along the base of the sparsely timbered rock knoll, is 90 feet long and 20 to 30 feet high, and has been cut into the mountain a maximum of 20 feet.

The pegmatite crops out for about 1,000 feet in a northeast direction and is 700 feet wide. Overburden in most places consists only of 1 or 2 inches of moss or 3 to 6 inches of dirt. The wall rock is pyritiferous quartz-biotite schist that strikes northeast and in general dips steeply southeast. Contact relations are poorly exposed on the southwest, east, and southeast sides of the pegmatite but are highly variable. Contacts are covered on the northwest by large blocks of pegmatite. The body appears to be a sheet that dips northwestward. The quarry is centrally located along the northwest edge of the pegmatite outcrop. Nearly continuous outcrops extend 400 feet on each side, and 250 feet up the slope from the working. Strong sheet jointing dips 38°–40° N. and NW.

The pegmatite has a distinct, sharply defined zonal structure. A thin border zone is present along the wall rock contacts. In some places this is aplitic and composed of quartz, plagioclase, and muscovite, and in others it is a thin layer of graphically intergrown quartz and muscovite with accessory tourmaline and garnet. The wall zone, 10 to 15 feet thick, consists chiefly of quartz, plagioclase (An_{10-12}), perthite, biotite, and muscovite. Tourmaline, garnet, and apatite are common accessories. The biotite is commonly intergrown with muscovite, and is in long prominent laths, most of which are oriented normal to both the outcrop surface and to the inner zones. Patches of graphic granite, fine-grained quartz and tourmaline in graphic intergrowth, and a few crystals of perthite 6 to 10 inches broad occur in this zone. A lens of pale rose quartz occurs in the quartz-plagioclase-perthite-biotite pegmatite northeast of the opencut, and there are three bodies of milky quartz southwest of the working. Boulders 125 feet south of the cut suggest the presence of a quartz body there, and a large, irregular quartz body occurs in the quartz-plagioclase-perthite-biotite zone about 375 feet S. 72° E. of the center cut.

A discontinuous zone of fine-grained pegmatite containing plagioclase (An_{10-12}) lies below the wall zone. The upper contact of the zone is less sharp than the bottom contact, along which there is a band of aplitic material one-half inch thick containing plagioclase (An_{10-12}). The fine-grained pegmatite has a maximum thickness of 3 feet, and lenses out along the quarry face. It lies upon a zone 2 to 5 inches thick composed of wedge muscovite, quartz, and plagioclase. The wedge-mica-bearing zone is present, even where the fine-grained pegmatite is absent. The thick ends of the mica books are frozen to the aplitic layer and the books point downward into several inches of plagioclase (An_{10-12}) and quartz. The plagioclase-quartz material grades into a core of coarse-grained cream to gray blocky perthite and interstitial quartz. Some of the perthite contains a few small patches of plagioclase, 0.04–0.4 inch in diameter, the twinning striae of which are normal to the direction of perthitic texture. The bottom of the perthite-quartz core is not exposed, but the core has a thickness of at least 8 feet normal to the upper zonal contact.

A few hundred tons of high grade feldspar has been recovered from this pegmatite, and large reserves remain if the zones exposed in the cut are typical of the greater part of the body. The presence or absence of the quartz-perthite zone could be determined by core drilling beyond the quarry face. All visible mica is wedge-shaped. It could easily be separated for use as scrap mica.

PEAKED HILL MICA MINE

The Peaked Hill mine, on a peak 0.2 mile southeast of the summit of Peaked Hill, is in the town of Gilead 1.85 miles S. 87° W. of the village of West Bethel. To reach the mine from this village, drive 1.2 miles west on U. S. Route 2 to a left fork. Follow the dirt road 0.65 mile to the second farmhouse on the west side of the road. From this point follow a poorly defined trail northwest about 0.4 mile up a steep slope to the mine. The land is reported to be owned by Dr. W. B. Twaddle, and Mrs. Hulda E. Mason, Bethel. Three small cuts in the pegmatite were made a few years prior to 1942. The mine was examined in 1943 by the Maine Geological Survey (Trefethen, 1945, pp. 44–45), and was mapped in September 1942 by D. M. Larrabee and I. S. Fisher (fig. 26).

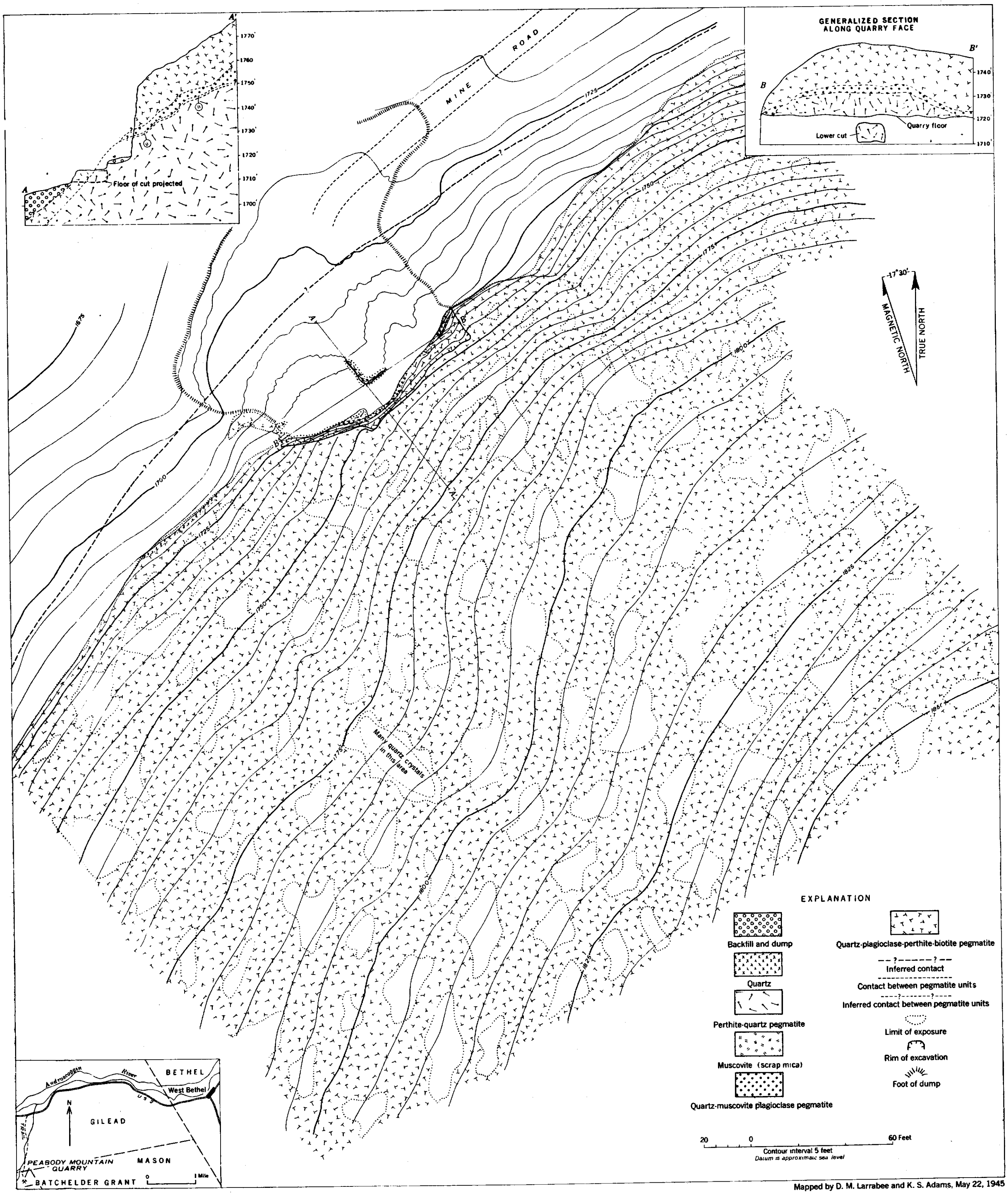


FIGURE 25.—Geologic map and sections of the Peabody Mountain feldspar quarry, Batchelders Grant, Maine.

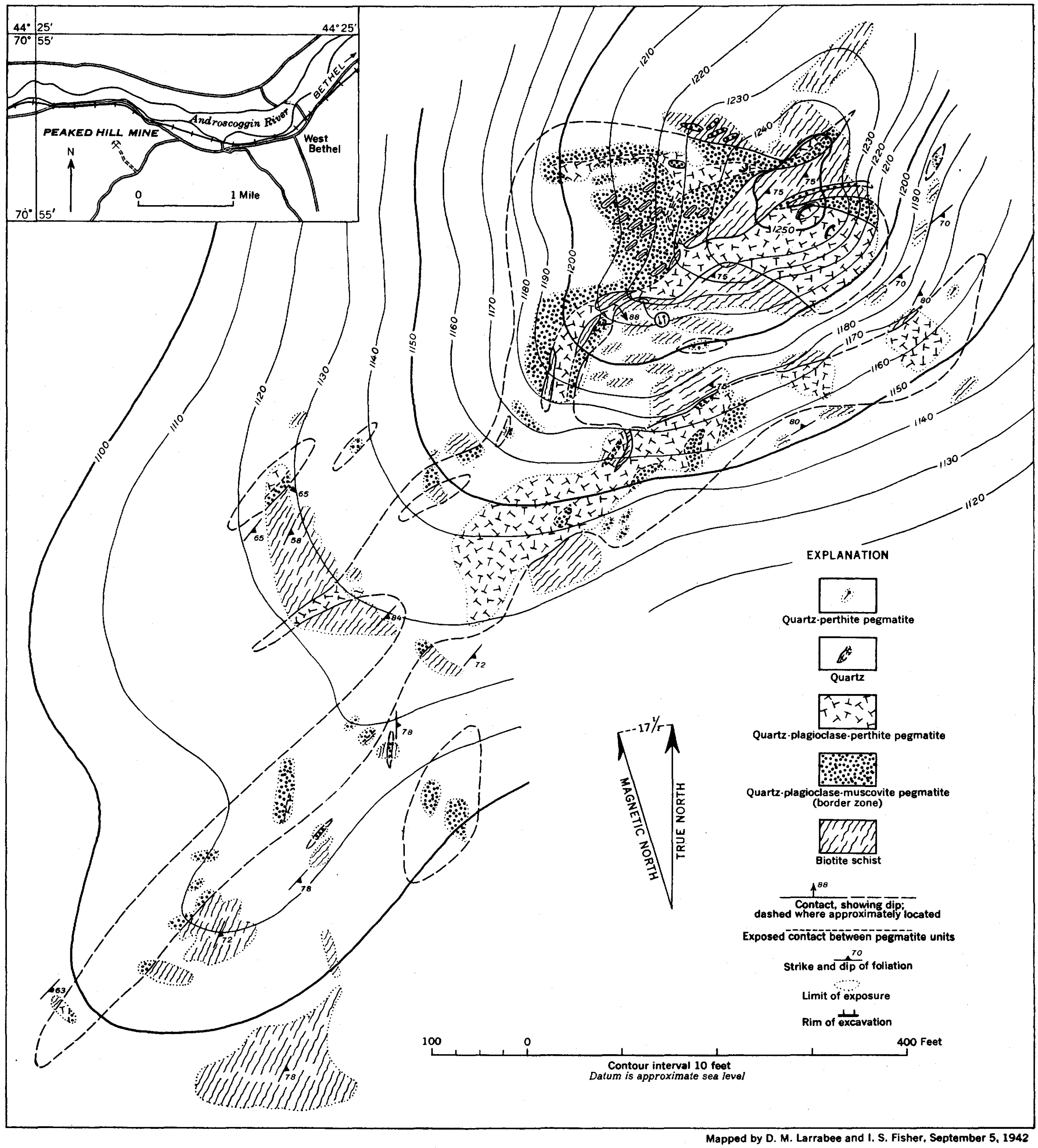


FIGURE 26.—Geologic map of the Peaked Hill mica mine, Gilead, Maine.

The pegmatite trends southwest along the shoulder from the peak, narrowing in that direction and forking to the northeast. Numerous schist inclusions surrounded by fine-grained aplitic material similar to that of the border zone, together with patches of aplitic material on the surface that appear to be remnants of the border zone, suggest that the pegmatite has not been deeply eroded. Several small pegmatites nearby are probably connected with the main pegmatite at shallow depths. The pegmatite is about 1,300 feet long and ranges from 50 to 300 feet in width. The attitude of the contacts is extremely varied. The hanging-wall contact, on the south slope of the peak, dips 45° SE. The wall rock, muscovite-biotite schist, strikes northeast and dips 58° to 84° SE.

The pegmatite has a fine-grained border zone that is mostly aplitic. The zone contains accessory small garnets and plumose muscovite. Inward, the pegmatite is predominantly fine- to medium-grained quartz, plagioclase, perthite, and muscovite, with some graphic granite. Several irregular patches of coarse-grained material consisting of quartz, perthite crystals less than one foot in length, and small muscovite books are exposed. Red garnets, one-half inch across, occur in the coarse pegmatite near the hanging wall.

Mica books 3 to 6 inches in diameter occur in the coarse-grained quartz-perthite pegmatite, particularly on the southeast slope of the peak. The mica is wedged and has "A" structure. The poor quality and the small percentage of mica in the pegmatite prevented operation of the two small opencuts under 1942–44 conditions.

PERHAM FELDSPAR QUARRY

The Perham quarry is in the town of Paris, 1 mile S. 21° W. of the village of West Paris. To reach the quarry from this village, drive 0.45 mile northwest across the Little Androscoggin River to a road turning southeast. Follow this road 0.1 mile to a house west of the road. From the house follow a quarry road 0.7 mile southwest to the workings west of the hilltop. The land and mineral rights are owned by the United Feldspar & Minerals Co., West Paris. The quarry was mapped in May 1945 by D. M. Larrabee and K. S. Adams (fig. 27).

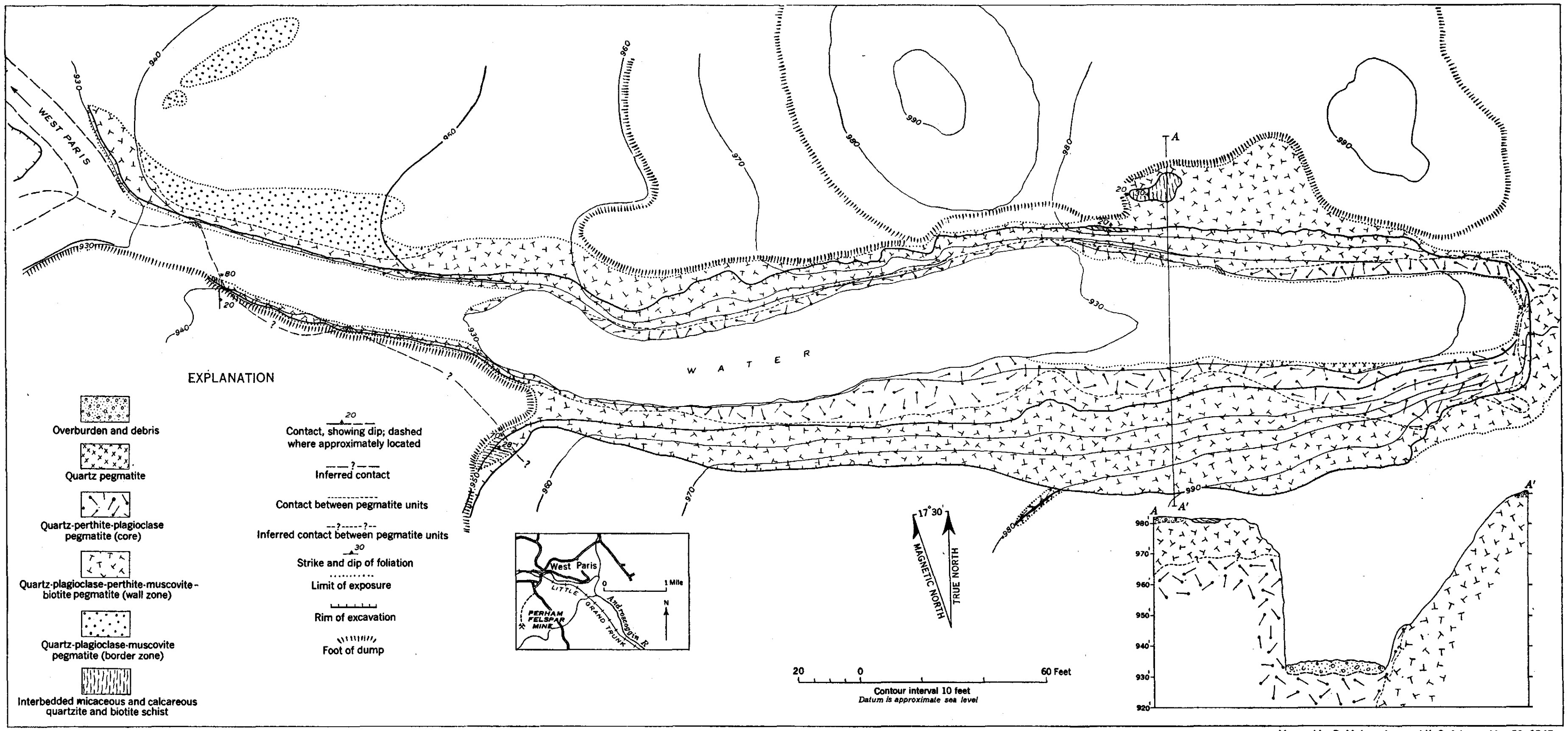
One large cut and several small pits and cuts have been made on the property. The main cut was opened about 1922 by A. C. Perham, West Paris, who operated it until 1925, when it was purchased by the Oxford Mining & Milling Co., West Paris. This company worked the opencut until about 1930. The company was then merged with the United Feldspar & Minerals Co., who continued the operation until 1932. The opencut is 460 feet long, 20 to 80 feet wide, and 10 to 60 feet deep. The central part is flooded to a reported depth of about 20 feet. The cut trends N. 85° W. along the pegmatite, which is in interbedded gray to greenish calcareous quartzite and gneiss and biotite schist. The wall rocks strike north to northwest and dip 20° E. to 30° W. Only the southwest contact of pegmatite with wall rock is exposed; this strikes about N. 65° W. and dips from vertical to 80° NE. Inclusions of wall rock are present along the top of the north face, near the east end of the cut, and near the floor level. A strong shear plane or joint, dipping northward in the pegmatite, forms the south face of the quarry. The pegmatite probably plunges westward.

The pegmatite contains a narrow aplitic border zone along the wallrock contact near the southwest side of the cut. Near the west end of the cut, the border zone crops out over a considerable area, suggesting that the hanging wall has barely been removed by erosion. The zone consists chiefly of quartz, plagioclase, and muscovite. Inside this is a medium- to coarse-grained wall zone probably 10 to 15 feet thick, composed of quartz, plagioclase, perthite, small muscovite books, biotite blades, black tourmaline, garnet, apatite, and pyrite. Much of the muscovite in the north face contains abundant magnetite stains. The wall zone grades inward into a central core of quartz and perthite that contains much pyrite in crystals one-fourth inch in diameter. Most of the pyrite is in small, irregular cavities and along fractures. It is common in all faces of the cut but is most abundant along the north face of the quarry. The core apparently extends northward beneath the margin of the cut, and to the east beyond the end of the cut. It probably dips steeply northward. Irregular bodies of quartz occur within the quartz-perthite core, and are most common near the base of the south face.

Considerable feldspar has been produced from the quarry and much probably remains in the north face and below water. It is assumed that satisfactory removal of the pyrite and limonite could be accomplished by magnetic separation. Quartz and scrap muscovite were minor byproducts, and a little beryl has been reported.

PLUMBAGO MOUNTAIN BERYL PROSPECT

This prospect is in the town of Newry on a knoll at the northeast end of the main shoulder of Plumbago Mountain. It is 0.5 mile west of the old Newry gem mine, and 4.0 miles N. 48° W. of the bend in the Androscoggin River at the village of Rumford Point. To reach the prospect from the junction of Routes 2 and 5 near Rumford Point, go 4.7 miles north to a point 0.1 mile beyond Spruce Hill Farm, which is near the mouth of Howe Brook. Follow an old logging road



Mapped by D. M. Larrabee and K. S. Adams, May 31, 1945

FIGURE 27.—Geologic map and section of the Perham feldspar quarry, Paris, Maine.

0.8 mile southwest along a small gully to the place where the road forks and crosses the brook. Go southwest along the brook 0.1 mile to the end of the road, and follow a true bearing S. 50° W. about 0.7 mile to the knoll. There is no trail. The prospect is on land owned by the International Paper Co. It was visited by geologists of the Maine Geological Survey (Trefethen, oral communication, September 1942) in August 1942 and was mapped in September 1942 by D. M Larrabee and I. S. Fisher, at the suggestion of J. M. Trefethen (pl. 6). The prospect is undeveloped. Although the lower contact of the pegmatite is not well exposed, the body appears to be a sheet 15 to 20 feet thick, the outcrops of which surround the knoll and extend east-northeast down the mountainside.

The gently undulating top of the pegmatite in general strikes a few degrees west of north and dips approximately 20° eastward. The wall rock consists of gabbro and interbedded quartz-mica schist and micaceous quartzite. The gabbro contains minor amounts of ilmenite and magnetite, and has been tourmalinized near the pegmatite.

The upper part of the pegmatite is characteristically aplitic, but in some places it contains irregular patches of quartz and muscovite in graphic intergrowths. The aplitic material contains red garnets, small green apatite crystals, and short stubby crystals of blue and black tourmaline. Albite (An_{5-6}) is the predominant feldspar in the border zone. Inward the pegmatite is medium-grained and consists chiefly of quartz, plagioclase, and perthite, with minor amounts of muscovite, cleavelandite, white beryl, and heterosite or purpurite. This material forms the wall zone. Lenses and irregular bodies of quartz, and of quartz and perthite, lie within the medium-grained pegmatite, and the quartz-perthite lenses contain green beryl, cleavelandite, and heterosite or purpurite. Crystals of spodumene and perthite up to 3 feet long are present in the coarser parts of the mass, east of the knoll.

Beryl crystals are largest and most abundant in and near the quartz bodies, most of which appear to be in the upper one-third of the pegmatite. The largest crystals, up to 12 inches in diameter, are west and northwest of the knoll. In 27 outcrops having a total area of about 5,000 square feet, 755 square feet of beryl-bearing pegmatite surface, had 278 beryl crystals with a total surface area of 8 square feet. The beryl content of all exposed pegmatite is calculated to be 0.16 percent. The total area of the pegmatite surface is about 180,000 square feet. Most of the beryl seems to be within 3 feet of the upper surface, or in 540,000 cubic feet (45,000 tons) of pegmatite. If the beryl content of the unexposed parts of the pegmatite is similar to that of the exposed rock, the total content is about 72 tons.

Mica marred by ruling and by wedge and "A" structures occurs commonly in and near the quartz masses, but no sheet-bearing mica was seen. No satisfactory estimate of the feldspar and spodumene could be made. Operation of this deposit for the recovery of beryl, scrap mica, feldspar, and spodumene would require removal of much rock overburden, difficult and costly transportation, and the mining and milling of large quantities of rock containing little of the minerals desired. The operation was not feasible under 1942–44 conditions.

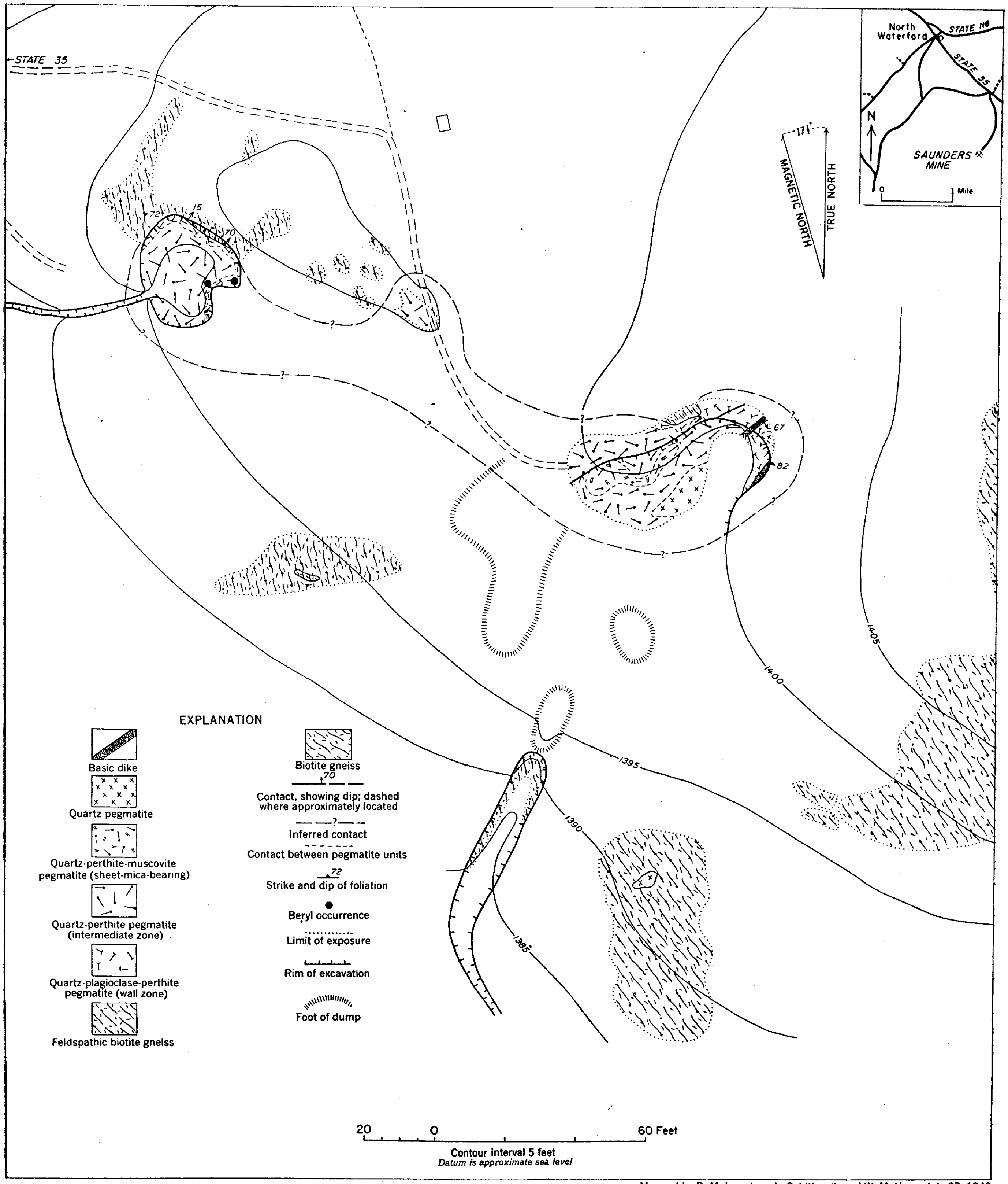
SAUNDERS FELDSPAR MINE

The Saunders mine, near the north end of the ridge on Beach Hill, is in the town of Waterford 1.85 miles S. 21° E. of the village of North Waterford. To reach the mine from North Waterford, drive southeast 1.2 miles on Route 35 to the Saunders farmhouse west of the highway. Turn southwest at the house and follow an old logging road about one mile south-southwest to the mine, on the property of C. P. Saunders. The area surrounding the mine was mapped in August 1942 by D. M. Larrabee and I. S. Fisher, and a detailed map of the mine was prepared in July 1943 by Larrabee, L. Goldthwait, and W. M. Hoag (fig. 28).

Three small open pits were excavated during intermittent, small scale operations for feldspar a few years prior to 1942. In 1943 the United Feldspar & Minerals Co., West Paris, leased the property and worked the mine for mica and feldspar for a few months.

Three masses of pegmatite, possibly connected beneath the surface, are exposed in and near the workings. The outcrops range from 10 feet long and 6 feet wide to 60 feet long and 25 feet wide, and suggest a single pegmatite trending east-southeast. The wall rock is fine-grained quartz-feldspar-biotite-muscovite gneiss and (shown as feldspathic biotite gneiss on fig. 3) biotite gneiss that is impregnated with pegmatite near the contacts. Gradations from feldspathic biotite gneiss to fine-grained pegmatite are visible in many places east and southeast of the mine. The foliation of the gneiss generally strikes NNW. and dips 34° W. to 72° E. Small patches of granite and pegmatite are scattered throughout the gneiss. Two fine-grained basic dikes cut the pegmatite in the southeastern pit.

The border zone of the pegmatite is aplitic in most places, but in others contains fine-grained intergrowths of quartz and muscovite. Garnet and black tourmaline are commonly present. Inside the border zone is a medium-grained wall zone consisting of quartz-plagioclase-perthite-muscovite pegmatite. Inside this is a



Mapped by D. M. Larrabee, L. Goldthwait, and W. M. Hoag, July 27, 1943

FIGURE 28.—Geologic map of the Saunders feldspar mine, Waterford, Maine.

quartz-perthite zone containing scattered quartz bodies. The pegmatite in the southeast pit contains a quartz core surrounded by coarse-grained quartz and perthite. In the northwest pit, the perthite crystals range from a few inches to 3 feet long. Wedge and "A" mica, and a small quantity of beryl occur with the coarse-grained quartz and perthite. The beryl crystals are 1 to 5 inches across and 3 to 8 inches long. The beryl occurs in clear or smoky quartz, some of which has an oily luster.

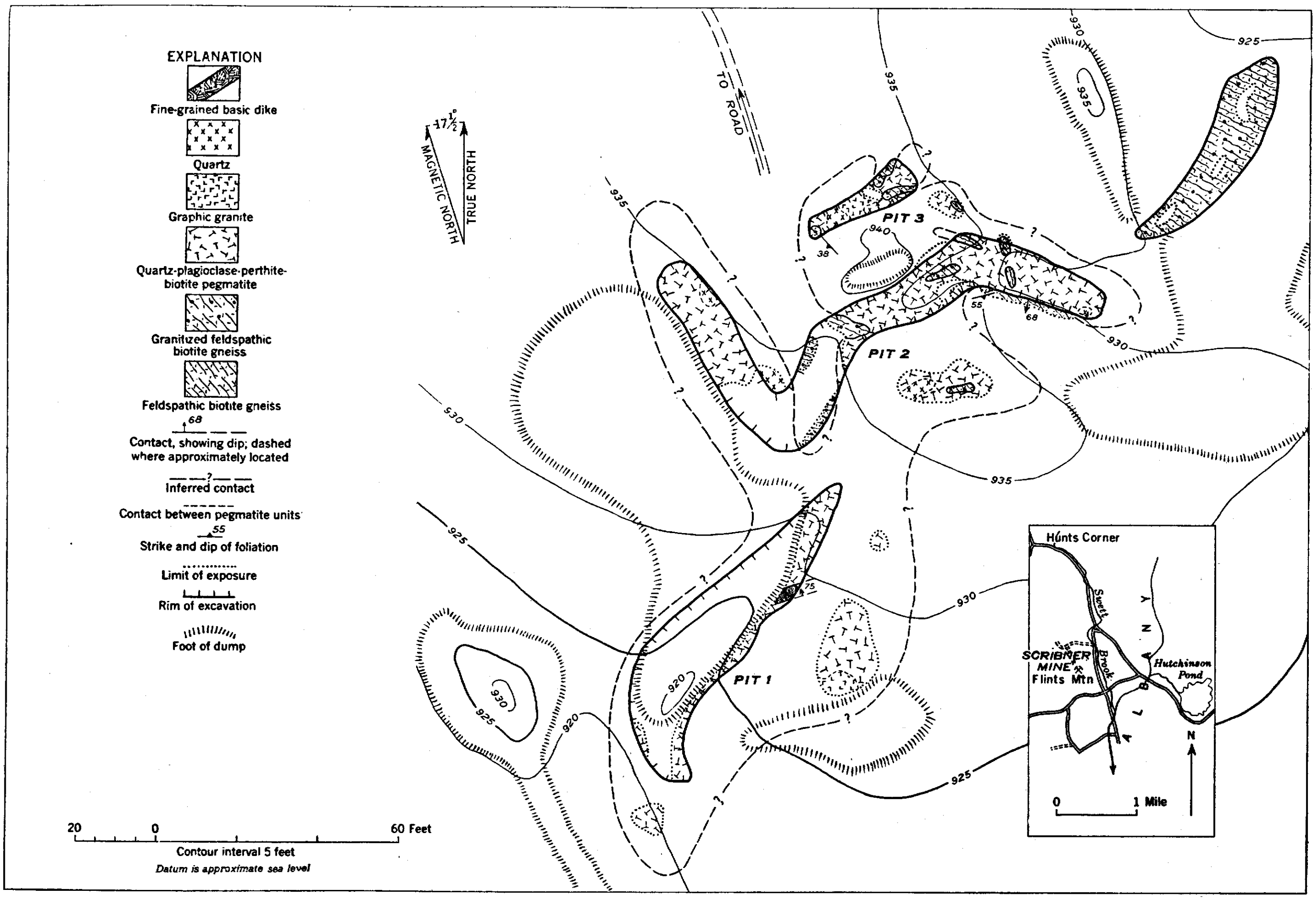
A worm-shaped body of quartz, perthite, and wedge muscovite occurs in the pegmatite of the easternmost pit; this pod is 15 percent mica. Small irregular masses of pyrrhotite and chalcopyrite are present in this unit. Much of the rum to ruby mica from both workings is warped and intergrown with biotite, marred by "A" and wedge structures, and ruled. Magnetite is common. Quartz and tourmaline crystals cause pinholes.

The quality and quantity of mica did not warrant extensive development during 1942–44. Further work, however, might reveal substantial quantities of blocky feldspar in the center of the pegmatite.

SCRIBNER MICA MINE

The Scribner mine is in the town of Albany 0.5 mile northeast of Flints Mountain, and 8.8 miles S. 70° W. of the village of West Paris. To reach the mine by auto road from Hunts Corner, drive southeasterly 1.4 miles to a west fork; follow this 0.3 mile to another west fork; follow this 0.35 mile to a fork which turns off to the southeast and in 0.3 mile leads to the mine. The property is owned by Fred Scribner, from whom the mining rights were leased by the Douglass Mining Co., Portland, Maine. The company exploited the pegmatite for a five-month period beginning June 12, 1943. The mine was studied by the Maine Geological Survey in 1943 (Trefethen, 1945, p. 34–35). D. M. Larrabee, L. Goldthwait, and W. M. Hoag mapped the mine in July 1943 (fig. 29) and revisited the deposit in September of the same year.

Four shallow open pits, alined in a general northeast direction, are the chief mine workings. Pit 1 is 85 feet long, 20 feet in maximum width, and 13 feet deep. Pit 2 is 160 feet long, 10 feet in average width, and a maximum of 8 feet deep. Pit 3 is 30 feet long, from 5



Geology by D. M. Larrabee, L. Goldthwait, and W. M. Hoag, July 1943

FIGURE 29.—Geologic map of the Scribner mica mine, Albany, Maine.

to 10 feet wide, and 4 feet deep. Pit 4 is not shown in figure 29. Smaller prospect pits and trenches were excavated in pegmatite a few hundred feet southeast of the main workings. At least 1,600 tons of rock was moved in all operations. Stripping of the shallow overburden, and trenching, were done by use of a small bulldozer and one compressor-jackhammer unit. Blasted rock not removed from pit 4, and waste in pits 1 and 2, prevented complete examination.

The pegmatite crops out over an area 180 feet by 40 feet and may be a sheetlike body of considerable extent. It was injected into feldspathic biotite gneiss that is porphyritic in places and locally is impregnated with pegmatite. The border zone of the pegmatite is aplitic and contains garnet, apatite, and black tourmaline. Inward from the margins is a medium-grained wall zone containing quartz, plagioclase, perthite, biotite, and muscovite. Small crystals of beryl are present in some places, and garnet, apatite, and black tourmaline are common. Muscovite is disseminated in the medium-grained material exposed in pits 1 and 3, and in the central part of pit 2. A lean mica shoot lies below the unreplaced, steeply dipping wall or inclusion at the east end of pit 2. Mica concentrations adjacent to or near thoroughly impregnated inclusions of gneiss are similar to those in the disseminated deposits—mica concentrations appear to be richer near wall rock that has not been thoroughly impregnated by pegmatitic material. Lenses of clear, smoky, and rose quartz and irregular masses of graphic granite occur within the wall zone, and the lenses contain well-developed crystals of perthite up to several inches in diameter, in addition to small crystals of golden and green beryl, some of which are of gem quality. These lenses are most common in pits 2 and 3.

The average content of ruby mica in the rock mined is 0.25 percent for the mine as a whole and 1.4 percent at the east end of pit 2. Most books are small, firm, and unwarped, but have "A" structure, reeves, fractures, and mineral inclusions forming pinholes and larger openings in the sheet. Some muscovite is intergrown with biotite. The mine-run mica yielded a small amount of sheet, insufficient to insure profitable operation under 1942–44 conditions.

STEARNS BERYL PROSPECT

The Stearns mine is in the town of Albany, 8.2 miles S. 70° W. of the village of West Paris, and 1.5 miles S. 40° E. of Hunts Corner. To reach it from Hunts Corner, follow a dirt road southeasterly 1.4 miles to a left fork. Follow this, the Hutchinson Pond road, 0.3 mile to the home of Hugh Stearns, owner of the deposit. An old woods road leads 0.25 mile north to the prospect, which was opened in 1938 by Stearns and mined sporadically on a small scale for feldspar, scrap mica, and beryl. Two open pits have been made. The larger is 50 feet long, 15 feet wide, and 5 feet deep, and the smaller is 20 feet long, 10 feet wide, and 4 feet deep. About 400 tons of rock was removed from the excavations. The prospect was mapped August 19, 1943, by D. M. Larrabee, L. Goldthwait, and W. M. Hoag (fig. 30).

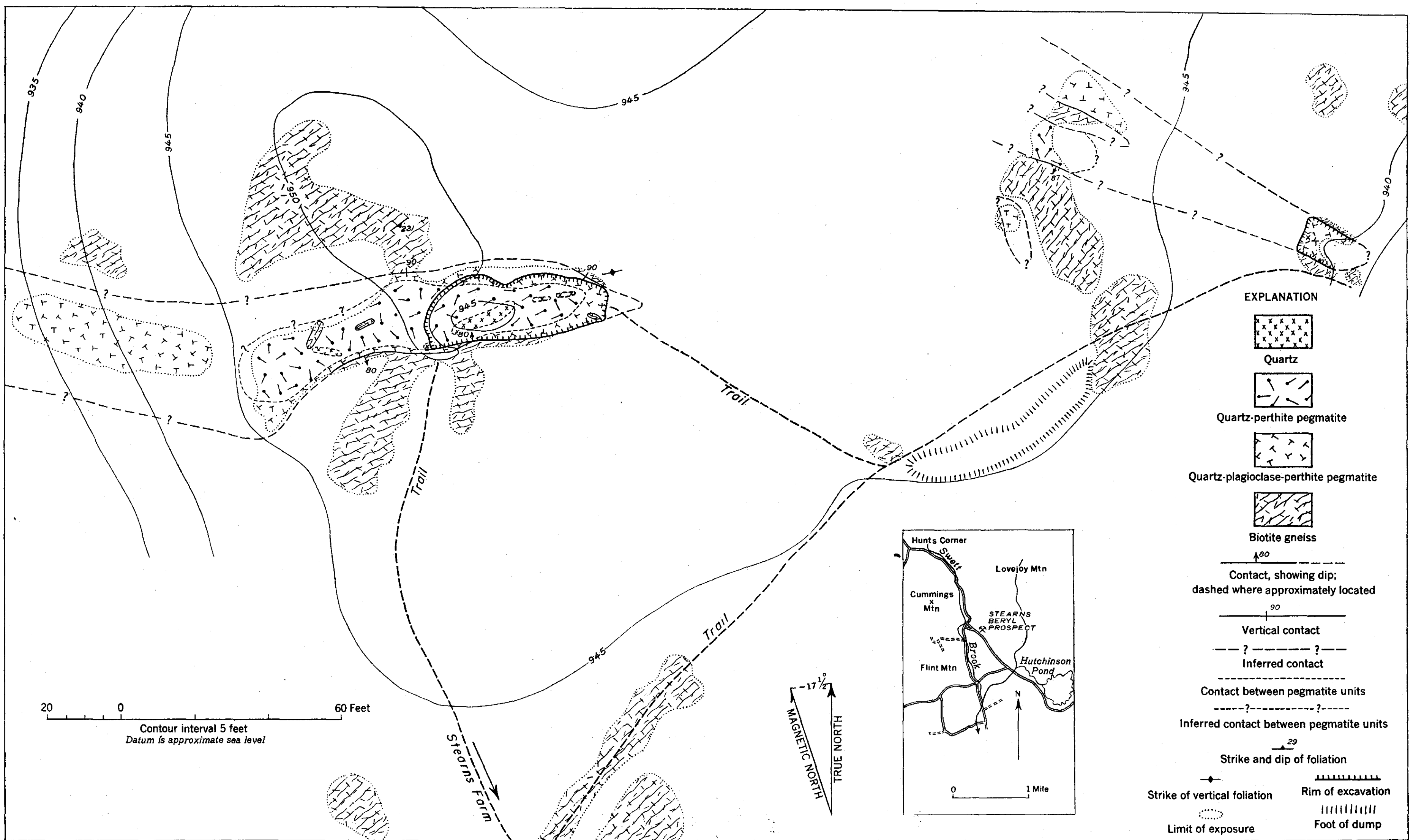
Three pegmatites occur on the property. The westernmost and largest body strikes eastward and dips 80° N. to 80° S. It is at least 170 feet long and 20 feet wide. It probably lenses out or narrows eastward 10 feet beyond the end of the pit. Its western end is not exposed. In its western outcrops, it contains a narrow, aplitic border zone, enclosing a medium-grained wall zone composed of quartz, plagioclase, perthite, biotite, muscovite, and tourmaline. The eastern half of the pegmatite, near the pit, contains a core-margin zone consisting of larger crystals of perthite that surround disconnected quartz pods. The pods form a core near the center of the pegmatite. They are elongate roughly parallel to the pegmatite contacts. Wedge muscovite is present near the margins of the quartz bodies. A small green beryl crystal associated with perthite lies at the south margin of the westernmost pod, and a small quantity of beryl is reported to have been removed from margins of other pods.

The pegmatite exposed in the eastern pit is 10 feet wide, strikes N. 65° W. and is probably the same body as that exposed 60 feet northwest on strike. The contacts of the pegmatite are partly exposed in the pit. They vary markedly in attitude from place to place but appear to be vertical in general. The south contact at this point dips 87° SW. The pegmatite here consists of a narrow border zone of aplite enclosing a wall zone of quartz, plagioclase, medium- to coarse-grained perthite, biotite, and muscovite. The pegmatite seems to split into two branches 80 feet northwest of the pit. The northern branch is medium-grained and contains no large perthite crystals; the southern branch is composed of quartz and perthite. A small outcrop to the south contains medium-grained quartz, plagioclase, perthite, and small books of muscovite.

The beryl recovered was 0.07 percent of the pegmatite mined. Recovery was virtually complete and was accomplished by hand cobbing. Stearns reported that the largest crystal was 13 inches in diameter. The beryl content of the pegmatite is too low to allow profitable operation for beryl alone. The mica is of poor quality. Reserves of feldspar are unknown.

WAISANEN MICA MINE

The Waisanen mine lies in the town of Greenwood, 3.0 miles S. 23° E. of Greenwood village. To reach it



Geology by D. M. Larrabee, L. Goldthwait and W. M. Hoag, August 19, 1943

Figure 30.—Geologic map of the Stearns beryl prospect, Albany, Maine.

from Greenwood, drive southward 2.7 miles on the North Norway road to a gravel road leading westward. Follow this road for 0.75 mile to the Waisanen farmhouse, from which a poorly graded gravel road leads 0.4 mile southward to the mine.

The property and mineral rights are owned by Matti Waisanen of West Paris, Maine. It is reported that the Oxford Mining & Milling Co. of West Paris began operations about 1935 and mined feldspar for an unknown length of time. The Douglass Mining Co. of Portland, Maine, mined mica from January 1943 to December 1944. The workings are an irregular opencut, 200 feet long, 50 feet wide, and 30 feet in average depth; a broad adit 20 feet long, 30 feet wide, 11 feet deep; and a shaft at the head of the adit 25 feet long, 15 feet wide, and 20 feet deep. Waste rock was moved at first by a stiff-leg derrick and power shovel, and later by a drag-line scraper having a capacity of about 2 tons.

The mine was mapped by D. M. Larrabee, L. Goldthwait, and W. M. Hoag in July 1943. Open cut ropeations necessitated a resurvey in June 1944 by V. E. Shainin and K. S. Adams (fig. 31). Shainin and A. H. McNair examined the mine in October 1944.

The pegmatite is an irregular body cutting medium-grained feldspathic biotite gneiss. The pegmatite has an exposed length of about 150 feet and an average thickness of 30 feet. It strikes N. 75° W. and seems to dip steeply to the northeast. The walls are extremely irregular, and locally dip southwestward.

The upper edge or crest of the pegmatite appears to plunge eastward. Several irregular patches of gneiss were encountered in the shaft (sec. B-B′) in the extreme eastern end of the workings. These might be xenoliths or irregular projections of an overlying wall of gneiss that steepens in plunge in this direction. In the eastern face of the quarry the pegmatite terminates upward in a series of apophyses extending 30 to 40 feet into the overlying gneiss (sec. A-A′). Five steeply dipping basic dikes, 2 to 4 feet thick, cut obliquely across the pegmatite in the northeastern part of the workings.

The pegmatite shows a distinct zonal structure. A fine-grained border zone 1 to 5 inches thick lies adjacent to the contact with gneiss and is present wherever the contact is exposed. This zone consists of quartz-muscovite-plagioclase pegmatite with accessory apatite, garnet, and tourmaline. Inside the border zone is a sheet-mica bearing wall zone, 1 to 3 feet thick, likewise composed of quartz-muscovite-plagioclase pegmatite. This zone is present along parts of both walls of the pegmatite. Subordinate amounts of perthite and accessory garnet, tourmaline, and apatite are also present. The zone is exposed along the north wall in the eastern part of the workings but is absent or has been mined out in the western end of the quarry.

Directly below the crest, in the uppermost 20 to 30 feet of the pegmatite, a perthite-quartz-biotite zone is in contact with the border zone. It consists of perthite and quartz with subordinate biotite, plagioclase, muscovite, and accessory garnet, tourmaline, and apatite. Portions of the zone are large masses of perthite with minor amounts of the other minerals. Biotite occurs entirely in long, narrow, thin blades.

A discontinuous quartz-perthite-muscovite zone 1 to 2 feet thick lies between the perthite-quartz-biotite zone and the core of the pegmatite. It is absent in many places and was exposed at the time of mapping only in the shaft at the eastern end of the working. Its lower half consists of coarse quartz; its upper half is composed of perthite and quartz with subordinate biotite, plagioclase, and accessory tourmaline, garnet, and apatite. Sheet-bearing books of muscovite and euhedral prisms of beryl 1 inch to 1½ feet long occur scattered throughout the zone.

A quartz-perthite core about 25 feet thick occupies the central part of the pegmatite below the perthite-quartz-biotite zone. The top of the core is 20 to 30 feet below the crest of the pegmatite. In the shaft the core seems to end eastward in a rounded "nose," hence it seems likely that the pegmatite becomes narrower or terminates in that direction. The core consists of coarse milky quartz and scattered euhedral perthite crystals with accessory garnet, beryl, and book muscovite. At the time the map was revised, the contact of the core with the wall zone was exposed along the north wall. The mica there may be regarded as part of the wall zone or part of the core-margin zone.

The mica books are deep ruby, hard, and mostly free from stain. They range from 1 inch to 3 feet in diameter and from ½ to 14 inches thick, averaging about 4 inches by 1 inch. Ruling is common and some books show cross-fracturing, but "A" structure is uncommon. Some books are wedge-shaped.

The pegmatite contains both wall-zone and core-margin mica deposits. Three features make it difficult to estimate reserves: (1) the very irregular external form of the pegmatite; (2) the discontinuous nature of the wall and core-margin zones; and (3) the apparent termination of the core (with its marginal mica deposit) east of the shaft. These features suggest that future operations for mica should be undertaken cautiously, but it is possible that substantial reserves of sheet-bearing muscovite lie in the wall-zone and core-margin deposits. Exploration is needed to clarify the structural relationships.

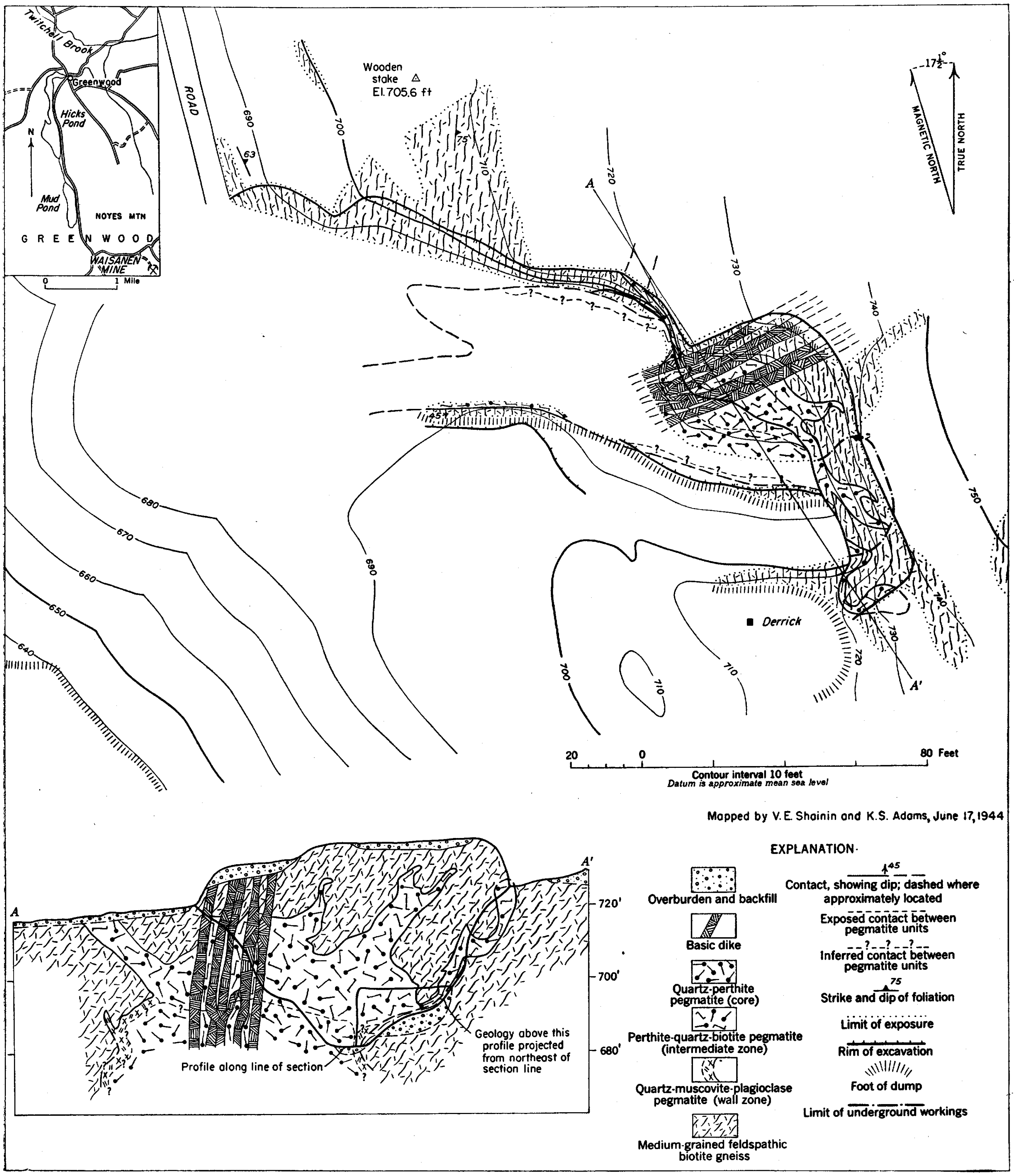


FIGURE 31.—Geologic map and section of the Waisanen mica mine, Greenwood, Maine.

WARDWELL NO. 1 MICA MINE

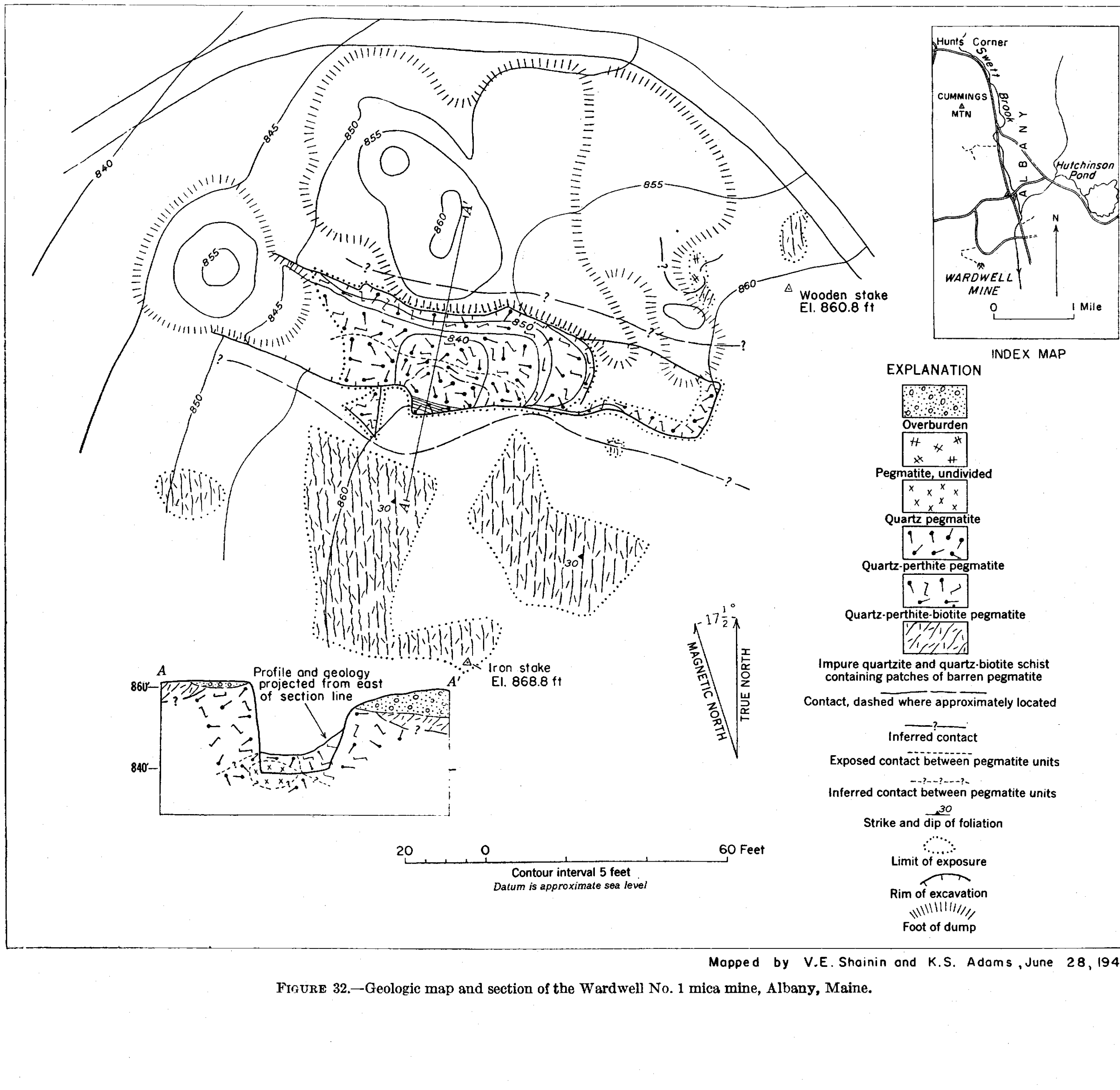
The Wardwell mine lies in the town of Albany, 6.0 miles S. 48° W. of Greenwood village. To reach it from Hunts Corner, drive 3 miles southeastward on a well-graded gravel road along Sweet Brook Valley to a gravel road leading westward, one mile to the mine.

The property is owned by Roy Wardwell of Albany and is said to have been operated many years ago. It was worked for mica by Joseph Pechnic of South Paris during 1941–44. The workings consist of five opencuts and several prospect pits lying within 700 feet of one another. Recent operations have been almost entirely restricted to the westernmost cut, or no. 1 mine, one of the larger openings. This cut is 120 feet long, 22 feet wide, and 23 feet deep.

The property was mapped by D. M. Larrabee, L. Goldthwait, and W. M. Hoag in June 1943. The no. 1 cut was mapped in detail by V. E. Shainin and K. S. Adams in June 1944 (fig. 32) and was visited subsequently by A. H. McNair and Shainin.

The no. 1 quarry and three other opencuts are in a pegmatite that is at least 360 feet long and as much as 35 feet wide. The contact of the pegmatite with overlying wall rock is visible only east of the quarry, where it strikes N. 75° W. and appears to dip gently northward. The fifth opencut lies southeast of the other workings and appears to be in another pegmatite, which has a length of at least 300 feet and an outcrop width of 40 feet. It was not studied in detail, but in attitude, internal structure and composition it resembles the pegmatite of the no. 1 quarry.

The wall rocks are interbedded impure quartz and



Mapped by V.E. Shainin and K.S. Adams, June 28, 1944

FIGURE 32.—Geologic map and section of the Wardwell No. 1 mica mine, Albany, Maine.

quartz-biotite schist that strike north-south and dip 30° W. These rocks are heavily impregnated with pegmatitic material.

The pegmatite in the no. 1 mine consists of three units, consisting of medium- to coarse-grained quartz, perthite, biotite, muscovite, and plagioclase, with minor amounts of black tourmaline, garnet, autunite, torbernite, and uraninite(?). Perthite and graphic granite seem most abundant in the lower part of the unit. Biotite occurs in long, narrow blades, commonly intergrown with muscovite. Muscovite books occur in the lower part of the unit, where they are associated with perthite and quartz, and some plagioclase.

A quartz-perthite zone lies below the quartz-perthite-biotite zone. It consists of coarse-grained quartz and euhedral perthite with muscovite, plagioclase, and beryl. Beryl occurs in light green euhedral crystals in quartz and may be a common accessory constituent. Crystals range from one-half inch in diameter and 2 inches long to 10 inches in diameter and 3 feet long.

Disconnected pods of coarsely crystalline quartz, 1 to 20 feet long, are exposed in the floor of the cut. These may be segments of the core of the pegmatite. Beryl occurs in the pods, in crystals up to 4 feet long, and sheet-bearing mica books occur adjacent to the pods. The books are associated with quartz, perthite, and minor amounts of plagioclase.

Mica in the pod deposits is ruby in color, much of it exhibits "A" structure, warping, ruling, and reeving. The books have an average diameter of 4 inches and an average thickness of three-fourths of an inch. They are of better quality than muscovite in the lower part of the quartz-perthite-biotite unit.

The quartz pods with which sheet-bearing muscovite is associated appear to be small, and for this reason it is unlikely that large reserves are present. Large amounts of barren rock between pods would have to be mined.

WILLIS WARREN FELDSPAR QUARRY

The Willis Warren quarry is in the town of Stoneham, 2 miles N. 28° W. of the village of North Lovell and 1.5 miles west of Virginia Lake. To reach it from this village, drive 0.7 mile northwest; turn southwest and proceed 0.6 mile, then turn northwest and drive 0.7 mile to Great Brook. Turn north along the east bank of Great Brook and drive 0.85 mile to a road turning left; follow this road 0.3 mile to a cemetery west of the road. The quarry is 0.1 mile east of the cemetery on the land of Willis Warren, who also owns the mineral rights. The quarry was examined several times during 1943 and was mapped in August by D. M. Larrabee, L. Goldthwait, and W. M. Hoag. The map of the surface workings was revised by Larrabee and K. S. Adams in May 1945 (fig. 33), but flooding prevented an examination of the stope and floor of the pit at this time.

The quarry was opened for feldspar in 1937 by Warren, who operated it intermittently until 1943, and then leased it to the Douglass Mining Co., Portland. This company mined the pegmatite for mica from July to December 1943. Lawrence Anderson, Stoneham, operated the quarry for mica from January to October 1944. The main working is an open pit that trends northeast. It is 90 feet long, 50 feet wide, and 14 feet in average depth below the southeast rim. Inclined underground workings are reported to extend about 8 feet horizontally beneath the southeast rim.

The wall rock is fine-grained gneissic biotite granite containing small patches of biotite-rich material and inclusions of biotite schist and gneiss. The pegmatite appears to be a northeast-trending elliptical body about 100 feet long and 50 feet wide. The southeast contact strikes N. 40° E. and dips 45° to 52° SE. The contact with wall rock in the north corner of the pit dips 10° to 20° SE. in general, but its attitude is extremely varied. The granite here might be either an inclusion or the gently dipping continuation of the hanging wall exposed across the pit. Both pegmatite and granite are cut by a narrow fine-grained basic dike that trends N. 50° E. and dips 78° SE.

The pegmatite has a fine-grained aplitic border zone one-half inch thick consisting of quartz, plagioclase, and garnet. The wall zone, 2 to 5 feet thick, contains medium- to coarse-grained plagioclase, quartz, sheet-bearing muscovite, black tourmaline, and apatite, together with garnet crystals ⅛ to 1.5 inches in diameter. The mica books are largest and most numerous near the hanging wall contact, but nowhere in the zone are they abundant. This zone is coarser-grained toward the center of the pegmatite than near the wall. Cleavelandite is the predominant feldspar of the inner part but some perthite is present. The core of the pegmatite consists chiefly of quartz and perthite, with plagioclase and a few small green beryl crystals. The upper contact of the core dips steeply southeast.

Muscovite of exceptionally fine quality is present in the wall zone along the hanging wall contact. It is flat, firm, and in general free from structural defects, and it yielded an unusually high proportion of good sheet during 1943–44. The ratio of mine-run mica to rock moved, however, was very small. Good block feldspar was produced prior to mica mining, and more can be recovered from the pegmatite in the inclined floor of the mica workings. Recovery of a small quantity of beryl can be anticipated if the mine is operated for feldspar.

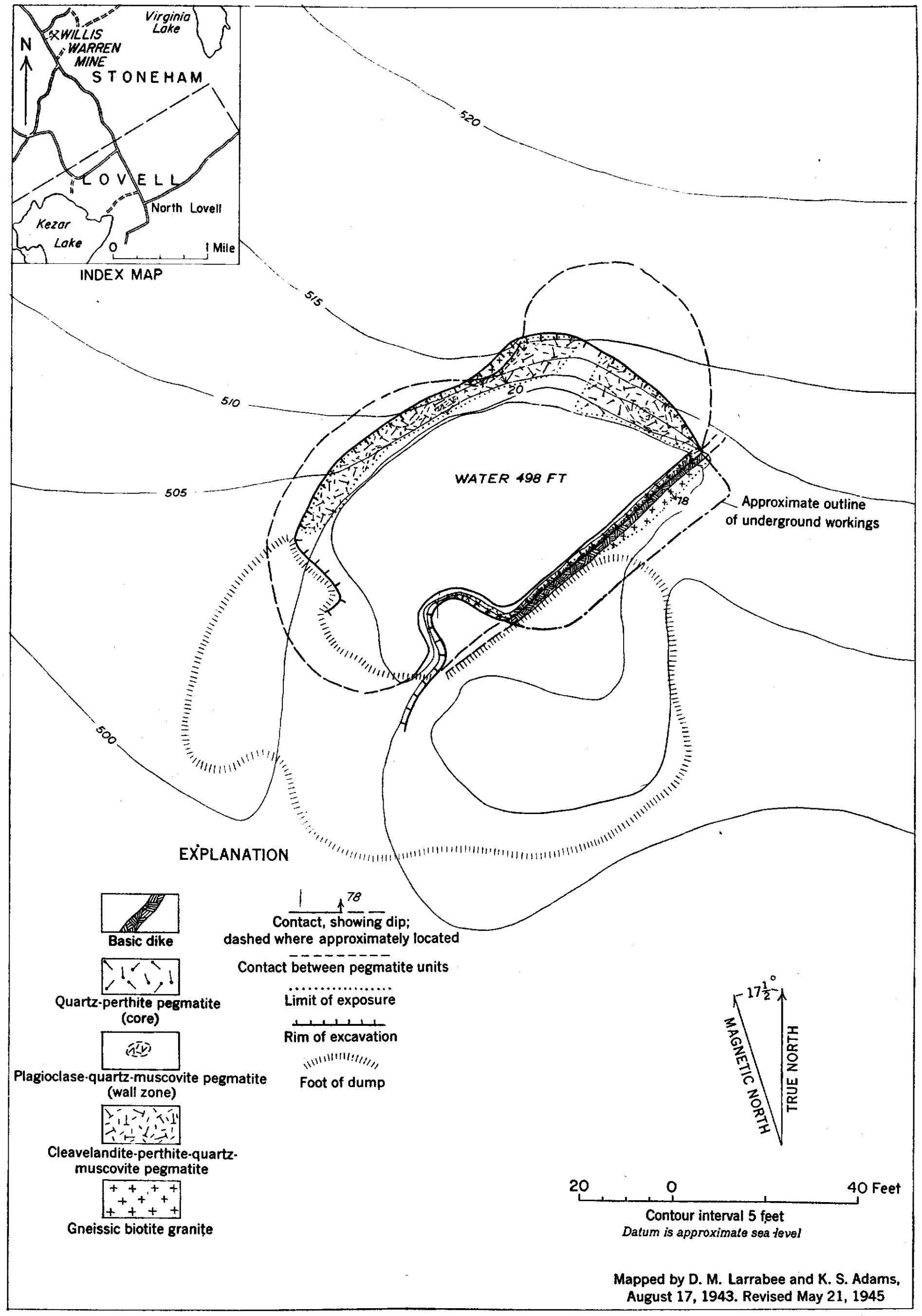


FIGURE 33.—Geologic map of the Willis Warren feldspar quarry, Stoneham, Maine.

SAGADAHOC COUNTY

CONSOLIDATED FELDSPAR QUARRY

The Consolidated (Golding's) quarry is in the town of Georgetown, 2.2 miles S. 16° W. of the village of Georgetown and 0.25 mile east of Todd Bay on the Kennebec River. To reach the quarry from Georgetown, follow the Bay Point road approximately 2 miles south to the poorly indicated quarry road turning off to the southwest. Follow this about 0.7 mile to the main pit. The deposit is owned by the Consolidated Feldspar Co. of Trenton, N. J., and Topsham, Maine. Bastin (1911) studied the geology of the quarry in 1906 and 1908. It was mapped in October 1942 by D. M. Larrabee, I. S. Fisher, and G. H. Brodie (pl. 7).

According to Bastin (p. 105) the deposit was worked intermittently from 1876 until 1906, when it was being operated by Golding's Sons Co., Trenton, N. J. The quarry was operated by the present owners for several years; their work ceased in February 1942. The chief development is an opencut 780 feet long and 50 to

250 feet wide. It is reported to be as much as 110 feet deep at the south end, where the pegmatite was stoped southward beyond the pit wall. The south end and the central part of the pit were flooded at the time of examination. Several small opencuts have been made on the hill northeast of the main working.

Many large pegmatites are exposed on the property; the largest trends N. 25° W. and appears to dip vertically. The northwest and southeast ends plunge in opposite directions. Relations to wall rock are variable and poorly exposed, and little could be determined concerning the shape of most of the pegmatites. The wall rock is interbedded quartz-muscovite-biotite schist and impure, micaceous quartzite that in general strike north and dip steeply west. It is garnetiferous at and near contacts with the pegmatites.

The margins of the pegmatites are commonly fine-grained and in places garnetiferous. Inward from the margins, the pegmatites contain fine- to medium-grained wall zones that consist of quartz, plagioclase, perthite, and muscovite. The muscovite books are mostly 1 inch or less in diameter. Biotite is rare. Watermelon and green tourmaline, together with lepidolite, occurs in fractures in the medium-grained pegmatite at the small opencut 275 feet east of the north end of the large pit. Small bodies of clear, smoky, and rose quartz occur locally within the wall zones of all pegmatites. In the largest pegmatite there is an irregular intermediate zone composed of coarse-grained graphic granite and perthite, with small quartz lenses.

Yellowish-green beryl crystals were observed in a small quartz lens enclosed in the intermediate zone in the northeast wall of the main pit and in a large vertical quartz core that was left as an island or small column within the pit. The core is surrounded by graphic granite and coarse-grained quartz-perthite pegmatite. It contains beryl crystals ½ inch to 18 inches in diameter. Of the 139 crystals seen, 59 are more than 2 inches across, 65 are between 1 and 2 inches, and 15 are less than 1 inch across. The crystals have a total surface area of 15 square feet and amount to about 6 percent of the beryl-bearing quartz on the north and west sides of the core, or possibly 0.5 percent of the entire quartz body. One ton of beryl may remain in the dump at the foot of the core. Gummite, autunite, and many large black tourmaline crystals occur with the beryl.

Some large irregular perthite masses have been recovered from within the graphic granite that forms the central part of the largest pegmatite, but most of the perthite was mined near the southeast end of the pit, where the pegmatite plunges beneath the schist. This feldspar body is surrounded by graphic granite. The body is 100 feet wide and is said to be at least 80 feet thick. The stopes were flooded and could not be examined.

Except for the feldspar unit and a few coarse-grained lenses of perthite and quartz, the pegmatites in the area mapped are fine- to medium-grained and contain large quantities of graphic granite. Reserves of high grade perthite in large crystals could not be determined, but the largest amounts are probably in the south end of the large pit, provided the unit has not been mined out below water level. No muscovite of sheet quality was observed, and none has been reported. A small tonnage of easily recoverable beryl occurs in the quartz core within the large pit.

COOMBS FELDSPAR QUARRY

The Coombs quarry is in the town of Bowdoin, 2.5 miles N. 35° W. of the village of Bowdoinham. To reach it from Bowdoinham, drive northwest 2.1 miles on Route 125, and follow an old road north about 1 mile to the quarry. Benjamin Coombs, Bath, Maine, owns the land, and Caesari Trusiani owns the mineral rights. The deposit was studied in May 1942 by L. R. Page and J. B. Hanley. It was examined by the Maine Geological Survey (Trefethen, 1945, p. 40) in 1943 and mapped in November 1943 by J. J. Page and L. Goldthwait (fig. 34).

Workings include five open pits, all flooded at the time of examination. The quarry has been operated intermittently for many years. It was worked most recently by Trusiani for feldspar, scrap mica, and beryl during the period August–October 1943.

The pegmatite is exposed in workings that lie along a line trending N. 20° E. and in a few small outcrops between the pits and west of them. The west contact strikes about N. 25° W.; it is nearly vertical where exposed in the west side of pit 1. In pit 3, the contact strikes about N. 10° E. and dips 35°–60° NW. The wall rock is coarse tourmalinized biotite schist. It is strongly contorted but in general strikes east and dips 30°–40° N. In places small offshoots of the pegmatite extend into the schist along foliation planes, forming an injection gneiss. There are small exposures of pegmatite west of the main pegmatite, apparently separated from it by schist.

The pegmatite has a narrow aplitic border zone that grades into a medium-grained wall zone 3 to 8 feet thick composed of graphic granite containing blades of biotite. Inside this is a unit composed of coarse perthite that encloses irregular quartz pods 2 to 10 feet long and 2 to 3 feet wide. The pods have their long axes parallel to the strike of the west contact. The quartz bodies may be the discontinuous core of the pegmatite. Beryl crystals and mica books are most abundant near the quartz pods. It is reported that

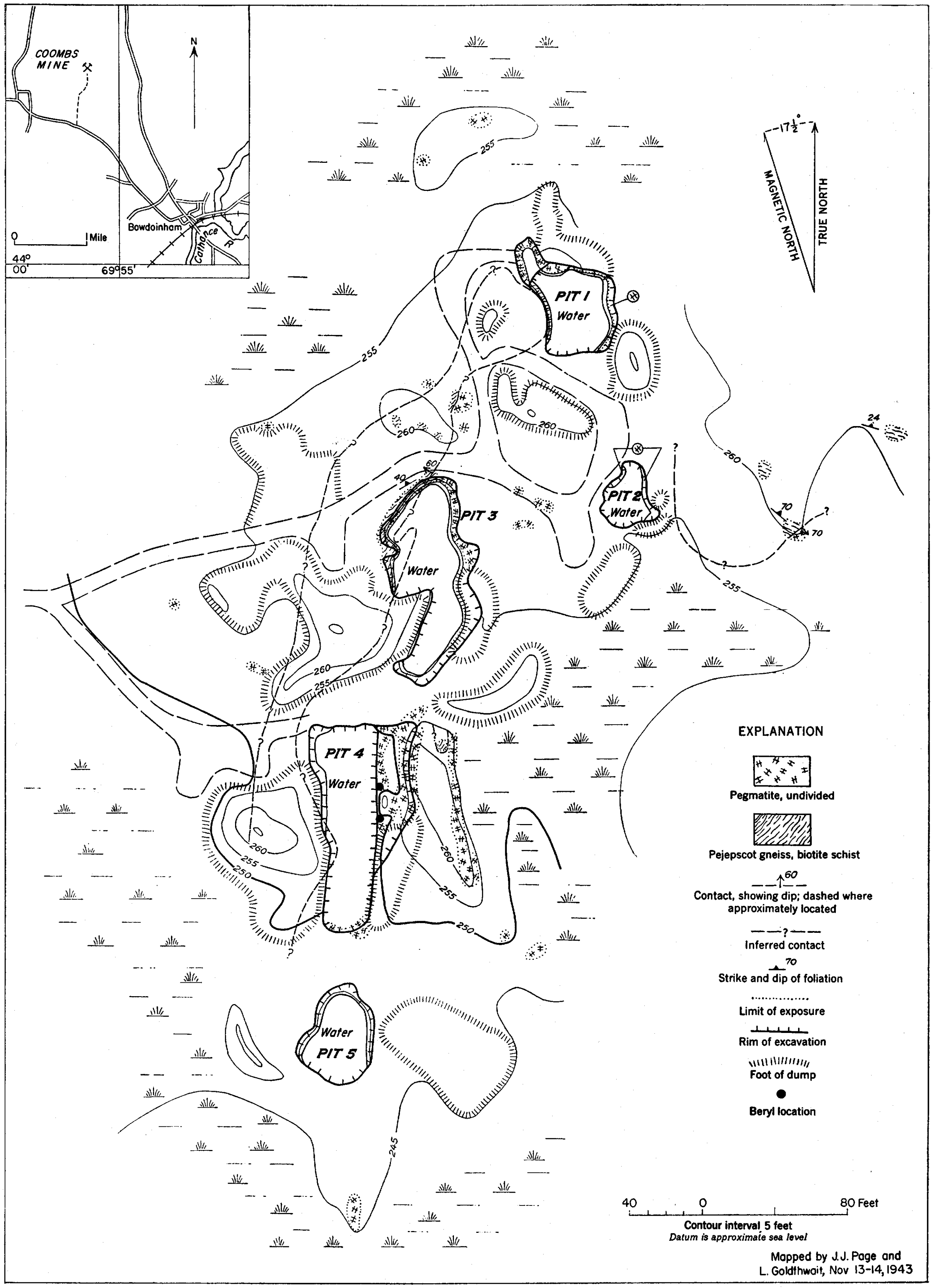


FIGURE 34.—Geologic map of the Coombs feldspar quarry, Bowdoin, Maine.

masses of columbite-tantalite weighing as much as 15 pounds, were recovered from the contact between the perthite and biotite pegmatite. Black tourmaline and garnet occur throughout the pegmatite.

Perthite and coarse graphic granite have been produced from this deposit. Most of the beryl crystals are dark greenish-blue and small, but a few crystals are 15 inches by 6 inches. The crystals occur with wedge mica and appear to be most abundant near the quartz mass in the east wall of pit 4. Golden beryl is present in the dumps, but none was seen in place. Much of the mica is ruled and further damaged by "A" and wedge structures. Some medium-sized sheet was recovered by Trusiani, but most was small and of such quality that it could not be mined profitably at the time.

DAVIS MICA MINE

The Davis mine lies in the town of West Bath 2.0 miles S. 46° W. of the center of the city of Bath. To reach it from Bath, drive 1 mile westward on U. S. Highway 1 to a secondary road that leads 0.8 mile southward to the Davis farmhouse. The mine is about 400 feet south of the house.

The property is owned by Warren Davis of West Bath, and was operated by a Mr. Seppala until January 1943. William Bryant of Wilson's Mills, Maine, operated the mine intermittently in 1944. The workings consist of an open pit 80 feet long, 10 to 20 feet wide, and 17 feet in maximum depth. About 700 tons of rock had been mined as of June 1944. The pit was flooded in October 1944 but apparently was not backfilled. The mine was mapped by V. E. Shainin and K. S. Adams in June 1944 and revisited by Shainin and A. H. McNair in October 1944 (fig. 35).

The pegmatite has an outcrop length of 80 feet and a maximum outcrop width of 19 feet. It is probably a sheet or lens. The contact is exposed only in the western face of the quarry, where overlying wall rock is cut discordantly by the pegmatite. The contact strikes N. 35° W. and dips 80° SW. Outcrops of country rock southeast of the quarry suggest that the pegmatite either ends within a short distance or plunges southeastward. The wall rock consists of interbedded medium- to coarse-grained feldspathic biotite-garnet gneiss, fine-grained biotite-garnet quartzite and medium-grained quartz-mica schist. These rocks are folded and intruded by thin stringers and lenses of pegmatite. The foliation of the wall rock strikes a few degrees east of north and has a steep or vertical dip. Two areas of wall rock exposed in the east face of the quarry may be xenoliths or irregular projections from the east wall of the dike.

The pegmatite is indistinctly zoned. The border zone is 1 to 10 inches thick and consists of fine-grained quartz, plagioclase, and accessory garnet and tourmaline. Locally the zone consists almost entirely of quartz and muscovite, or of quartz and plagioclase. The wall zone, 0.5 to 1 foot thick, consists of medium-grained quartz, plagioclase, muscovite, and accessory perthite, garnet and green apatite. In several places the zone is either very thin or absent. The quartz-perthite intermediate zone is exposed only in the western part of the body. It is at least 10 feet thick and consists of medium- to coarse-grained quartz, perthite, and plagioclase, with accessory muscovite, tourmaline, garnet, and apatite.

Two large oval quartz pods, each 15 to 20 feet in maximum diameter, are exposed in the eastern face of the quarry. A few widely separated books of mica lie at or near the margins of the masses. Their quality is reported to be very poor. A few large perthite crystals are associated with the pods.

The mica from the wall zone is rum to ruby. The books range from 1 inch in diameter and ⅛ inch thick to 10 inches in diameter and 8 inches in thickness. The books average 3 inches in diameter and ¼ inch in thickness. Most of the books show "A" structure and a few exhibit reeving and ruling. Some of the books are slightly curved, but a few are flat. The mica is hard, and is rarely stained although some contains inclusions of red garnet and black tourmaline. The visible part of the wall zone is narrow and contains little mica. Probably not enough sheet could be recovered to justify operations even under conditions comparable to those of 1943 and 1944.

PARKER HEAD AREA

The Parker Head area is in the town of Phippsburg, 9 miles south of the city of Bath, Maine, between the Kennebec River and Casco Bay. The area is about 3.4 miles long and 2.3 miles wide, and occupies about 7.8 square miles. Most of it is defined by Route 209 on the east, by Route 216 on the west, by the road from Ashdale to Popham Beach on the south, and by an old road extending westward from the village of Parker Head, on the north. Parker Head village, on Route 209, is in the northeast corner of the area. It was examined briefly in May 1942 by L. R. Page and J. B. Hanley and was mapped by pace and compass in September and October 1942 by D. M. Larrabee, I. S. Fisher, and G. H. Brodie (pl. 8). Traverses were spaced at intervals of about 500 feet.

There are many pegmatites ranging from small lens-shaped bodies to roughly tabular or irregular masses 2,000 feet long and 200 feet wide. Most of the pegmatites trend north and dip steeply westward. They form ridges that are separated by lowland and swamps underlain by wall rock. In the eastern half of the area, the wall rock is chiefly interbedded quartz-muscovite-

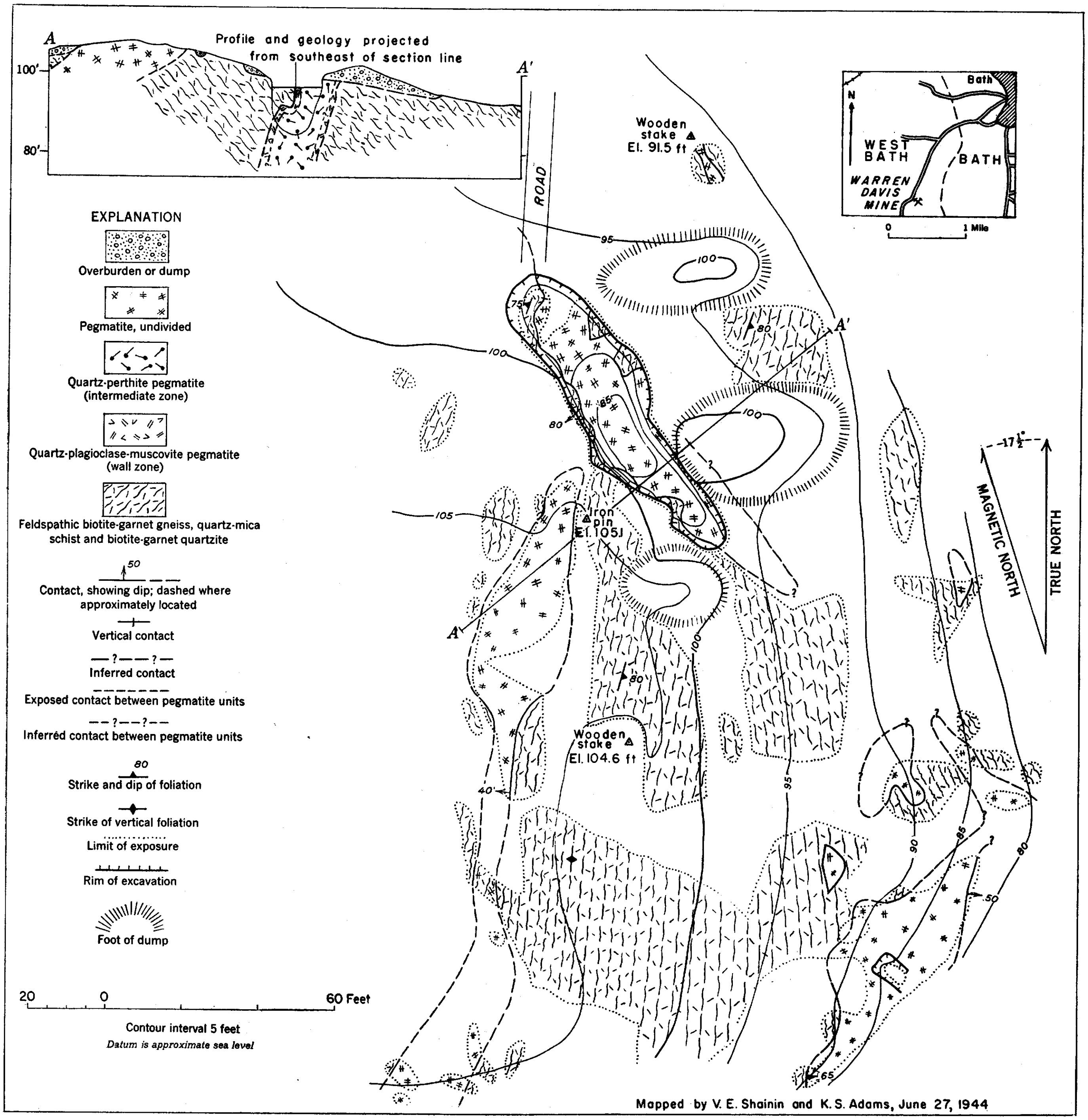


FIGURE 35.—Geologic map and section of the Warren Davis mica mine, West Bath, Maine.

biotite schist and micaceous quartzite. In the western part of the area, quartzite is more abundant than schist. Feldspathic biotite gneiss, injection gneiss, coarse-grained gneissic granite, and fine-grained biotite granite occur chiefly in an irregular band trending northward near the center of the area. Complete gradations from pegmatite to gneiss, indicating replacement of gneiss by pegmatitic material, are present in all but the westernmost part of the area. The pegmatites contain small irregular inclusions of the biotite granite, and in most places the boundaries between pegmatite and granite are gradational. In general, the wall rocks strike a few degrees east of north and dip steeply westward.

The pegmatites are similar in mineral composition and texture. Thin wall-rock remnants commonly adhere to the east and west sides of the outcrops. The pegmatites contain narrow aplitic border zones consisting of quartz, plagioclase, muscovite, tourmaline, apatite, and garnet. Inside these are wall zones composed of medium-grained quartz, plagioclase, perthite, muscovite, and biotite, with small amounts of apatite, garnet, and tourmaline, and sparsely distributed beryl crystals. Both green and golden beryl occur as small crystals in quartz-rich parts of the wall zones of the eastern pegmatites. Magnetite and ilmenite occur with fine-grained quartz and plagioclase as small irregular, kidney-shaped pods in the outer parts of the wall zones of many pegmatites, particularly those in the southern half of the area. Similar pods occur in the fine-grained biotite granite. Some of the pegmatites have discontinuous, irregular central cores of coarse-grained quartz, perthite, and graphic granite. Green beryl is associated with these cores in a few places.

The fine- to medium-grained texture of the pegmatites on outcrop surfaces, the thin remnants of wall rock and aplite adhering to the sides and upper surfaces of the outcrops, and the increase in size of crystals with depth in the open-cuts suggest that erosion has exposed only the tops of the bodies. The close spacing of the pegmatites, together with the textural relations, may indicate that the bodies are parts of an undulating upper surface of one or more large, sheetlike pegmatites.

Small tonnages of feldspar have been produced from quarries in the area. Both grain size and perthite content increase downward in these pegmatites, and exploration to depths greater than the present maximum of of 30 feet might reveal additional deposits of block feldspar. No sheet-bearing mica deposits that could be operated profitably under 1942-44 conditions were observed. All pegmatite outcrops were examined for beryl, but few crystals were found.

RUSSELL BROTHERS' MICA MINE

The Russell Brothers' mine lies in the town of Topsham, 0.8 mile S. 84° W. of the village of Topsham. To reach the property drive 0.8 mile west from the center of Topsham on a hard-surfaced road. From this point a winding gravel road, the first one east of the Russell farmhouse, leads 0.8 mile southwest to the mine.

The property is owned by Hughbert, Strafford, and Hiram Russell, all of Topsham. Joseph Pechnic of South Paris, Maine, is said to have begun operations by working the pegmatite for feldspar about 1930. Earl Williams of Brunswick, Maine, leased the mine in September 1943 and operated it for mica and feldspar until the fall of 1944. V. E. Shainan and K. S. Adams mapped the mine in June 1944 (fig. 36), and it was revisited five months later by A. H. McNair and Shainin.

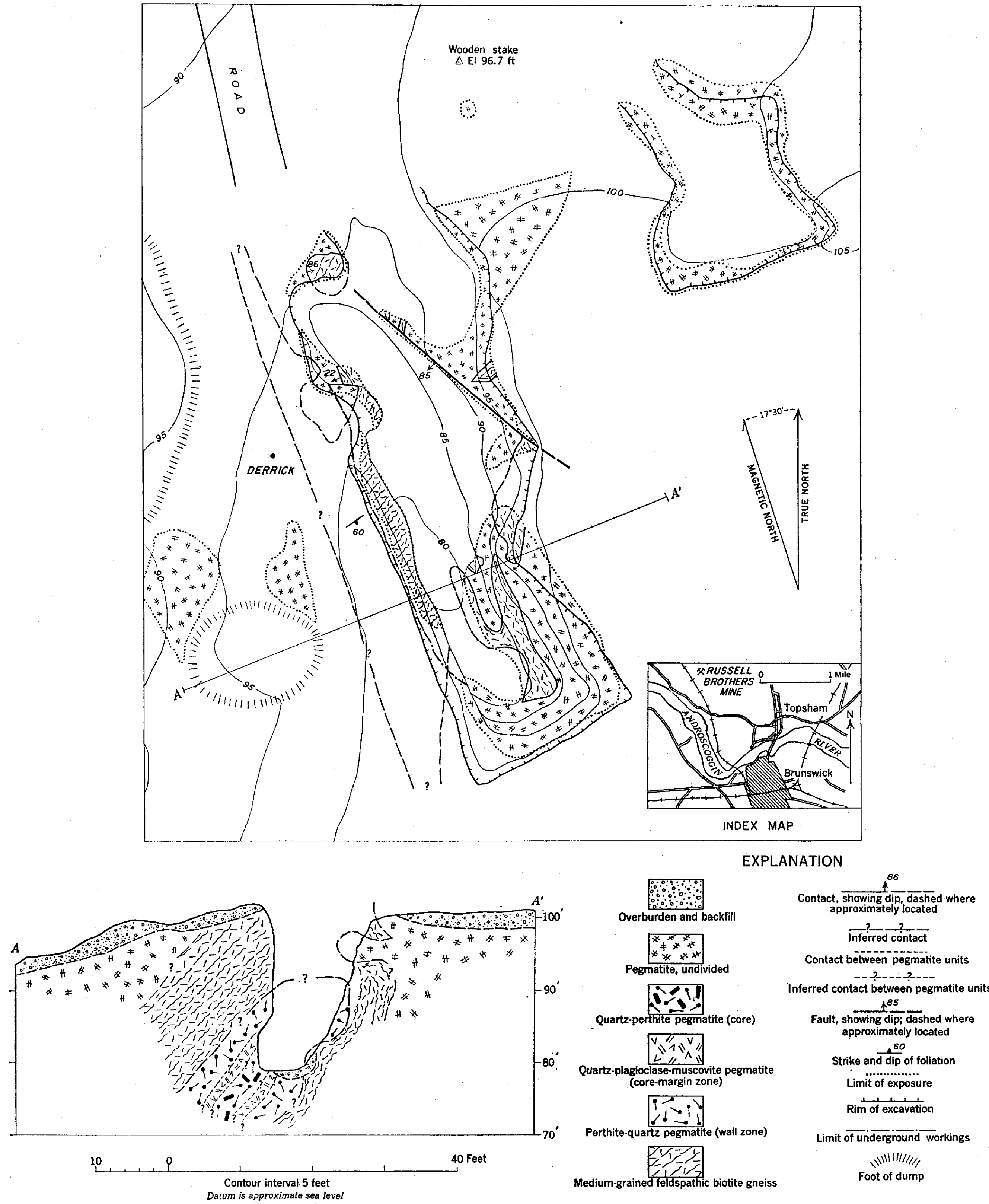
The workings consist of three cuts. The largest was the site of the recent operations and is the only one that has been worked for mica. It is 75 feet long, 20 feet wide, and 20 feet deep. The other two cuts are small prospect pits less than 10 feet deep. The large cut was flooded late in 1944.

The pegmatite apparently consists of interconnected bodies that are parts of a large complex body. The contacts are irregular, and only partly exposed. The sheetlike part of the pegmatite mined in 1943–44 is about 80 feet long and 10 feet thick. It strikes N. 20° W. and has an average dip of 45° W. In places it is discordant to the wall rock, which is a medium-grained feldspathic biotite gneiss. Some of the gneiss is contorted and contains numerous lenses of aplite, and the aplite and pegmatite have been injected lit-par-lit into the gneiss. A fault cuts the pegmatite in the northeastern corner of the pit; neither its direction nor amount of displacement along it are known.

The pegmatite is a medium- to coarse-grained mixture of quartz, perthite, and plagioclase, with accessory scrap muscovite, biotite, and garnet. The productive part of the pegmatite consists of the following zones:

1. Border zone, ½-inch to 3 inches thick. Consists of fine-grained quartz, plagioclase, and perthite with accessory muscovite and garnet.
2. Perthite-quartz wall zone, 3 to 4 feet thick. Consists of medium- to coarse-grained perthite and fine- to medium-grained dark milky quartz, with a subordinate amount of plagioclase and accessory muscovite, garnet, columbite-tantalite, biotite, and rare black tourmaline. Perthite occurs in coarse anhedral crystals and in graphic intergrowths with quartz. Plagioclase is more common along the margins of this zone than in the center.
3. Quartz-plagioclase-muscovite core-margin zone, 1 to 2 feet thick. A poorly defined discontinuous core-margin zone, consisting of quartz, equant white plagioclase, sheet-bearing muscovite, and coarse-grained perthite.
4. Quartz-perthite core, 4 feet thick. Exposed for 30 feet along strike, appearing to pinch out along strike in the quarry both to northward and southward. Consists of coarse-grained quartz and anhedral to subhedral perthite, with accessory beryl. Beryl is rare. It occurs in quartz in green euhedral prisms ½ inch in diameter and 1 inch in length to 6 inches in diameter and 2 feet in length.

The mica deposit in this pegmatite is of the core-margin type. The books are pale green and show many structural defects, the most serious of which are reeving, ruling, "A" structure, and cross-fracturing. Some books are wedge-shaped. Most of the mica is neither hard nor flat, but most is unstained. The books average 4 to 5 inches in diameter; the largest book recovered is reported to have been 2 to 2½ feet across and 18 inches thick, and to have weighed about 240 pounds.



Mapped by V. E. Shainin and K. S. Adams, June 23, 1944

Figure 36.—Geologic map and section of the Russell Brothers mica mine, Topsham, Maine.

Recovery of mine-run mica to the end of 1944 was slightly more than 1 percent of the total rock mined, and it is likely that mica in the core-margin deposits will continue to be irregular and "spotty" in distribution. Extreme irregularities in the structure of both walls at depth would not be surprising, and it is possible that such irregularities are accompanied by radical changes in the zonal structure and in the mica content. The content of recoverable sheet mica in mine-run mica is probably low.

THOMAS FELDSPAR QUARRY

The Thomas quarry is in the town of Phippsburg, 1.3 miles S. 17° W. of the tide mill in the village of Parker Head. To reach it from this village, drive south 1.6 miles on Route 209, the Popham Beach road, to the Thomas residence west of the highway. An old quarry road leads northwest from a point on the highway about 200 feet north of the house; follow this road 0.6 mile to the quarry. E. P. Thomas is the owner. It was examined by L. R. Page in June 1942, and was studied and mapped in October 1942 by D. M. Larrabee and I. S. Fisher (pl. 9).

The quarry was opened in 1914 by the Eureka Flint and Spar Company, Trenton, N. J., who mined feldspar from the cut in the west ridge. It was operated later on a small scale by A. E. Buzzo for Golding's Sons Co., Trenton, N. J., and Topsham. In 1929 it became the property of Thomas, from whom it was leased in 1937 by Messrs. Adams and Dean of Yarmouth, who obtained a few hundred pounds of beryl from the dumps and from the small trench along the road to the main pit. Since then Thomas has prospected the many pegmatites by means of small trenches and shallow pits, and has recovered a few golden beryl crystals of gem quality.

Large and small pegmatites are present on the property. The large pegmatites trend a few degrees east of north and have dips ranging from steep east to steep west. The small pegmatites have gentler dips. The largest pegmatite, which forms a ridge along the west margin of the area mapped, is about 2,000 feet in length and 100 feet in average width. The large ridge-forming pegmatite in the eastern part of the map area is probably 1,000 feet long and 70 to 124 feet wide. Low flat outcrops of pegmatite occur between these ridges. The low outcrops in the southern part of the area mapped consist chiefly of pegmatite containing inclusions of wall rock. Exposures in the northern part are chiefly schist containing small lenses of pegmatite; in all prospect pits pegmatite underlies the schist. If these outcrops had been more deeply eroded pegmatite might have been the most abundant rock exposed. The wall rock is fine-grained faintly foliated quartz-feldspar-biotite-muscovite granite, biotite gneiss, and interbedded quartz-mica schist and micaceous quartzite. The foliation and bedding strike a few degrees east of north and dip 50°–70° W. Thin remnants of the walls, impregnated with pegmatite and containing tourmaline and garnet, are present on the sides and tops of many pegmatites. The contacts between pegmatite and granite are gradational in many places.

In some places the border zones of the pegmatites are aplitic and contain bands of small garnets parallel to the walls. In others they contain graphic intergrowths of quartz and muscovite. The wall zones are fine- to medium-grained and contain quartz, plagioclase, perthite, biotite, muscovite, and tourmaline. Fine-grained graphic granite is widespread. Green and blue-green apatite crystals (analyzed by K. J. Murata of the U. S. Geological Survey) less than ¼ inch in diameter are common; many of these are clear and resemble beryl. Garnet occurs in crystals as much as 1½ inches in diameter, and a few small green and golden beryl crystals are exposed. Most of the beryl is in or adjacent to irregular quartz-perthite lenses enclosed in the medium-grained pegmatite of the wall zones. In the main quarry and in each of the small pits and trenches, the texture becomes coarser with depth, but few of the feldspar crystals exceed 12 inches in diameter. Rum to ruby muscovite books commonly occur in coarse-grained quartz-perthite-plagioclase pegmatite lenses. The books are small and have "A" and wedge structures. Few would yield sheet mica. Mica books are present in places, near inclusions, but nowhere do they constitute a zone or well-defined unit.

The coarse-grained pegmatite that is crossed by the quarry road 900 feet northwest of the Thomas residence contains tapering green beryl crystals 2 inches in diameter and as much as 16 inches long. These are in quartz and perthite at the sharp bend in the cut, 40 feet west of the road. The golden and green crystals of gem quality are small, and are in quartz masses 40 feet south of the larger crystals. Beryl is present in an outcrop 1,000 feet west of the house and in exposures southeast of the area mapped. Altogether, 74 beryl crystals having a total surface area of 0.69 square feet are present in 311 aquare feet of coarse pegmatite. The beryl-bearing parts of the pegmatites, containing 0.22 percent beryl, represent only 0.09 percent of the total exposed pegmatite. About 350,000 square feet of exposed pegmatite is estimated to contain about 0.0002 percent beryl.

The low beryl content of the bodies, together with difficulties in extraction and separation of the mineral, prevented the development of these pegmatites in 1942-44, although some gem beryl was recovered by careful hand sorting. The quality and quantity of mica did not justify mining for this mineral. Where exposed, the pegmatites do not contain large quantities of easily recoverable feldspar, but large crystals of hand-separable feldspar may occur at depth in some of the pegmatites.

TROTT COVE MINE

The Trott Cove mica mine is in the town of Woolwich, near the head of a small cove on the east bank of the Kennebec River, 0.7 mile S. 20° E. of West Woolwich. From West Woolwich, follow State Highway 128 southeastward for 0.6 mile to a dirt road on the right. Follow this dirt road to the house at the top of the hill and continue on a wood road for about 0.2 mile southwest to the mine. The property is owned by Sam Guptill of Woolwich and was leased and operated intermittently for about a year prior to October 1943 by Earl F. Williams, 20 Bath Street, Brunswick, Maine. The mine was mapped by R. Miller and L. Wing of the Maine Geological Survey, Maine Development Commission, in July 1943 and was visited by J. J. Page and L. Goldthwait in November 1943.

Workings consist of two small cuts, respectively, 70 feet and 210 feet north of the river. The south cut, worked in the winter of 1942–43, is 35 feet long, 10 feet wide, and 2 to 5 feet deep. The north cut, opened in April 1943, is 40 feet long and 15 feet wide and has a maximum depth of 20 feet. It contained about 5 feet of water in November 1943.

The cuts were opened in separate pegmatites that strike about N. 50° W. and dip 50° SW. Although poorly exposed, the pegmatites appear to be lenses in coarse-grained biotite gneiss. They are roughly conformable to the strike of foliation of the gneiss but cut across the dip, which is about 50° NW.

The north cut was opened in the only outcrop of this pegmatite. The maximum thickness of the pegmatite is probably not more than 12 feet. Mining has exposed it for 8 feet below the hanging wall. The strike length of the pegmatite is unknown. The northwest face of the cut appears to show a zonal arrangement of the minerals. Against the hanging wall there is a distinct wall zone, 8 inches thick, consisting chiefly of muscovite with subordinate amounts of plagioclase and quartz. The footwall part of the zone was not visible but was reported to contain less mica. Most of it was in small "tanglesheet" books. Inside the wall zone is an intermediate zone of perthite approximately one foot thick, within which is a core of gray quartz 3 feet thick. On the footwall side of the pegmatite a finer-grained plagioclase-quartz zone lies between the perthite zone and the mica zone. Green to golden beryl crystals less than 1 inch in diameter but as much as 1 foot long are found on the dump.

The south cut was opened along the footwall of a pegmatite that extends at least 60 feet southeast of the working. The maximum exposed thickness is about 10 feet; the hanging wall is concealed. No zonal arrangement of minerals was noted. Plagioclase, quartz, and perthite are the major constituents. Muscovite is present in the dump but is small, stained, and largely tanglesheet.

Muscovite from the mica zone along the hanging wall in the north cut is green, and most of the books are heavily stained. It is flat, free-splitting and of satisfactory size, however, and yields some clear sheet. Many books 1 inch thick extend completely across the 8-inch width of the mica zone. Approximately 3.0 percent of the rock mined over an 8-foot mining width during 1942–43 was mica.

Operations in 1942–43 yielded a satisfactory amount of mine-run muscovite. The mica, however, was green and yielded only a small percentage of sheet. The mine probably could not be operated profitably under conditions similar to those of 1942–44.

NEW HAMPSHIRE

BELKNAP COUNTY

STORER MICA PROSPECT

The Storer prospect lies in the town of New Hampton 3.7 miles S. 83° E. of the village of Bristol. To reach it from Bristol, follow the old Bristol-New Hampton road across the Pemigewasset River for 2.6 miles to the Fisk School, which is located at a road intersection. Turn left and proceed 1.0 mile to an unimproved road on the right; turn right and proceed 1.2 miles to a farm lane on the left; then follow the farm lane 0.2 mile to a dilapidated farm house. The prospect is on the southwest end of a hill, approximately 0.2 mile east of the farm house. The property and mineral rights are owned by Vernon King of Meredith, N. H. A small cut was excavated in 1933 or 1934. The property was examined in May 1944 by Glenn W. Stewart.

The pegmatite is a lens that is 30 feet wide and can be traced about 100 feet along strike. It strikes about N. 50° W. and dips 40° SW. It is essentially concordant to the foliation of the enclosing quartz-mica schist.

The pegmatite has a narrow border zone, 1 to 3 inches thick, consisting of fine-grained quartz and muscovite. Inside the border zone is a medium- to coarse-grained core composed of plagioclase, quartz, minor amounts of perthite, and muscovite. The muscovite books average 2½ by 2½ inches. They are cracked and ruled, and only sparsely disseminated through the pegmatite.

Neither the quantity nor size of the mica books appeared to warrant further prospecting during 1944.

CARROLL COUNTY

WEEKS FELDSPAR QUARRY

The Weeks quarry, 1 mile S. 30° W. of Province Lake, is in the town of Wakefield 5.6 miles S. 78° E. of Ossipee village. To reach it from this village, drive east 3.2 miles to Granite, and turn right at the crossroad. Go southeast 3.1 miles, passing through crossroads at 1.8 and 2.4 miles, to a trail leading 0.1 mile south to the quarry. The deposit, owned by Raymond B. Weeks, Burleysville, N. H., was studied and mapped in June 1942 by L. R. Page, whose geological work is embodied in the Bureau of Mines War Minerals Report 81 (Bardill, 1943). It was examined in August 1942 by H. M. Bannerman. In November and December 1942 it was remapped in greater detail and studied by D. M. Larrabee, G. H. Brodie, and J. B. Headley, Jr. The property was explored for beryl by the Bureau of Mines at this time. The quarry was visited and the map revised in May 1945 by Larrabee and K. S. Adams (fig. 37), to show development.

The open pit is 125 feet long, 65 feet wide, and about 35 feet deep. Work at the quarry began in the 1920's, when feldspar, scrap mica, and beryl were recovered. In the early 1930's, a Mr. Day, Kittery, Maine, operated the quarry for feldspar and scrap mica; since then it has been idle. In September 1942, J. D. Bardill, District Engineer for the Bureau of Mines, arranged a sampling program under the direction of E. E. Maillot and W. H. Evans. The Bureau of Mines quarried beryl from the north and west sides of the pit, dug 10 small pits and trenches, and drilled 5 horizontal jackhammer holes 12 to 16 feet long in an effort to locate the contacts of the pegmatite. They also pumped out the flooded part of the pit.

The pegmatite body appears to be oval in plan; it is about 160 feet long in an easterly direction and 75 feet wide. The north contact dips about 45° southward where encountered in drill holes, and the south contact dips about 85° S. The wall rock is pink to gray coarse-grained granite that may be genetically related to the pegmatite. The granite is best exposed south of the pit. A fine-grained basic dike cuts pegmatite and granite and is exposed in the east and north faces of the quarry and in the prospect pit to the east.

Along the south contact, the border zone of the pegmatite consists of a 2-inch band of fine-grained quartz and plagioclase (An_{19}) that grades inward into 1 to 2 inches of graphically intergrown quartz and muscovite. The wall zone is 10 to 25 feet thick and consists of white and pink albite (An_{7-8}), interstitial quartz, muscovite, and flesh-colored perthite. Many 1-inch garnet crystals are present, and small quartz bodies are scattered through the zone. Lenses of yellowish-green wedge muscovite occur in the albite-rich parts of the zone. The books of muscovite are 6 inches to 2 feet long. Blue-green beryl crystals are associated with the wedge mica and are commonly surrounded by a narrow border of small muscovite books and albite. Chayes (1944, p. 320) discovered and described the occurrence of chrysoberyl in thin plates between the beryl and enclosing minerals, and between the small books of muscovite. Cleavelandite is a common accessory mineral in the zone. Masses of intergrown columbite and samarskite weighing as much as 60 pounds occur in albite, which is discolored reddish brown at the contacts. Scattered flakes of molybdenite occur with the plagioclase and quartz of the wall zone in the west face of the pit. A large body of quartz exposed in the southeast part of the pit forms the core of the pegmatite.

The pegmatite was richest in beryl in a bulge extending south from the north face of the quarry. Here 145 crystals, ranging from ¼ inch to 6 inches in diameter and from 1 to 23 inches in length, occurred with wedge mica and plagioclase. The Bureau of Mines personnel quarried this part of the body, recovering one ton of beryl from about 300 tons of pegmatite. Few crystals are present in the remaining vertical face, but whether the beryl-bearing unit continues in depth has not been ascertained. Beryl occurred with muscovite and plagioclase in two lenses in the west face. Part of the face was removed, and about 500 pounds of beryl was recovered from an estimated 30 tons of pegmatite. The remaining face, which has an area of 18 square feet, contains 14 crystals with a total surface area of 1.38 square feet. Several crystals, all less than 5 inches in diameter, occur with wedge mica in the south face of the pit.

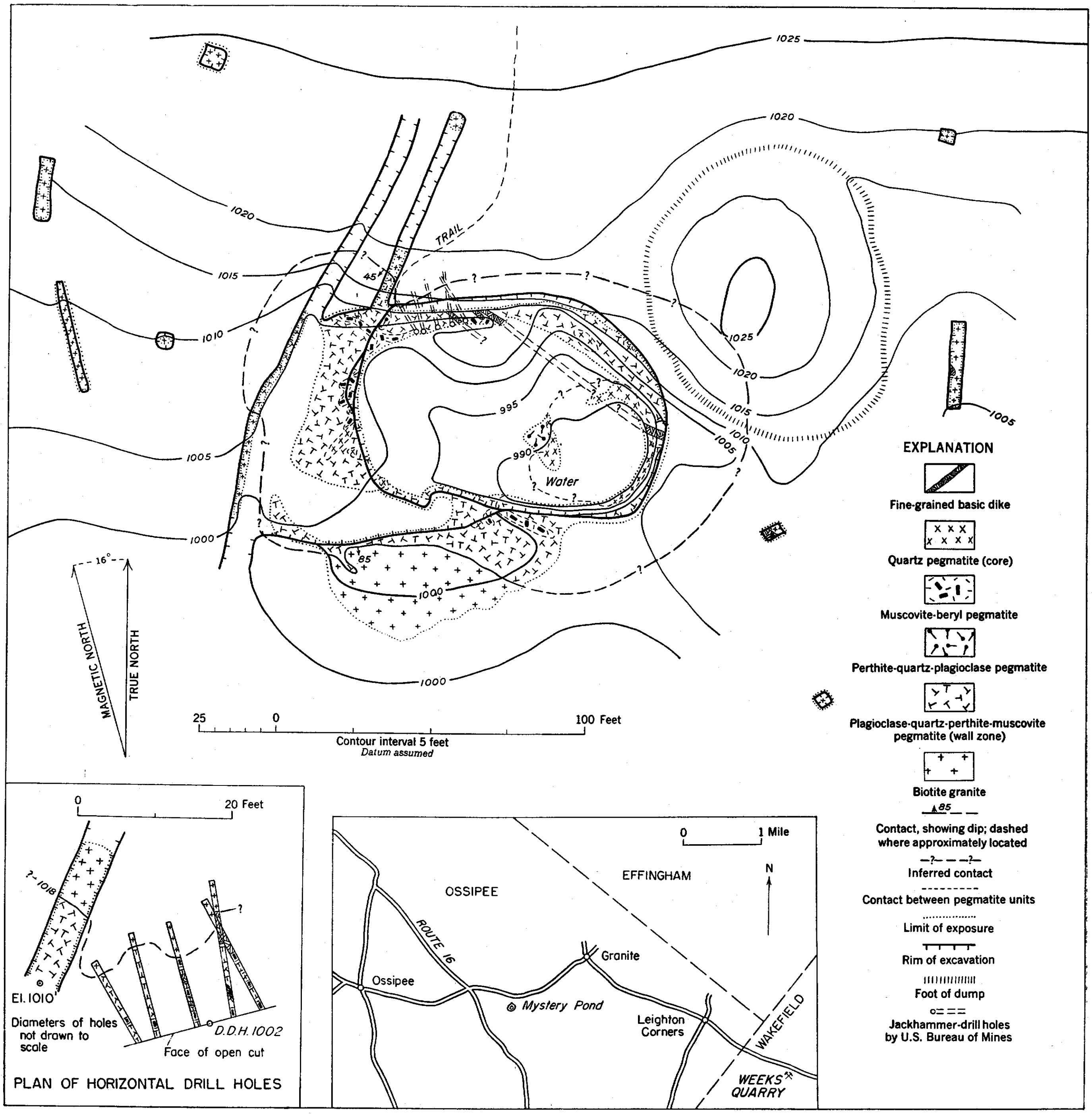
Muck covered the floor of the pit, so that it could not be examined, but small quantities of beryl, perthite, and scrap mica probably could be recovered by further operation of this mine.

CHESHIRE COUNTY

ALLEN FELDSPAR QUARRY

The Allen quarry (pl. 2, no. 5) lies in the town of Alstead 2.9 miles due east of Alstead village. To reach the quarry from Alstead, drive 2.9 miles eastward on State Highway 123 to its intersection with the main road. Follow this road northeastward 1.5 miles to the mine.

The property is owned and operated by the Golding-Keene Co., Keene, N. H. Operations began in May 1941 and were still in progress in March 1945. The workings consist of an open pit 250 feet long, 140 feet wide, and 100 feet in maximum depth. An ore bin of 150 tons capacity and a mill equipped with two jaw crushers and picking belt lie immediately west of the

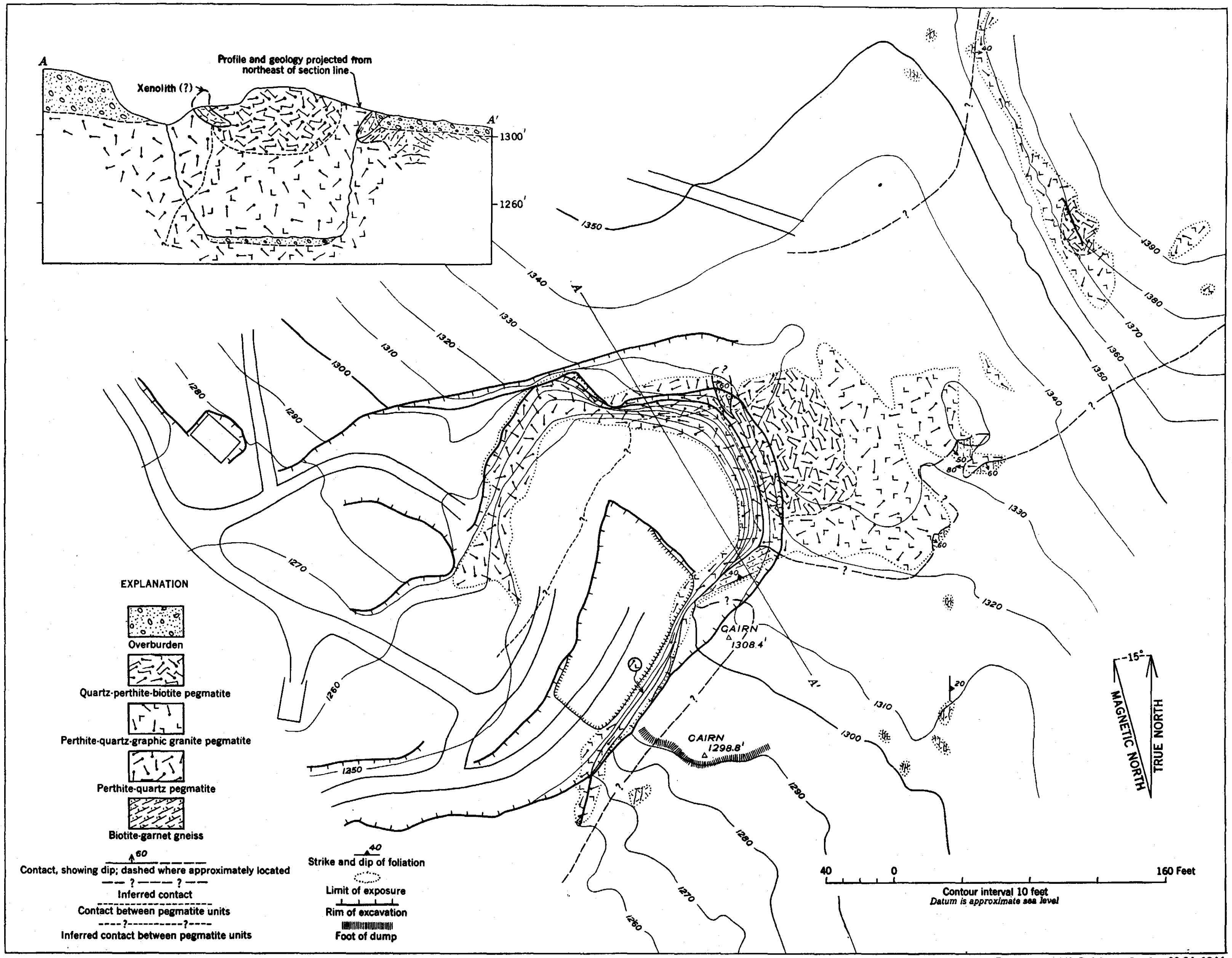


Mapped by D. M. Larrabee, G. H. Brodie, and J. B. Headley, November 7, 1942.
Revised December 5, 1942 and May 31, 1945

FIGURE 37.—Geologic map of the Weeks feldspar quarry, Wakefied, N. H.

quarry. The mine was mapped by V. E. Shainin and K. S. Adams in October 1944 (fig. 38).

The pegmatite appears to be an irregular tabular body. It has a length of at least 900 feet and is more than 100 feet thick in the vicinity of the quarry. It trends northeast and probably dips southeastward at a moderate angle. It is nearly conformable to the enclosing poorly foliated fine-grained gray to white dense biotite-garnet gneiss. The foliation in the area mapped appears to strike north to east-northeast and dips southeast at low to moderate angles. Numerous persistent shear joints cut the pegmatite and most of these strike N. 50° E. and dip 45° E. No mineralization along the joint surfaces is apparent.



Mapped by V. E. Shainin and K. S. Adams, October 22-24, 1944

FIGURE 38.—Geologic map and section of the Allen feldspar quarry, Alstead, N. H.

The pegmatite is rich in quartz and perthite and consists of four indistinct units. The border zone is 1 to 3 inches thick and averages ⅛ inch in grain size. It consists of quartz and perthite with accessory muscovite and garnet.

Two isolated units of quartz-perthite-biotite pegmatite are visible. Neither their form nor their relation to the walls of the pegmatite are known. The largest is 90 feet long. It consists of medium- to coarse-grained quartz, perthite, and plagioclase with accessory biotite, tourmaline, garnet, and muscovite. Milky quartz occurs in places in coarse-grained milky masses 4 feet in diameter; these are bordered by subhedral perthite crystals 4 feet long. Greenish plagioclase is present in many places in anhedral crystals. Biotite occurs in blades averaging ⅛ inch in thickness, 8 inches in length, and ¼ to ½ inch in width.

A perthite-quartz graphic granite unit forms most of the pegmatite exposed. The unit consists of anhedral perthite crystals 1 to 6 feet in diameter, together with quartz and graphic granite. The accessory minerals are plagioclase, black tourmaline, pink garnet, and muscovite. Bodies of coarsely crystalline quartz as large as the perthite crystals are not uncommon. Plagioclase occurs in pale-green anhedral ellipsoidal bodies, 1 to 4 feet in length, but these probably constitute less than 2 percent of the unit. Surrounding them is a 5-inch shell of perthite stained bluish-black by manganese oxide. Some muscovite occurs in coarse perthite, associated with small amounts of milky quartz. The mica books are grayish green and average 2 by 5 inches on cleavage faces and ¼ inch in thickness. Defects are common; they include herringbone structure, cross-fracturing, reeving, ruling, and inclusions of tourmaline.

Another unit, which consists of perthite-quartz pegmatite, may be the core of the pegmatite. It consists of anhedral perthite, in masses 4 to 20 feet long, with some coarse milky quartz and graphic granite. The accessory minerals are muscovite (in scattered books averaging ½ inch in diameter), tourmaline, and garnet. More perthite occurs in this unit in bodies relatively free from quartz intergrowths than in the units described above.

In the northeastern half of the quarry about 10,000 tons of the perthite-quartz unit is inferred to remain within 10 feet of the quarry face. Probably the unit extends farther, but there is no evidence of its shape or its relation to the walls of the pegmatite. The perthite-quartz graphic granite unit, which outcrops over a large area, is a poorer source of quartz-free feldspar because the quartz is more intimately associated with the perthite.

BEAUREGARD MICA MINE

The Beauregard (Boynton) mine (pl. 2, no. 14) is in the town of Alstead, one-fourth mile southwest of the French mine and 1.8 miles N. 28° W. of Gilsum village. To reach the mine from Gilsum, drive 1.6 miles north to a quarry road turning west. Follow the road about 0.5 mile west to the mine, which is on the land of J. H. and H. S. Tillson, Gilsum. The mineral rights are held by O. E. Cain, Keene. The mine and surrounding area were mapped in May 1943 by D. M. Larrabee, W. M. Hoag, W. H. Ashley, and H. R. Morris, and the mine itself was mapped in greater detail in June 1945 by Larrabee and K. S. Adams (pl. 10).

The mine was operated intermittently in the early 1900's, and was worked for mica by H. E. Boynton, Keene, during a 6-months period in 1936–37. It was idle until September 1943, when Arthur Whitcomb, Keene, made an operating agreement with Cain and mined mica until December 1943. The mine is a northwest-trending open pit 90 feet long, 20 to 40 feet wide, and 15 to 40 feet deep. The northwest half of the pit was excavated by Whitcomb. Four small open pits and prospect trenches have been made near the main pit.

Several pegmatites crop out in and near the mine. Most of these trend north and dip 35° to 70° E. They are in Bethlehem gneiss and in interbedded micaceous quartzite and quartz-mica schist of the Littleton formation. The foliation of the wall rocks strikes northeast to northwest and dips 17° to 74° E. The rocks are commonly tourmalinized and garnetized near the pegmatite.

The pegmatite west of the mine is about 240 feet long and 20 feet wide. It contains a narrow border zone of fine-grained pegmatite; a wall zone, 1 to 2 feet thick, composed of quartz, plagioclase, perthite, and muscovite; and a core of quartz with small amounts of perthite. One green beryl crystal, 8 by 36 inches, lies at the contact between the core and wall zone near the north end of the pegmatite.

The pegmatite east of the quarry is about 400 feet long and 20 to 40 feet wide. A hook-shaped projection extends 200 feet southwest from the north end. This pegmatite contains a narrow border zone that in some places consists of fine-grained quartz, plagioclase, and muscovite, in others of graphic intergrowths of quartz and muscovite. The wall zone is 2 to 5 feet thick and consists chiefly of quartz, plagioclase, perthite, and muscovite, with small amounts of black tourmaline, garnet, apatite, and beryl. Much of the beryl occurs as small green crystals associated with small bodies of intergrown quartz and muscovite. A discontinuous core is represented by lenticular bodies of coarsely crystalline quartz or quartz and perthite.

The pegmatite northeast of the mine is about 500 feet long and 40 to 80 feet wide. It is similar in composition to the pegmatite east of the mine, but its central part contains more large crystals of perthite. The pegmatite in the northeast corner of the map contains zones similar to those of the other pegmatites, but the quartz-perthite core is coarser grained.

The pegmatite mined in the open pit is 320 feet long and 10 to 80 feet wide. It strikes about N. 15° E. and dips 60° E. It has a narrow border zone of aplitic material and a wall zone, about 3 feet thick, that contains quartz, plagioclase, perthite, muscovite, black tourmaline, garnet, and apatite. The wall zone grades into a core that is about 30 feet thick and is composed of coarse-grained quartz, cleavelandite, and minor quantities of perthite. Beryl occurs in the quartz-rich parts of the wall zone and core. The many small beryl crystals are green or yellowish green and have been replaced in part by cleavelandite.

In 1943 most of the mica was recovered from the wall zone along the northwest contact, or footwall. Earlier production was from small fracture-controlled units and disseminated deposits in the quartz-rich parts of the body. The mica content of the footwall part of the wall zone was high. The mica is ruby and fairly flat, but a large proportion is marred by reeves and "A" structure. Inclusions of garnet, quartz, tourmaline, and apatite are common. Most books are less than 8 inches in diameter. The mica yielded an unsatisfactory percentage of sheet, and the beryl crystals were considered too small for recovery by hand cobbing.

BIG MINE (GILSUM AND VICTORY MINES)

The Big mine (pl. 2, no. 11) is 2.5 miles N. 13° W. of Gilsum village. To reach it from Gilsum, follow the Gilsum-East Alstead road northward for 2.5 miles to a left fork. Turn left and proceed 400 feet northward to the mine.

The mine has two parts, known during the war period as the Victory and Gilsum mines. The Victory mine consists of the workings northeast of and including a large opencut. It formerly was known as the Tripp No. 2 or Rhoda mica mine. The Gilsum mine lies southwest of the cut and was known as the Bowers or Davis mine. The early history of the Big mine has been summarized by Sterrett (1923, p. 109–111). It was opened about 1810 by Simon Bowers and was worked by three generations of the Bowers family and by Silvester Mitchell. James Davis began operations in 1894 and did considerable underground work. In 1914, the mine was owned by the American Mica Co., Newton Lower Falls, Mass. The Victory mine had been worked for mica prior to Sterrett's visit in October 1914 and was being reopened by the Keene Mica Products Co. of Keene, who operated it from 1914 to 1922.

The Golding-Keene Co., Keene, N. H., present owners of the Big mine property, operated the mine for potash feldspar from 1921 to 1940. The mine was then permitted to fill with water. About this time, the New Hampshire Mica & Mining Co., Keene, N. H., began work for mica in the large cut. They reopened the Gilsum mine in the spring of 1942 and operated it continuously until January 1945. The Victory mine was pumped in October 1942, and mica operations were started by the Golding-Keene Co., who worked the mine for mica until October 1944 and for feldspar from October to January 1945. From November 1944 to January 1945, Arthur Whitcomb, Keene, N. H., worked it for mica.

The mines were mapped by D. M. Larrabee and G. H. Brodie in October 1942 and revised to show later development in November 1943 by J. J. Page, V. E. Shainin, and E. Ellingwood III. The Victory mine was core-drilled by the U. S. Bureau of Mines from February to May 1944; in connection with this work both the Victory and Gilsum mines were completely remapped by Page and N. K. Flint (fig. 39, pl. 11). The core-drilling was supervised by S. B. Levin. Maps and sections were revised in January 1945 by Page and F. H. Main.

Operations for feldspar by the Golding-Keene Co. resulted in a cut 300 feet long and 150 feet wide, with a maximum depth of 285 feet. Subsequent caving of the east wall widened the cut to 240 feet and partly filled it. Its present maximum depth is 140 feet. During feldspar mining two large stopes were driven northeast from the cut. Much of the floor of the upper stope has been removed. The lower stope extends as much as 340 feet northeast of the cut. It consists of two main chambers separated by pillars. The floor of the eastern chamber is in places 250 feet below the rim of the opencut. The chamber was at least 110 feet high, but much of it is now filled with waste and backfilled. A drift, now largely inaccessible, was driven for feldspar from the cut at least 150 feet southward into the Gilsum mine.

Mica workings at the Victory mine prior to 1942 consisted of several tunnels and narrow stopes along the northwest wall, or footwall, of the pegmatite. Most of the work was done between the opencut and the Rhoda shaft northeast of it. From 1942 to 1945, other stopes that are now largely backfilled were opened on the west wall. The largest was about 200 feet long, 60 feet deep, and 8 feet in average width and extended northeastward below the old mica stope. Another stope was dug along the footwall southwest of the crosscut. This stope underlies old backfilled workings.

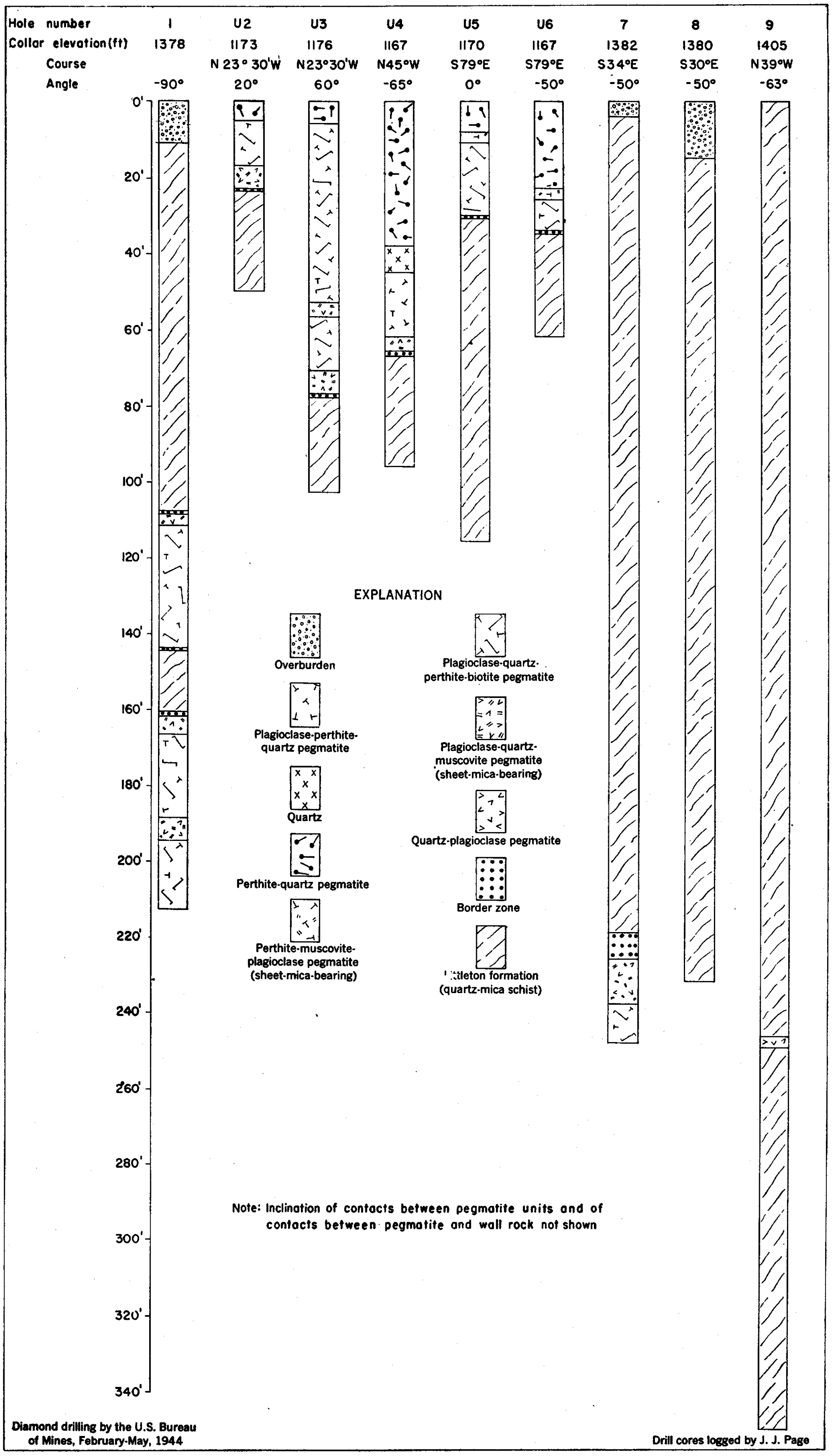


FIGURE 39.—Logs of diamond-drill cores, Victory mine, Alstead, N. H.

The workings along the lower footwall are entered from the western chamber in the lower feldspar stope by a 20-foot crosscut. A stope 8 feet wide was driven 70 feet eastward along the wall, increasing in height from 8 to 30 feet. Drifts have been driven parallel to and near the east wall of the pegmatite.

The total tonnage of rock mined during mica operations from 1942 to 1945 at the Victory mine is estimated to be 7,500 tons, of which about 4,300 tons was mined along the northwest wall. Waste was dumped into the mica workings or the lower feldspar stope.

Mica workings at the Gilsum mine prior to 1942 consisted of a narrow backfilled stope, now inaccessible, along the hanging wall of the pegmatite. This was reported to be 120 feet deep and 200 feet long. Shallow opencuts were opened along the footwall, and three small cuts were opened 300 feet south of the present opencut. The main cut was opened in 1942, and an inclined stope was driven 220 feet southward from it along the footwall of the pegmatite. The stope is 90 feet deep, measured down dip to the main floor, and 10 to 15 feet wide. In the center of the main floor, a winze extends 30 feet farther down dip. Short drifts extend along the footwall from the bottom of the winze, and a crosscut has been driven to the hanging wall. The floor of the crosscut is about 115 feet vertically below surface. It is estimated that 15,000 tons of rock was mined from October 1942 to January 1945.

The wall rock of the pegmatite is medium-grained quartz-mica schist of the Littleton formation containing much pegmatitic material. Locally, the rock is gneissic, particularly northwest of the pegmatite. Biotite is more abundant than muscovite and is chloritized at many places near the surface or near shears. Small pink euhedral garnets are commonly present in the schist, and in places are more abundant away from the pegmatite contact. The schist is markedly tourmalinized at the contact, and irregular bodies of plagioclase and quartz have been injected into it, particularly along the footwall. Most of these are lenses less than 1 foot long and 2 inches or less thick. They contain traces of black tourmaline, garnet, biotite, and greenish muscovite. The strike of the foliation of the wall rock is extremely varied. Southeast of the pegmatite, the strike averages N. 10° to 15° E., whereas northwest of it, the strike ranges from north to approximately east. The average dip is 50° to 60° E. or SE.

The Big mine pegmatite is at least 1,200 feet long and 15 to 200 feet thick. It strikes about N. 40° E. The average dip is steeply southeast, but the walls locally dip northwestward. In the east face of the Victory cut, a lens-shaped offshoot of pegmatite extends southward into the schist. A large roll in the schist footwall almost pinches out the pegmatite between the Gilsum and Victory opencuts, and another large roll of the hanging wall causes an abrupt thinning of the body from 200 feet to 75 feet at the northeast end of the Victory mine. A large outward roll of the pegmatite into the footwall schist is present at the Victory mine. This roll continues on strike at least 450 feet northeast of the opencut and has a maximum vertical height of 80 feet between upper and lower "keels" (abrupt changes in the dip of the pegmatite wall). The upper "keel" and the top of the perthite-quartz-plagioclase core plunge 12° to 15° NE., but other rolls in the walls plunge steeply southward.

A very well defined zonal structure is present in the pegmatite. The zones, from the walls inward, are: (1) quartz-muscovite border zone, (2) quartz-plagioclase wall zone, (3) plagioclase-quartz-muscovite outer intermediate zone (sheet mica-bearing), (4) plagioclase-quartz-perthite-biotite middle intermediate zone, (5) perthite-muscovite-plagioclase core-margin zone (sheet-mica bearing), (6) perthite-quartz core containing quartz bodies, and a (7) plagioclase-perthite, quartz unit.

The quartz-muscovite border zone lies against the schist contact and is much finer grained than other zones in the pegmatite. Its maximum thickness of 1 foot is shown along the footwall of the pegmatite in the Victory mine. It consists of gray quartz, small books and flakes of greenish muscovite, and minor amounts of plagioclase, black tourmaline, pink garnet, green apatite, and green beryl.

The quartz-plagioclase zone is commonly less than 5 feet thick, but is as much as 12 feet thick along the footwall of the pegmatite in the Gilsum mine. It appears to be gradational between the border zone and the sheet mica-bearing plagioclase-quartz-muscovite zone. It is distinguished from the border zone by greater plagioclase content and larger grain size and from the mica zone by a lower mica content. It consists essentially of gray quartz and plagioclase, with minor amounts of muscovite and accessory tourmaline, garnet, and apatite.

The plagioclase-quartz-muscovite zone (sheet mica-bearing) is found along all exposed parts of the footwall, commonly within a few feet of it. It has been traced below the lowest workings by diamond drilling (fig. 39, pl. 11). Its average thickness is 3½ feet, but it is thicker in the Gilsum mine than in the Victory mine. The mica-bearing zone near the surface along the hanging wall in the Gilsum mine probably is similar to the plagioclase-quartz-muscovite zone near the footwall, for it lies outside the perthite-quartz-plagioclase zone, whereas the productive core-margin zone of the Victory mine lies inside. A similar occurrence on the hanging wall at the northeast end of the pegmatite was cored in drill hole no. 7. The zone consists of plagioclase

(An_4 to An_{12} in the Victory mine), gray quartz, and muscovite. Tourmaline, biotite, garnet, apatite, and green beryl are minor accessories and in places are intergrown with the muscovite. The muscovite content is not as high in the Gilsum mine as in the Victory mine although the zone itself is commonly wider.

A plagioclase-quartz-perthite-biotite zone forms a thick cap over the central part of the pegmatite. It thins down dip, apparently extending deeper on the footwall side of the pegmatite than on the hanging wall side. At the Gilsum mine, it is present over the top and along the footwall of the pegmatite, but is absent along the hanging wall. The thickness of the biotite capping at the Victory mine exceeds 75 feet. The zone consists essentially of plagioclase, chiefly massive plagioclase ($An_{10\text{-}11}$ in the Victory mine), but partly cleavelandite. Large perthite crystals, some of which consist of graphic intergrowths with quartz; biotite, in isolated books or flakes and in large strips that are less than 1 inch thick but are as much as 5 feet long and 6 inches wide; muscovite in flakes and books and as parallel intergrowths with biotite; and scattered small beryl crystals are also present. The biotite strips commonly are chloritized in the upper parts of the pegmatite. In drill hole 1 between 112 and 145 feet, muscovite is as abundant as biotite in this zone.

The plagioclase-perthite-quartz unit is known only from the 45 to 62-foot interval of the core from drill hole 4. Its relations to the zones are therefore not known. It may be a separate zone or a variation of the biotite zone, or it may be part of the core, especially as the western part of the core contains the largest amounts of plagioclase. The quartz body adjacent to the zone in drill hole 4 is a further indication of this relationship, for most quartz bodies at the mine are within the core. The plagioclase-perthite-quartz unit is shown in sections as separate from other units. It consists of plagioclase, perthite, and quartz, with minor amounts of muscovite. Much of the plagioclase is cleavelandite.

A second source of sheet mica is the core-margin or perthite-muscovite-plagioclase zone, which is thickest and most persistent on the southeast side of the perthite-rich core at the Victory mine, below the upper feldspar stope. Scattered mica books that occur at the top and on the northwest margin of the perthite-rich core may mark a thin, discontinuous part of the zone. In the southeast drift of the east wall mica workings, this zone lies beween the schist wall and the perthite-rich core, because the biotite zone, which elsewhere in the workings separates it from the wall, is lacking. The occurrence along the hanging wall of the Gilsum mine is similar. The zone ranges from less than 1 foot to 6 feet in thickness but averages 4 feet. The mica books extend out into the core. Perthite is the dominant feldspar. Muscovite and plagioclase (An_5 to An_{12} at the Victory mine) are other essential minerals in the zone, and minor amounts of quartz, tourmaline, biotite, garnet, and apatite occur in it. All of the accessory minerals are in places intergrown with muscovite.

Perthite-quartz pegmatite forms the core of the pegmatite; it is closer to the hanging wall than to the footwall. The core is continuous through the entire strike length of the workings and ranges in thickness from 5 feet in the Gilsum mine to 180 feet in the Victory. Perthite is the most abundant mineral. Quartz occurs as graphic intergrowths in the perthite and also as interlocking grains with plagioclase (An_9 at the Victory mine). Irregular bodies and stringers of fine-grained cleavelandite and quartz surround or cut the perthite and apparently have formed partly by replacement of perthite. The cleavelandite is most abundant in the northwest part of the zone at the Victory mine. Small quartz bodies similar to that one in drill hole 4 occur throughout the core. These commonly have gray rims that grade into milky, rose, or clear centers. Other small bodies consisting of aggregates of diversely oriented books of greenish-rum muscovite are present in the zone, commonly near the quartz bodies. This mica is usable only for scrap. Occasional pockets of beryl are present adjacent to the mica and quartz bodies. Small green beryl crystals, approaching aquamarine in color, are found in gray quartz, and crystals as much as 2½ by 4 feet occur between quartz and perthite. Narrow gray quartz veins containing scrap mica and scattered beryl crystals cut the core.

Sheet mica has been obtained from the outer intermediate zone of the pegmatite near the footwall and from the discontinuous core-margin zone on the hanging wall side of the perthite-quartz core. Mica from the intermediate zone near the footwall is ruby to rum, hard, flat, and free splitting. Ruling is the most common defect, but a satisfactory percentage of sheet can be obtained. In the Gilsum mine, the mica is commonly cracked and of smaller size. Approximately 6.6 percent mine-run mica was recovered per ton of rock mined during operations in this zone at the Victory mine, and about 3.1 percent from the Gilsum mine during 1943 and 1944. The average recovery for this zone in both mines during 1943 and 1944 was 4 percent.

Mica from the core-margin zone at the Victory mine is rum-colored. It is commonly cracked and slightly stained. It is "softer" and has a much lower value than that from the zone near the footwall. Mica recovered from the core-margin zone was about 9.1 percent of the rock mined. This zone has not been worked recently at the Gilsum mine. The average recovery for both mica-bearing zones throughout the entire Big mine for 1943 and 1944 was 4.75 percent.

The Big mine has produced more feldspar than any other mine in New Hampshire, and from 1942 to 1945 it produced more mica. Reserves of feldspar remaining in the mine are limited and are mostly in pillars or in the floors of stopes in the Victory mine. Most of the floors, however, are covered by considerable backfill from mica operations. Reserves of mica left at the mine are large. At the Victory mine, indicated and inferred reserves of crude mica developed by core-drilling are respectively about 2,000 tons and 2,600 tons. These reserves are located northeast of the present workings. At the Gilsum mine, the quality and abundace of mica have decreased down dip and southwestward along strike. Reserves cannot be estimated.

BLISTER MINE

The Blister mica mine (pl. 2, no. 16) is in the town of Alstead, 1.85 miles N. 12° W. of Gilsum village. It is adjacent to, and in part under, the Gilsum-East Alstead gravel road, 1.9 miles north of Gilsum. It was opened by the New Hampshire Mica & Mining Co., of Keene, in August 1942 and was worked continuously until March 1945, except for the period January 1 to April 15, 1943. The New Hampshire Mica & Mining Co. owns the property west of the road on which the Blister pegmatite crops out and holds mineral rights to the property east of the road.

The mine was mapped by D. M. Larrabee and G. H. Brodie in November 1942, during open pit development. The progress of operations led to remapping by E. N. Cameron and V. E. Shainin in October 1943, soon after underground operations were begun. The map was brought up to date in April 1944 by Cameron and J. J. Page (pl. 12). The U. S. Bureau of Mines core-drilled the mine in May and June 1944 (fig. 40). The drilling was supervised by S. B. Levin. Further work by Page and F. H. Main brought the maps and sections up to date as of January 1945. Frequent visits to the mine were made between October 1943 and January 1945 by Cameron, Shainin, and Page.

The Blister mine was first opened on the steep east face of a small pegmatite knob. The face of the knob was stripped off for 80 feet along strike. A shaft was then sunk near the middle of the cut at the edge of the road and short crosscuts were driven eastward from it to the hanging wall at levels 20 feet, 35 feet, and 50 feet below the road. Drifts were then driven north and south along the walls. An incline was sunk along the hanging wall of the pegmatite near the south end of the opencut, and a fourth level about 65 feet below the road was driven 40 feet southward from its bottom.

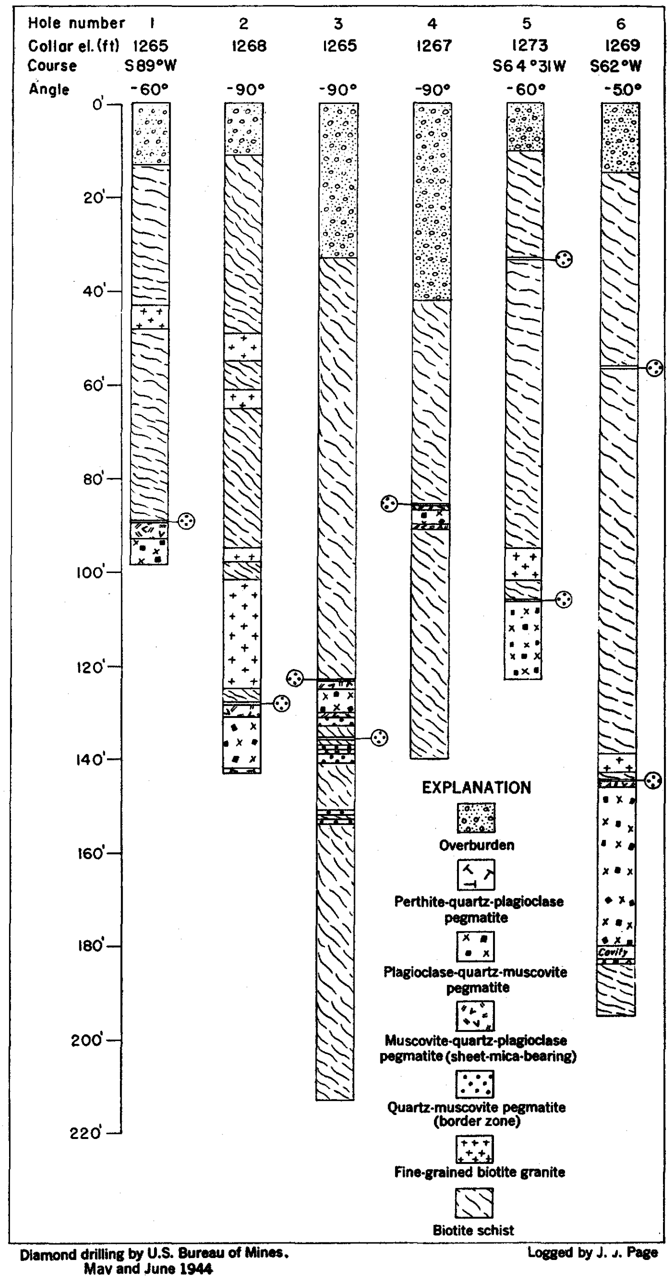


FIGURE 40.—Logs of diamond-drill cores, Blister mine, Alstead, N. H.

About 3,100 tons of rock was mined from August 1942 to January 1945, exclusive of rock taken from the shaft. Waste rock was hoisted in a skip on a wooden track. Mica was sorted out at the head frame and the waste trammed to the dump.

The Blister pegmatite crops out in a knob about 25 feet high, with a steep east side. It is exposed over a roughly elliptical area 220 feet long, north and south, and as much as 170 feet wide. Most of the original outcrop is covered with dump. The hanging wall dips 40° to 50° E., steepening to vertical at its northernmost exposures. The footwall is exposed poorly in two places, where it dips 25° to 35° E. The pegmatite is lens-shaped, pinches abruptly to the south at the surface, and apparently forms a blunt nose northward. Southward and down dip from present surface exposures it appears to split into several thin "fingers."

The wall rock is medium- to coarse-grained biotite schist of the Littleton formation. Considerable pegmatitic material has been injected along the foliation of the schist, giving the rock a gneissic texture locally. Small pink garnets are common and scattered tourmaline crystals are abundant near the pegmatite. The average strike of the foliation is north, but the foliation near the pegmatite conforms roughly to the shape of the body. The average dip is 45° E., but the dip is vertical near the northeastern pegmatite exposures. Fine-grained, faintly foliated, quartz-rich biotite granite has also been intruded along the foliation planes of the schist. Small streaks of medium- to coarse-grained biotite granite are present in the finer-grained granite. Equigranular quartz-rich aplite was recovered in drill hole 2 at 61 feet. The relative ages of the pegmatite, granite, and aplite could not be determined.

A well-defined zonal structure is developed in the pegmatite. The zones from the walls inward are: (1) Quartz-muscovite border zone, (2) muscovite-quartz-plagioclase wall zone (sheet-mica-bearing), (3) plagioclase-quartz-muscovite outer intermediate zone, (4) plagioclase-quartz-perthite-biotite inner intermediate zone, (5) perthite-quartz-plagioclase core.

The quartz-muscovite border zone was observed against the hanging wall schist and in narrow pegmatite "fingers" encountered during core-drilling. Its thickness is commonly 6 inches or less. It consists of fine-grained gray quartz and small books and flakes of greenish muscovite. Plagioclase, tourmaline, garnet, and apatite occur in minor amounts.

Inside the border zone on the hanging wall of the pegmatite, the muscovite-quartz-plagioclase zone forms a mica-rich shoot and appears to plunge almost directly down dip. Its strike length in about 80 feet, and it is roughly delineated by the workings in the opencut and in the first three underground levels. It is intersected 100 feet down dip from the fourth level by drill hole 2. Its thickness averages 3½ to 4 feet but in places is as much as 6 feet. The thickest parts of the mica shoot are near a roll in the hanging wall in the center of the first level and directly down dip from it. In general, the zone becomes thinner to the north and south of the center of the shoot.

At the south end of the third level and directly below it on the fourth level, the workings lie in a thin pegmatite "finger" that extends southward from the main body. A thin, discontinuous exposure of the wall zone is present along the footwall schist on the third level. The zone was found along both schist walls in drill hole 4 (fig. 40), but only the hanging-wall part of the zone was present in drill hole 3. At the south end of the fourth level, the mica-rich zone extends from wall to wall.

The zone contains abundant muscovite, commonly as much as 65 to 75 percent of the rock, and quartz with minor quantities of plagioclase. Accessory minerals are black tourmaline, green apatite, and pink garnet. The accessories, particularly tourmaline, are in part intergrown with the muscovite.

The plagioclase-quartz, muscovite zone is between the mica-rich zone and the central part of the pegmatite. It lies against the border zone where the wall zone is absent. The zone thickens down dip and southward along strike. It consists of plagioclase, gray quartz, and muscovite, and minor quantitites of perthite. Accessory minerals are tourmaline, apatite, and garnet. The muscovite content is somewhat higher in places where this zone lies just inside the border zone than it is where zone lies nearer the center of the pegmatite. The surface outcrops of this unit on the east and northeast sides of the knoll have very abundant muscovite. This is an extension of the wall mica zone, but because most of the mica books are too small to yield sheet it is mapped as part of the plagioclase-quartz-muscovite zone. Perthite occurs only near contacts with the central perthite-quartz-plagioclase zone except in drill hole 6, where it appears to be in the central part of the zone. In drill hole 6 a cavity was encountered in the zone between 180 and 183 feet. The material that partly fills the cavity consists of decomposed feldspar, small quartz grains, and muscovite books of thumbnail size.

The plagioclase-quartz-perthite-biotite zone appears to have formed a cap or hood over the perthite-rich core of the pegmatite prior to erosion. It is adjacent to the footwall schist and underlies the plagioclase-quartz-muscovite zone on the hanging-wall side of the pegmatite. The capping probably extends deeper along the footwall than on the hanging wall of the pegmatite. where it barely reaches the first level. Plagioclase is the dominant feldspar, although much perthite is present. Much of the perthite is graphically intergrown with quartz. Biotite occurs in strips as much as 2 feet long, 3 inches wide, and ½ inch thick. Muscovite is intergrown with the strip biotite and also occurs in small isolated books. Minor accessories are tourmaline, apatite, beryl, and garnet.

The central part or core is the perthite-quartz-plagioclase zone. It lies inside all other zones in the thicker parts of the pegmatite. The lowest few feet of core from drill hole 2 apparently consists of this material. This unit is composed of perthite, abundant graphic granite, gray quartz, and plagioclase. Accessory minerals are green wedge muscovite, golden to bluish-green beryl, black tourmaline, apatite, and red-brown garnet. Irregular bodies of perthite and graphic granite are separated by quartz-rich material consisting of quartz and plagioclase. Wedge mica and beryl appear to be associated with irregular areas of gray quartz. Many large black tourmaline crystals lie in the upper part of the zone on the east side of the pegmatite.

At the Blister mine sheet mica has been obtained almost exclusively from the mica-rich wall zone along the hanging wall of the pegmatite. The mica shoot has an average strike length of 80 feet and a dip length of at least 100 feet below the fourth level. Its thickness averages 3½ to 4 feet. A small part of the mica has come from the footwall part of this zone in a thinner part of the pegmatite. Mica is the most abundant mineral in the zone. The larger books are closely packed and spaces between the books are filled with quartz, plagioclase, and smaller muscovite books. The mica is dark rum to ruby, "soft," and commonly cracked and ruled. Mineral inclusions are abundant, especially tourmaline. Much of the mica has specks of iron oxide, but most of this can be removed by rifting and trimming. A satisfactory yield of sheet has been obtained during past operations. Approximately 14.3 percent mine-run mica was obtained from the rock mined from the mica zone.

Indicated reserves of mica developed by core-drilling are 450 tons, in the mica-rich shoot down dip from the fourth level. The mine appears to offer excellent possibilities for continued production of sheet mica. Mining difficulties, however, will increase as the shoot is followed down dip, because a heavy inflow of water hampered the later operations. Further prospecting of the pegmatite might be done to ascertain if other offshoots from the main pegmatite body south and down dip from the present exposures contain workable deposits.

BRITTON FELDSPAR MINE

The Britton mine (pl. 2, no. 10) is in the town of Alstead, 3.5 miles N. 12° W. of Gilsum village. To reach it from the village, drive 3.6 miles north-northwest on the Lake Warren road to an abandoned quarry road leading northeastward. Follow this road 0.4 mile to the mine, which is owned by Miss Alice Britton, Marlow, N. H. It was examined in August 1942 by H. M. Bannerman and G. B. Burnett, and was mapped in December 1942 and May 1943 by D. M. Larrabee and J. B. Headley, Jr., and W. H. Ashley (fig. 41). It was re-examined in June 1945 by Larrabee and K. S. Adams.

The mine was operated briefly for feldspar in the 1920's. An eastward-trending cut was made along the west end of the pegmatite, exposing it from wall to wall, and a sinuous tunnel was driven northeastward from the face along the south or footwall contact. The northeast end of the tunnel was connected with the surface by an inclined shaft.

Two pegmatites that trend east to northeast crop out on the property. The northern body strikes about N. 65° E. and dips 40°–55° N., the southern body strikes N. 85° E. and dips 55°–70° N. The wall rocks are quartz-biotite schist of the Littleton formation and fine-grained Bethlehem geniss. The wall rocks strike north to northwest, and dip 52° W. to 47° E.

The pegmatites contain border zones of aplitic material. These grade inward into quartz-plagioclase-muscovite-biotite wall zones containing various quantities of perthite, black tourmaline, apatite, and garnet. The inner parts of the pegmatites contain quartz, coarse perthite, and considerable amounts of graphic granite.

The north pegmatite is quartz-rich, and several beryl crystals are present in the face of the cut in this body. The crystals range from minute ones to others 13 inches in diameter and 26 inches long. The smallest are in a vein of albite 4 inches thick along the contact between quartz and perthite, and are oriented normal to the walls of the vein. The largest crystals lie between quartz and perthite. The total surface area of beryl exposed is 13.6 square feet.

No sheet mica has been produced from these pegmatites. Some good block perthite is present, and the quartz is clean and apparently free of iron.

BURROUGHS BERYL PROSPECT

The Burroughs prospect (pl. 2, no. 13) is northwest of the French mine, and is located in the town of Alstead 2 miles N. 19° W. of Gilsum village. To reach it from Gilsum, go north 1.7 miles on the Lake Warren road and turn west on an old quarry road. Follow this 0.2 mile, and turn north for an additional 0.2 mile to the French mine. Follow an old logging road west around the south end of the mine and turn north on a trail along the edge of the woods. Go along this trail about 700 feet to a point 200 feet northwest of the base of the high dump from the French mine. The prospect is on the cliff about 600 feet west of the base of the dump. Walter Burroughs, East Alstead, owns the property, which is undeveloped. It was mapped in November 1942 by D. M. Larrabee and G. H. Brodie (pl. 13).

The pegmatite trends N. 5° E., dips steeply east, and is more than 1,000 feet long, pinching out northward and gradually widening southward. It has an average width of 50 feet. The pegmatite lies along the contact between Bethlehem gneiss on the west and the quartz-sillimanite-mica schist of the Littleton formation

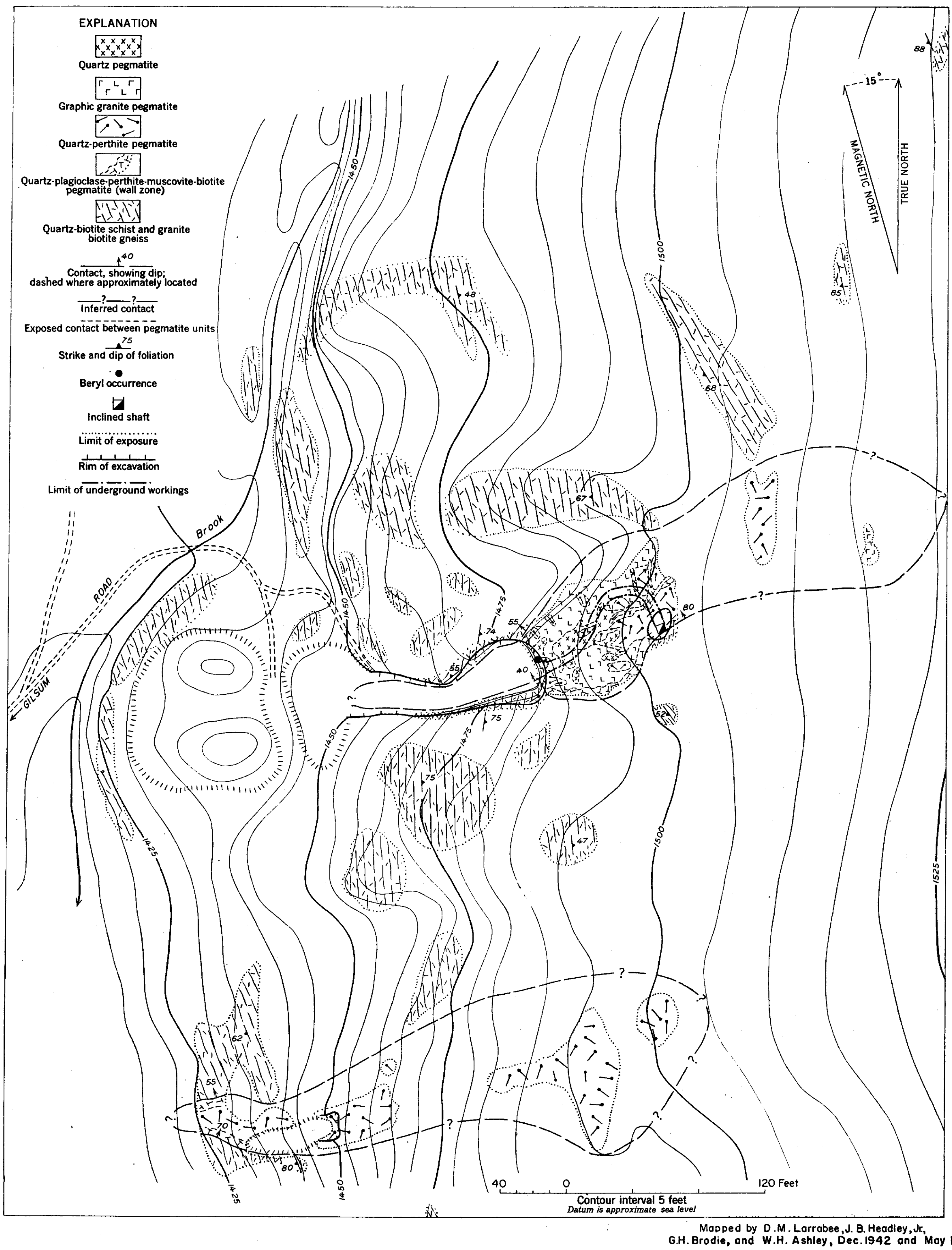


FIGURE 41.—Geologic map of the Britton feldspar mine, Alstead, N. H.

on the east, but the south part transects the contact at a low angle. Much black tourmaline and garnet, and a few small beryl crystals, occur in schist at the hanging wall contact. Olson (1942, p. 372–373) noted this occurrence of beryl in 1940. The foliation of the gneiss strikes N. 20° W. to N. 70° E., and dips 16° to 48° E. The foliation of the schist strikes N. 20° E. to N. 5° W., and dips 25° to 74° E. The sillimanite content of the schist appears to decrease eastward from the contact.

The border zone at the west margin of the pegmatite is aplitic. Along the east margin it consists of fine-grained quartz and muscovite and ranges from 2 inches to 2 feet thick. The zone is commonly fluted along this margin, and contains quartz, black tourmaline, muscovite books ranging from ⅛ to 1 inch in diameter, a little plagioclase, and small green and yellowish beryl crystals. The beryl and tourmaline crystals are commonly arranged parallel to the fluting. The long axes of the crystals lie in the plane of the contact. The crystals are flattened, bent, broken, and in places occur as fan-like aggregates up to 10 inches long. Quartz fills the fractures in the broken crystals. Inward from the border zone, the pegmatite consists essentially of fine- to medium-grained quartz, plagioclase, perthite, and muscovite, and minor amounts of green apatite, biotite, and beryl. Beryl is generally in the more quartz-rich, medium-grained parts of this unit, within 12 feet of the east contact. The crystals are not like those in the quartz-muscovite border zone, and most are short and less than 1 inch in diameter. Small pods of coarse-grained perthite and clear, smoky, and pale-rose quartz occur within the medium-grained pegmatite.

Beryl was observed in 30 places in the cliff and in the loose blocks that have fallen from the cliff. In 800 square feet of beryl-bearing pegmatite, 618 crystals having a total surface area of 6.6 square feet were measured. This part of the pegmatite, containing 0.8 percent beryl, could be selectively mined; it represents 2.2 percent of the estimated 37,000 square feet of exposed pegmatite. The estimated beryl content of the entire pegmatite is 0.016 percent; thus if the pegmatite were mined to a depth of 30 feet it might yield 30 to 35 tons of beryl.

No evidence of a feldspar or mica deposit has been found. The small tonnage of beryl estimated to be present, the large quantity of rock that would require handling, and the difficulties attending the beneficiation of beryl ore prevented the development of this prospect during 1942–44.

COLONY FELDSPAR MINE

The Colony mine (pl. 2, no. 4) is in the town of Alstead on the top of Cobb Hill, 2.4 miles N. 72° E. of Alstead village. To reach it from Alstead follow State Highways 123 and 123A northeast for 0.6 mile to a fork; turn right and follow route 123 for 0.8 mile to its junction with Route 12A; turn left and continue on Route 123 for 0.6 mile to the mine road on the left; turn left and proceed 1.3 miles to the mine.

The mine is owned and operated by the Golding-Keene Co., Keene, N. H. It has been operated steadily since July 1939, when it was first opened. Work began at the northern rim of the main pit directly beneath the cable of the aerial tramway. Nearly 200,000 tons of rock has been removed from the pit and underground workings. Prospect pits northeast and southwest of the main pit were made in 1941–42.

The mine was mapped in November 1944 by Glenn W. Stewart and Karl S. Adams (pl. 14).

The main pit, including a small cut at the northeast end, is about 570 feet long and 40 to 130 feet wide. It is 25 to 35 feet deep in the northeastern half and 65 to 90 feet deep in the other. A crosscut trench 10 to 25 feet wide and 50 feet long was excavated through the northwest face in the northeastern half of the main pit during the early period of mining to permit the removal of waste rock by trucks. The contact between the wall rock and the pegmatite is well exposed in this trench.

The underground workings are reached by a series of ladders and benches on the northwest face of the main pit; they consist of a northeast open stope, a middle open stope, and a southwest stope. Only the southwest stope is worked during the winter months. The southwest stope, the largest of the underground workings, is 22 to 45 feet wide, 30 to 35 feet high, and more than 230 feet long. Two drifts extend from the main stope; one extends northwest for 75 to 80 feet; the other south for 45 to 50 feet. The middle stope is 15 to 45 feet wide, 60 feet long, and 10 to 25 feet high. The northeast stope, which is connected with the northeast and southwestern parts of the main pit, is about 130 feet long, 20 to 35 feet wide, and 25 to 40 feet high. A small adit, 12 feet long, 7 to 15 feet wide, and 6 to 7 feet high was excavated in the pegmatite toward the southeast beneath the overlying schist in the northeast part of the main pit. (See sec. F–F′, pl. 14.)

At present all mining is underground. The stopes and drifts are usually enlarged by driving a heading along the roof, and the feldspar is then benched back to floor level. In the southwest stope feldspar is cobbed and hand-picked as it is shoveled into a 1- to 1½-ton bucket that rests on a flat car. Two crews of 3 or 4 men work at each car. Each car, running on a separate and movable track, is pushed from the working face to the main pit, where it is hoisted to the surface by aerial tramway. Feldspar is dumped into the storage bin according to quality. From the northeast stope feldspar is hoisted to the surface by a derrick, then taken by ore car to the storage bin. Waste rock is removed by the same methods. The feldspar is shipped to the Golding-Keene Co's. grinding mill in Keene, N. H., by truck.

The Colony pegmatite, probably the largest in the vicinity of Cobb Hill, was mapped for a distance of about 1,600 feet along strike, and is exposed for several hundred feet northeast and southwest of the mapped area. It is 3 to 110 feet wide in surface exposures but is as much as 120 to 150 feet thick in the vicinity of the main pit. The pegmatite strikes N. 55°–65° E., has contacts dipping 20°–90° SE., and appears to be plunging 15°–25° SW. In general, it transects the wall-rock foliation, both along strike and down dip.

The extreme variation in the exposed width is due to irregularities in the dips of the hanging wall and the footwall and to the plunge of the pegmatite. South and southwest of the main pit several fingerlike projections of the pegmatite appear along the hanging wall. Several of these "fingers," or rolls, are small topographic knobs. Depressions between the "fingers" and the main body of pegmatite are occupied by schist or gneiss. In most places the contact is concealed, but in others, scattered remnants of the wall rock remain attached to the pegmatite, or a thin border zone marks the position of the contact. In general, the strike of the foliation follows the outlines of the pegmatite "fingers" where the wall rock is largely schist. Where the wall rock is gneiss the strike commonly does not change at the contact. The direction and amount of plunge cannot be measured directly from the fingerlike projections. However, their longest dimension and some of the measured dips at the crest of the pegmatite are nearly parallel to the plunge of the crumpling and drag folds in the wall rock, which is 10°–22°, S. 30°–45° W. This is one of the principal indications of the plunge of the main body of pegmatite. The sloping surface of the pegmatite southwest of the main pit is about parallel to the plunge, indicating that here only small amounts of pegmatite have been removed by erosion. The footwall contact has local variations in strike southwest of the main pit that may be caused by rolls much less pronounced than those along the hanging wall. The footwall contact is exposed only in the extreme southwestern part of the pegmatite.

Northeast of the main pit a bulge in the pegmatite likewise appears to plunge southwest beneath overlying schist and gneiss. At one point where it is exposed sufficiently to permit an accurate measurement the contact plunges 30° SW. The hanging wall is rather uniform in strike between cuts 6 and 8.

In the northeast part of the main pit, most of the southeast face is composed of gneiss and schist. The pegmatite probably extends beneath this wedge of schist all along the face, but it is visible only at the northeast and southwest ends. Near the southwest end a small adit was driven into the pegmatite beneath the overlying schist wedge, but it did not expose more schist. An indication that the pegmatite plunges northeast beyond the limits of the northeast stope is a small exposure of pegmatite southeast of the southwest end of the schist wedge. The keel of the schist wedge between the pegmatite exposure and the pegmatite of the main pit plunges irregularly northeast. At the northeast end of the schist wedge this keel plunges southwest.

The pegmatite probably dipped steeply northwest along the upper side of the schist wedge between the northeast stope and the northeast end of the main pit, because the southeast face of the wedge dips steeply northwest and only small amounts of schist were removed from it by mining. The contact dips 43° to 50° SE. in the opposite face, between the crosscut trench and the northeast end of the main pit. However, the part of the hanging wall involved in a small roll, exposed opposite the schist wedge, dips 25° SE. to 80° NW.

Shear surfaces, showing slickensides and some brecciation, are numerous in the vicinity of the main pit and underground workings. In some places shear surfaces followed during mining bound parts of the stopes and adits. Most of them strike between N. 40° W. and N. 10° E. and dip 60° to 75° NE. or SE. Displacements are probably less than 3 to 4 feet in most places. Some of the shear blocks appear to have moved eastward, down the dip of the shear surface.

The wall rock consists of biotite gneiss, quartz-mica schist, and amphibolite of the Ammonoosuc volcanics. In general, the foliation strikes N. 20° to 40° E. and ranges in dip from 20° NW to vertical. Garnets are locally abundant in the gneiss, and small cavities near the contact in the trench cut through the northwest wall of the main pit contain pyrite. The schist is composed of quartz, muscovite, biotite, and small amounts of chlorite. The amphibolite is composed essentially of coarse-grained crystals of an orthorhombic amphibole, probably anthophyllite.

The Colony pegmatite is composed of perthite, quartz, and albite, small amounts of muscovite and graphic granite, and accessory tourmaline, garnet, apatite, biotite, and pyrite. The pegmatite has a well-defined zonal structure. The border zone, 1 to 10 inches thick, consists of fine-grained quartz, albite (An_{5-7}), perthite, and muscovite in various proportions. It is not shown as a separate unit on the map (pl. 14). The thickness, composition, and texture of this zone differ greatly from place to place apparently depending on the character of the wall rock. The zone is commonly 1 to 2 inches thick adjacent to the schistose rocks but 4 to 10 inches thick against biotite gneiss. Against the gneiss it is generally finer-grained and contains more albite and quartz, associated with very small quantities of muscovite. No contacts between the pegmatite and the amphibolite were seen. There are local gradations between the pegmatite and the biotite gneiss in some places; elsewhere the contact is sharp.

The perthite-quartz-albite wall zone, 15 to 60 feet thick, is a coarse-grained mixture of perthite and albite (An_{2-5}), with subordinate amounts of muscovite and graphic granite, and accessory tourmaline, garnet, apatite, biotite, and pyrite. This zone is best exposed in the main pit, but is present in all exposed parts of the pegmatite northeast and southeast of it. Near the northeastern end, in the vicinity of cuts 7 and 8, it is relatively rich in albite and muscovite and contains more quartz bodies and tourmaline crystals than elsewhere. The tourmaline crystals are also larger. Perthite is present, but it is not abundant and generally occurs as anhedral crystals less than 1 foot across. Some albite occurs in blocky anhedral crystals that measure 6 inches by 2 by 2 feet. In the main pit this zone is nearly uniform in composition and texture. Some perthite occurs in the subhedral crystals that measure 1½ by 1½ feet. There are only small amounts of tourmaline and garnet, and a few pyrite crystals partly or wholly altered to goethite. Slightly wedged muscovite books are unevenly distributed as radiating clusters or in lens-like bodies. They are most common along the hanging wall part of the zone, commonly associated with patches rich in quartz and albite or near small quartz bodies. The zone has a similar composition southwest of the main pit. In the vicinity of cut 2 the tourmaline crystals are more abundant and there is a slight increase in the proportion of graphic granite. This same zone contains one tabular quartz body, 1 to 3 feet wide, that extends N. 30° E. for a distance of 40 to 50 feet beyond the rim of the cut. It appears to have filled a fracture. In cut 1 a small proportion of partly chloritized biotite is present. Tourmaline crystals are also abundant. At the southwest limits of the area mapped the pegmatite has an exposed width of 3 to 20 feet and is finer grained than elsewhere but its composition is essentially the same.

The perthite core is composed largely of perthite, with scattered quartz bodies, scattered aggregates of quartz and albite, and small irregular bodies of graphic granite. The largest quartz bodies are 8 to 10 feet long and 2 to 5 feet thick. The boundary between the core and the perthite-quartz-albite zone is gradational. The thickness of the core is unknown, but is estimated to be 40 to 70 feet in the vicinity of the underground workings. The core appears to be thicker down dip and is essentially parallel to the walls of the pegmatite. No exploratory work has been done to determine the limits of the core along strike or down dip, but it can be inferred that: (1) the core may continue to the northeast for a short distance, at least, but probably has a greater angle of dip and plunge than in the southwest slope; (2) at present level of mining the core probably will extend much farther to the southwest than to the northeast (the strike of the contacts to the southwest is more uniform and the width of exposure is greater); (3) probably the core extends some distance down dip and lies essentially parallel to the dip of the pegmatite, which is 35° to 45° in the vicinity of the main workings.

The approximate limits of the central perthite core have been followed in mining in the southwestern half of the main pit, and all the underground workings lie essentially within the limits of the core. Structural and mineralogical features in the stopes and main pit indicate that the wall zone completely surrounded the core before erosion. Mr. J. Alfred Dennis, general manager of the Golding-Keene Co., reports that when work was first started at the mine, large feldspar crystals were exposed only in a small patch near the north rim in the southwestern half of the main pit. Presumably these crystals were part of a projection of the core.

All feldspar now being mined is recovered from the core. Most of the perthite is gray to white and free of mineral stains or visible inclusions. Some contains fine-grained quartz and small amounts of graphic granite, but it is necessary to separate the large quartz bodies from the perthite by hand. Iron stains are abundant along shear surfaces and the feldspar shows sericitization and kaolinization in places. During the early mining some of the perthite-quartz-albite wall zone was mined and sold as "glass spar." The black staining commonly associated with some of the albite and the scattered garnets and pyrite in some of the perthite crystals necessitated hand picking to obtain a commercial product.

The following chemical analyses were furnished by Mr. Dennis of the Golding-Keene Co.:

	Analysis of selected nearly pure feldspar Percent	*Average analysis of product from present workings Percent*
SiO_2	66.28	69.10
Al_2O_3	18.79	17.30
Fe_2O_3	.04	.09
CaO	.20	.30
K_2O	11.43	9.80
Na_2O	3.08	3.20
Ign	.30	.30

There is little muscovite in the southwestern part of the pegmatite and in the main pit, but it is abundant in the vicinity of cuts 6, 7, and 8. Nearly all is scrap. It is associated with patches rich in quartz and albite or with isolated quartz bodies. The muscovite is relatively soft and ranges from very light rum to light green. Many of the books are wedge-shaped; and cracks, rules, reeves, "A" structure, fishtail structure, mineral stains, and inclusions are common. The books average 4 by 5 inches. Very little sheet muscovite could be recovered from this pegmatite, and its quality would be poor.

Reserves of feldspar of high quality in the Colony pegmatite depend upon the extent of the core along strike and down dip. Core drilling or exploratory shafts and drifts will be necessary to determine the extent and dimensions of the core. There is no indication that the core is pinching out down the dip, hence reserves probably are large. If the core maintains a similar thickness and composition within the present limits between the northeast and southwest stopes, at least 45,000 to 55,000 tons of commercial feldspar should be recovered from this part of the core to a depth of 50 feet beneath the workings. It appears that the core extends farther to the southwest than to the northeast, owing to the plunge of the pegmatite. For every foot the core extends southwest along the strike (again assuming a constant thickness and composition for 50 feet down dip) at least 100 tons of commercial grade feldspar should be recovered.

It is extremely doubtful that sheet mica of good quality could be recovered by further prospecting at the surface or by enlarging the present cuts at the northeast end. Small quantities of quartz can be recovered from the quartz bodies scattered in the core.

FITZGIBBON MICA MINE

The Fitzgibbon (Parson) mine (pl. 2, no. 8), is in the town of Alstead, 1.4 miles N. 4° E. of East Alstead village. To reach it from East Alstead follow a gravel road north 1.0 mile to a fork, then take the right fork 0.4 mile. The mine is on the west side of the road, southwest of the adjoining Lyman mine. Six small opencuts, almost all now filled with water, were made prior to 1906. The cuts were enlarged in 1914-15 by the American Mica Co., of Newton Lower Falls, Mass. The property is owned by Samuel Craig of Alstead and was leased and prospected during the summer of 1943 by C. V. Purdy, 33 Lyman Field Street, East Lynn, Mass., and A. P. Hamelan, 34 Broad Street, Lynn, Mass. The pegmatite surrounding the cuts was mapped by A. H. McNair, J. H. Chivers, and R. P. Brundage in May 1943 (fig. 42).

The Fitzgibbon pegmatite is lenticular in plan. It is exposed for 680 feet on the Fitzgibbon property, extends across the road bounding the property and several hundred feet northward across the Lyman property. It is 12 to 220 feet wide, strikes in general N. 35° E., and dips 42°-80° E. It is widest in its southern part. It turns eastward at its north end, which is essentially parallel to the foliation of the wall rock. The wall rock is quartz-mica schist of the Littleton formation, the foliation of which strikes N. 35° E. and dips 40°-80° E.

The pegmatite is composed of plagioclase, perthite, gray quartz, muscovite, and black tourmaline. None of the cuts was completely pumped or cleaned when the mine was studied, and little of the internal structure of the body could be determined.

In the northeastern cut a well-defined wall mica zone 2 to 4 feet thick lies along the hanging wall. The poorly exposed footwall part of the zone contains less muscovite. This zone does not crop out along the hanging wall contact 140 feet south of the cut. Probably the zone extends across the road as a narrow projection of the body that is exposed in the most recent workings of the Lyman mine. A quartz-plagioclase-perthite zone, 4 to 6 feet thick, lies inside the wall zone. The central part of the pegmatite consists of a brownish-gray quartz core, 10 to 25 feet thick. The zones are exposed only in the cut and cannot be traced southward into the thicker parts of the body.

Muscovite obtained from the wall zone is hard and rum-colored. The books are large, but considerably marred by ruling and reeves. Only small amounts of mica were recovered from the hanging-wall part of the wall zone during prospecting in 1943, so that little is known of the quality or content of the mica in the zone. Sterrett (1923, p. 108), states that the best mica came from the vicinity of the quartz bodies. The observation could not be verified in 1943.

Perhaps mica can be obtained from the hanging-wall zone in the vicinity of the northeastern cut, but the extent of the zone along strike and down dip cannot be determined at present. It is improbable that large quantities of muscovite could be obtained from the margins of the quartz pods in the central part of the body, as the pods are small and mica does not seem to be abundant adjacent to them.

FRENCH MINE AREA

The center of the French mine area is in the towns of Gilsum and Alstead, 2 miles N. 20° W. of Gilsum village. The area extends 1.5 miles north from the Nichols mine to the Victory (Big) mine, and from the Gilsum-Lake Warren road west to the Beauregard

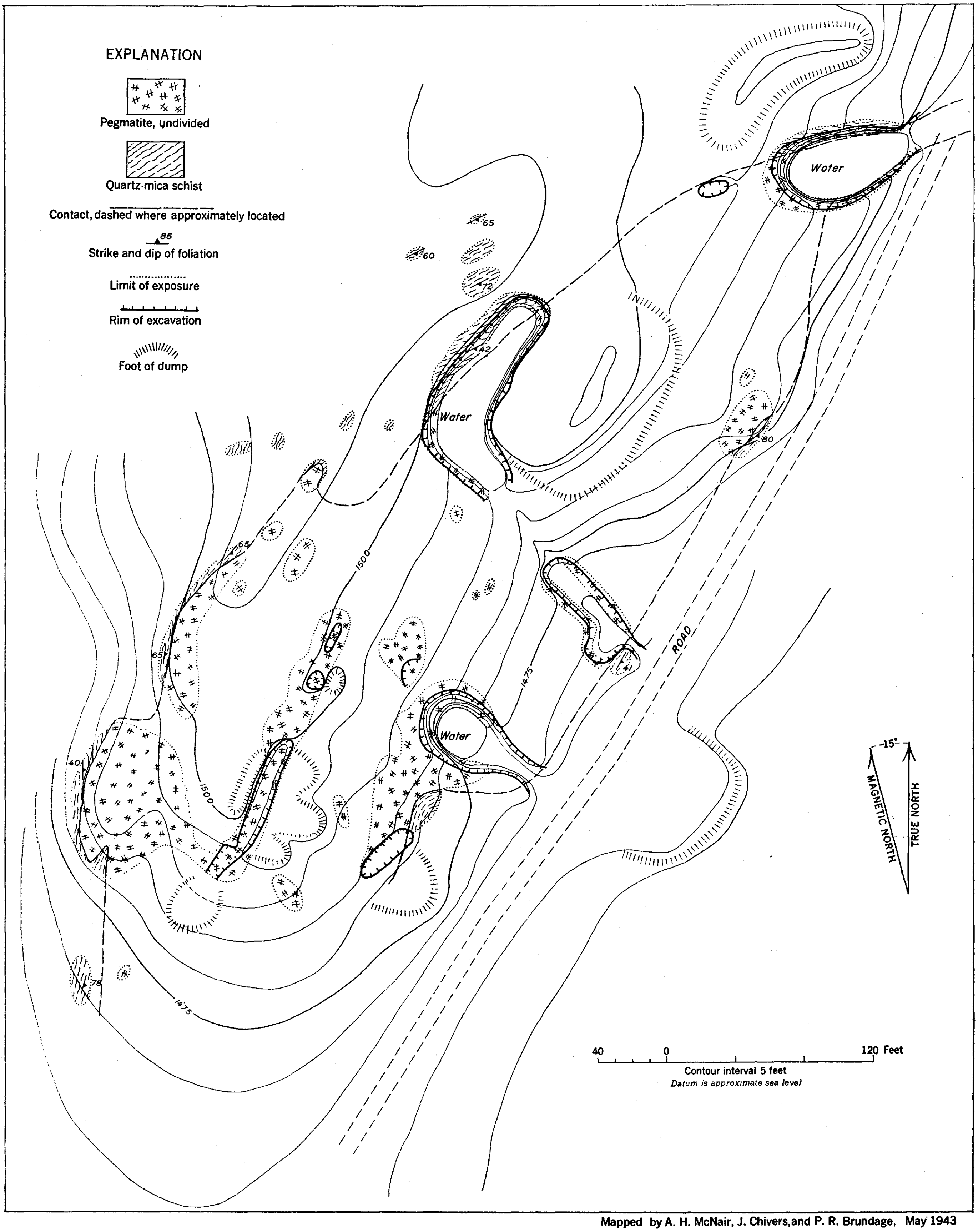


FIGURE 42.—Geologic map of the Fitzgibbon mica mine, Alstead, N. H.

(Boynton) mine. The area described by Olson in 1942 (pl. 61), and by D. M. Larrabee, H. R. Morris, W. H. Ashley, and W. M. Hoag (pl. 15) in May 1943.

Quartz-mica and sillimanite schists and micaceous quartzite of the Littleton formation underlie the eastern two-thirds of the area, and Bethlehem biotite gneiss occupies a band along the western margin. The strike of foliation of the wall rock ranges from northwest to northeast and dips 5°–65° E.

Many pegmatites, most of which trend north and dip steeply eastward, occur in the area. Detailed descriptions and maps of most of these appear elsewhere in the report. Generally, those in schist occupy low ground east of the range of hills underlain by the Bethlehem gneiss. Many have been operated successfully for mica at one time or another during the past 50 years in spite of strong flows of ground water into the mines. The French, Big, Blister, and Nichols are notable examples, and the Island and Clark mines were worked to some extent. Of all these, the Big mine has been the only important source of feldspar. In general, these pegmatites contain little beryl, other than scattered small crystals in the wall or intermediate zones and sparsely distributed large crystals in the cores.

The pegmatites in the Bethlehem gneiss generally contain little sheet-bearing mica of good quality but greater quantities of small beryl crystals than the pegmatites to the east. The beryl commonly occurs in the plagioclase-rich wall zones, bodies of cleavelandite, or in quartz bodies near or adjacent to the east or hanging wall contacts. Pegmatites containing numerous crystals of beryl occur at the Beauregard mine and Burroughs prospect. The flooded Tripp No. 1 mine, reported to have been operated chiefly for feldspar, also yielded some sheet mica and beryl.

Further prospecting of the pegmatites in the Littleton formation might reveal additional sources of sheet mica. The development of satisfactory, low-cost milling methods for the extraction of beryl and other minerals from pegmatites would permit the recovery of small amounts of beryl from several low-grade deposits in the Bethlehem gneiss.

FRENCH MICA MINE

The French mine (pl. 2, no. 15) is in the town of Alstead, 1.9 miles N. 18° W. of Gilsum village. To reach it from Gilsum, follow the Lake Warren road north 1.7 miles to a road turning west. Follow this road 0.2 mile and turn north 0.2 mile to the mine. It is owned by the New Hampshire Mica & Mining Co., Keene. The area surrounding the flooded mine was mapped in November 1942 by D. M. Larrabee, J. B. Headley, Jr., and G. H. Brodie (pl. 16). It was visited in May 1944 by J. J. Page and F. H. Main. Probably, according to Sterrett (1914, p. 89), the mine was opened in the 1860's by a Mr. Mitchell, and was later worked by a Mr. Bowers, and by W. A. and C. H. French. In 1913 it was operated by the American Insulator & Mica Co., and for some years thereafter until 1939 by the present owners. Development consists of a northeast-trending open pit 600 feet long, 25 to 175 feet wide, and 130 feet deep in the center. A crosscut was driven 40 feet westward in pegmatite from the west wall of the pit. The large pit is connected underground to a smaller pit to the north, which is about 135 feet long and 35 to 50 feet wide. The pegmatite is reported to have been stoped 50 feet north from this pit during 1938 and 1939. In May 1944, the owners sank a prospect pit 50 feet north of the northern pit; this prospect pit, 20 feet square and 13 feet deep, is in schist. Vertical, 14-foot drill holes from the bottom of the pit encountered no pegmatite.

The largest pegmatite is forked. The east branch trends N. 25° E. and dips steeply eastward. The west branch strikes about N. 25° W., but as no contacts are exposed, its inclination could not be determined. The northeast end of the east branch plunges beneath schist and may be connected to the pegmatite on the ridge a short distance on strike to the north. One large and several small pegmatites crop out west and northwest of the mine. The wall rock, quartz-biotite schist of the Littleton formation, contains sillimanite near the west side of the area mapped. The foliation of the wall rock strikes N. 12° W. to N. 20° E., and dips 38°–77° E. A large, northeast-trending inclusion is present in the floor near the center of the main pit. The schist at the contacts and in the inclusions is impregnated with pegmatitic material, tourmaline and garnet.

The margins of the pegmatites are fine grained, in places aplitic; in others, the border zones contain quartz with muscovite books that seldom exceed 1 inch in diameter. Inward from the margins, the pegmatites are fine to medium grained and consist of quartz, plagioclase, perthite, and muscovite. Small amounts of biotite, garnet, tourmaline, apatite, and green beryl are present in some of the medium-grained pegmatites. Black tourmaline is most common near the outer margins of the medium-grained parts. Within the medium-grained pegmatite, and commonly in central positions between walls, are irregular lenses of quartz, with subordinate perthite. One large perthite lens near the west wall of the opencut yielded about 150 tons of high-grade block feldspar. Much graphic granite has been reported from the center of the pegmatite mined in the large pit.

It is reported that three types of mica were recovered from the mine.[12] Ruby mica of good quality and size was recovered chiefly from the north end of the mine; smoky or cloudy, iron-stained, reeved and "A" mica from the center of the main working; and green mica having "A" and wedge structures from near the west wall. Some of the mica at the south end of the pit is ruby, soft, ruled, has "A" structure and contains inclusions of quartz and tourmaline. Most of the mica is reported to have come from the walls and from inclusions. According to information from many sources, the stoped north end of the pegmatite yielded the best quality mica in highest concentrations. This is directly below the roll in the hanging wall contact, where the pegmatite plunges northward.

Renewal of operations in this pegmatite will require pumping out the entire pit. Mica-bearing pegmatite is said to extend northward, but considerable expense would be involved in its development. Other pegmatites in the area included in plate 16 show no sheet-mica-bearing units at the surface. Surface exploration might be done between the main pit and the pegmatite knoll 100 feet to the west to find the east contact of the west branch. A mica shoot might be encountered at the junction of the two branches.

HOWE LEDGE BERYL PROSPECT

The Howe Ledge prospect is located near the top of the west slope of Derry Hill, in the town of Walpole, and lies 2.9 miles N. 60° W. of Surry village. To reach it from Surry village, drive 0.15 mile west to Route 12A, and turn north. Proceed 0.25 mile, crossing Merriam Brook, turn west and drive 3 miles along this back road to a road turning north. Drive north about 0.7 mile to an auto trail turning off toward the northwest. This trail is about 0.3 mile long and ends at a camp. The prospect is on a ridge, 0.1 mile N. 30° W. of the camp. The property is owned by Reginald F. Howe, Keene, who blasted a few small holes in the pegmatite in 1942. The prospect was mapped by tape-compass methods in November 1942 by D. M. Larrabee, G. H. Brodie and J. B. Headley, Jr., (fig. 43), and was re-examined by Larrabee and K. S. Adams in June 1945.

Two northward-trending pegmatites crop out on the property. Both pegmatites are discordant to the wall rock and contain small inclusions of it. The intrusives may be connected beneath the surface. The wall rock, quartz-mica schist and impure quartzite of the Littleton formation, strikes northeast, in general, and dips 17°–22° NW. Bedding and foliation are contorted near the contacts.

[12] Graham, Grindstaff, formerly General Manager of New Hampshire Mica & Mining Co., oral communication May 1944.

The northern pegmatite, about 500 feet long and 5 to 70 feet wide, contains a narrow border zone of quartz, muscovite, and plagioclase. The central part of the pegmatite is composed chiefly of quartz, and contains crystals of plagioclase. The quartz is white, pale smoky, or light rose, and in places is iron-stained. Wedge and "A" muscovite of ruby color, in books rarely exceeding 3 inches in diameter, and green beryl occur in the quartz. Patches of medium-grained pegmatite, composed of quartz, plagioclase, perthite, muscovite, and yellowish-green beryl, occur in the quartz pegmatite. These are not shown separately on the map. The beryl crystals range from ¼ inch to 6 inches in diameter, but most crystals are from 1 to 2 inches across. The larger crystals occur in quartz. Fanlike clusters of bent and broken crystals occur near the contacts and scattered over the surface. In about 14,000 square feet of pegmatite surface, 510 beryl crystals having a total surface area of 12.7 square feet are exposed, indicating a beryl content of 0.09 percent.

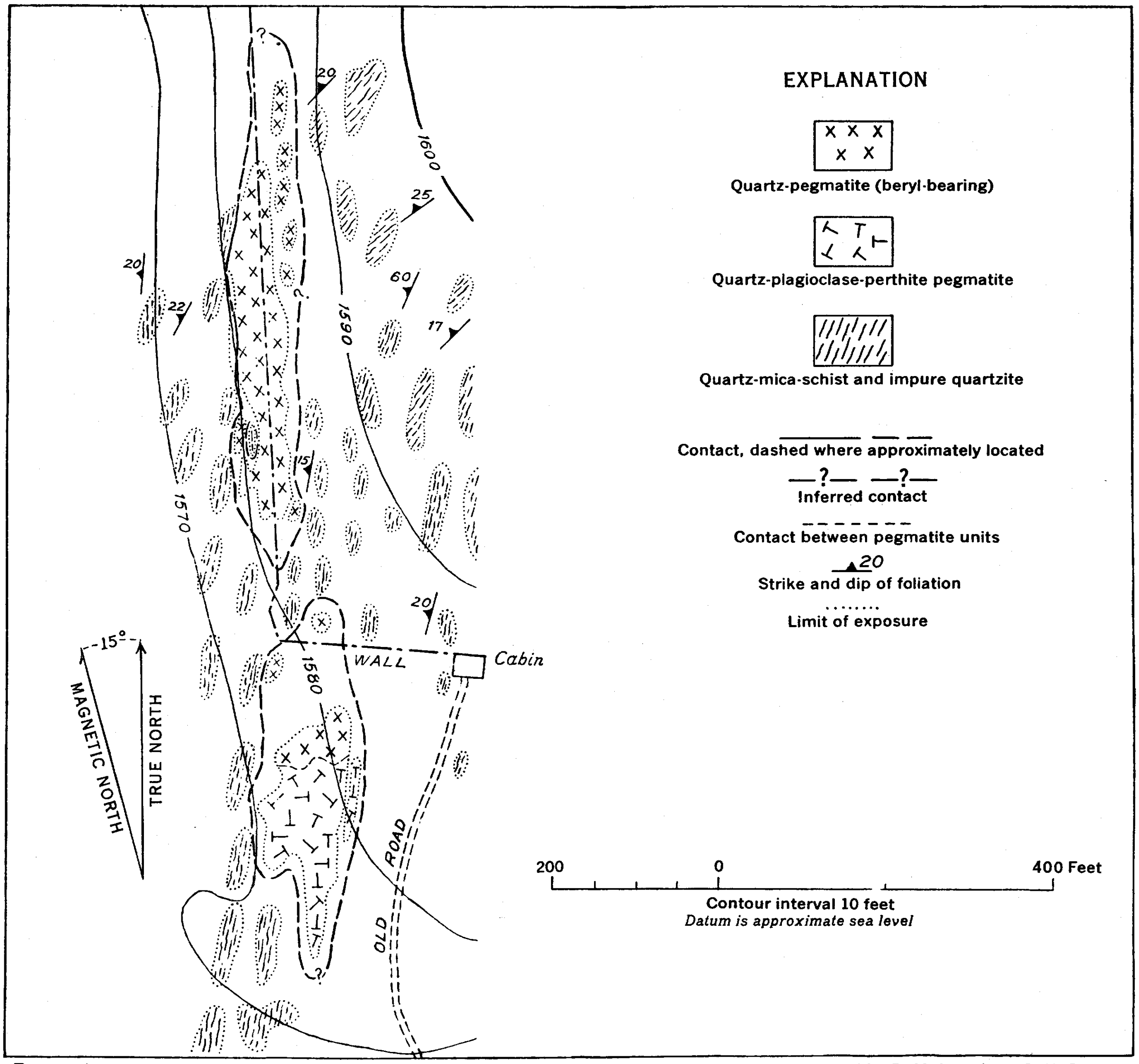
The south pegmatite is probably 400 feet long and 100 feet wide at the surface. It is chiefly fine to medium grained and is composed of quartz, plagioclase, perthite, biotite, muscovite, and yellowish-green beryl. Fifty-one beryl crystals having a total surface area of 0.26 square foot are present in small, isolated patches or pods of coarser quartz-rich pegmatite.

Mining and milling of large quantities of rock would be required for recovery of most of the beryl from these pegmatites. Under 1942–44 conditions development of this prospect was not considered feasible.

ISLAND MICA MINE

The Island mine (pl. 2, no. 12) is in the town of Alstead, 0.4 mile east of Cranberry Pond and 2.1 miles N. 18° W. of Gilsum village. To reach it from the village, follow the Lake Warren road 2.1 miles north to the Mica Mine School. Go west along a trail 0.4 mile, passing around the north end of a large swamp, to the mine on a small knoll at the west margin of the swamp. The deposit is on land said to be owned by certain Watson brothers, Boston, Mass. Sterrett visited and mapped the deposit in 1913. It was mapped in May 1943 by D. M. Larrabee, W. H. Ashley, W. M. Hoag, and H. R. Morris (fig. 44).

The mine was last operated in the early 1900's by James Davis, Gilsum. Two small open pits were made within a large opencut: each pit is 20 feet long, 20 feet wide, and about 20 feet deep. A short drift and one stope were made from the bottom of the south pit, and a short adit was driven westward from the cut. The Colonial Mica Co. pumped out the south pit at the time of the examination; the north pit was inaccessible because of flooding.



Tape and compass survey

Mapped by D. M. Larrabee, G. H. Brodie and J. B. Headley, November 1942

FIGURE 43.—Geologic map of the Howe Ledge beryl prospect, Walpole, N. H.

The pegmatite is probably 125 feet long, 15 to 30 feet thick, and as much as 80 feet in outcrop width. It strikes north, dips 20° to 40° E., and is discordant to the enclosing quartz-biotite schist of the Littleton formation, which strikes northeast to west and dips north, northeast, or southeast at moderate to steep angles. The wall rock is strongly contorted and tourmalinized near the pegmatite.

The border zone is fine-grained quartz-muscovite pegmatite and aplite containing garnet, tourmaline, and apatite. Inside this is a wall zone consisting chiefly of medium- to course-grained quartz and plagioclase, with minor amounts of muscovite, biotite, and perthite. This material encloses lenticular bodies of quartz-plagioclase-biotite pegmatite in which biotite and lath-shaped crystals composed of intergrown biotite and muscovite also occur in fractures. Ruby mica occurs along fractures in the medium- to coarse-grained pegmatite, in a lean unit below the hanging wall, and at the lower sides of inclusions. At each place quartz, plagioclase, and perthite are the common minerals with which it is associated. A few small coarse-grained quartz-perthite lenses (not shown in fig. 44) are present in the medium-grained pegmatite.

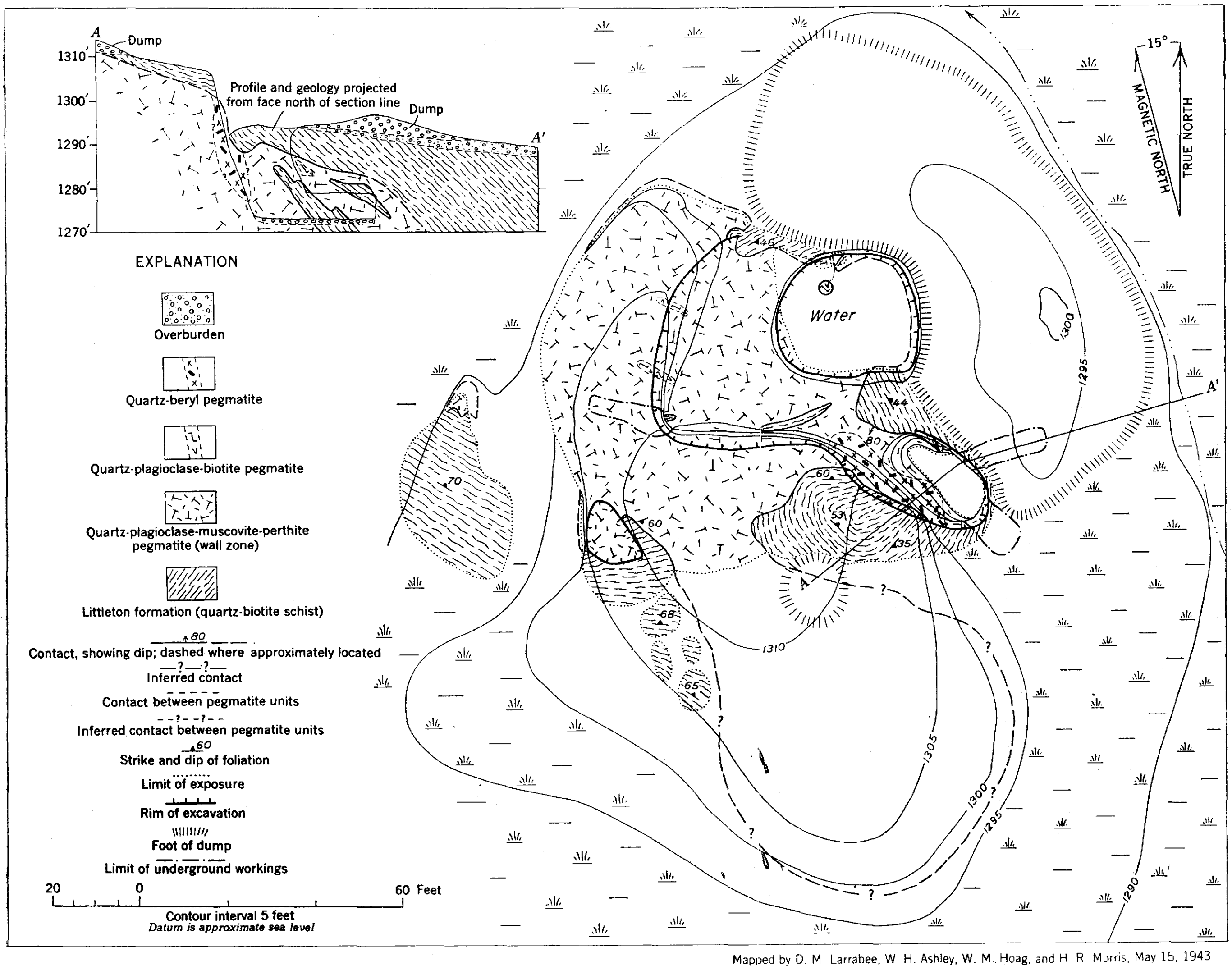


FIGURE 44.—Geologic map and section of the Island mica mine, Alstead, N. H.

Quartz in the south pit face contains green beryl crystals 1 to 12 inches in diameter. The crystals in the upper part of the face are flattened, broken, and fanlike, and occur near the hanging wall. The crystals in the lower part of the face are larger and better developed, and were probably formed in a zone of weakness extending downward from the sharp roll in the overlying wall rock. Golden beryl was seen on the dump. Most of the mica is small and firm, but has pinholes and defects such as warping, ruling, and "A" structure. Small tourmaline crystals are common in the books. One book yielding 3 by 3 inch sheet was found in the south pit.

The poor quality of the mica, its scarcity within the richest unit along the hanging wall and elsewhere in the pegmatite, and the difficulty of removing the large, steady inflow of water from the brook and swamp, prevented operation during 1942–44.

KIRK NO. 1 MICA MINE

The Kirk No. 1 (Bingham Hill) mine (pl. 2, no. 20), on the south side of Bingham Hill, is in the town of Gilsum 1.7 miles S. 10° W. of Gilsum village. To reach the mine from Gilsum, drive 1.9 miles south on Route 10 to a road turning west. Follow this mine road about 0.15 mile to the workings. The mine was visited by D. M. Larrabee during the winter and spring of 1943, and was mapped in May 1943 by Larrabee, H. R. Morris, W. H. Ashley, and W. M. Hoag. The map was revised in June 1945 by Larrabee and K. S. Adams to include development during 1943 (pl. 17).

This mine is reported to have been operated intermittently for mica and feldspar during a 10-year period in the early 1900's. The mine is a northwest-trending, irregular opencut nearly 240 feet long and 18 to 70 feet wide. In 1943, during operations for mica, the southeast half of the cut was cleaned out, and two stopes were driven eastward below the hanging wall by the present owners, the Hill Mining Co., Newport, N. H.

A group of pegmatites, mostly northwest-trending, is exposed at the mine. The largest pegmatite is about 300 feet long and has a maximum width of 70 feet near its center. It strikes N. 50° W. The northeast or hanging-wall contact dips 20° to 50° NE., and the footwall dips 20° to 60° NE. The southeast half of the pegmatite contains numerous faults that strike N. 20° E. to N. 50° E., and dip from 50° SE. to 78° NW. Displacements range from a few inches to more than 15 feet, and the movements have damaged the mica severely.

The other pegmatites are small, mostly 30 to 80 feet long and 5 to 15 feet wide. One pegmatite, northwest of the mine, is V-shaped, one arm trending northwest and the other southwest. The wall rock is of the quartz-biotite schist Littleton formation, the foliation of which strikes northwest in general and dips 22° to 57° NE. Inclusions are common in the largest pegmatite. The schist contains black tourmaline and garnet near the contacts with pegmatite, and in places west and north of the mine it is thoroughly impregnated with and replaced by pegmatite.

Each pegmatite has a narrow aplitic border zone of quartz, plagioclase, muscovite, and garnet. Inside this is a discontinuous wall zone of medium- to coarse-grained quartz, plagioclase, and muscovite, with minor perthite, and accessory garnet, black tourmaline, and apatite. The wall zone in the largest pegmatite is 2 to 4 feet thick and richest in muscovite along the hanging wall in the southeast half of the body, where the pegmatite is narrower than elsewhere. The mica constitutes 10 percent of the wall zone in places, and is associated chiefly with quartz and a little plagioclase. Muscovite also occurs in wall-zone material along the lower sides of xenoliths north of the recent working. Inside the wall zone is an intermediate zone composed essentially of coarse-grained quartz, plagioclase, and perthite with subordinate muscovite. A core of quartz and perthite, containing some plagioclase, a little green beryl, and irregular nests of wedge mica, occupies the center of the pegmatite at its widest part. Small bodies of graphic granite occur in places along the margin of the core.

Sheet-bearing muscovite from the wall zone is ruby. It contains many inclusions of garnet, apatite, tourmaline, and quartz, "A" structure is common, and the mica from the faulted parts of the pegmatite has been strongly ruled, warped, crumpled, and broken.

Although some good, flat mica was produced during 1943, the average recovery was insufficient to encourage operation during the following year. Probably reserves of feldspar that could be sorted by hand are not large.

KIRK NO. 2 MINE

The Kirk No. 2 mica mine (pl. 2, no. 18) also known as the Blake mine, is in the town of Gilsum, 0.55 mile N. 66° W. of Gilsum village. It is reached from Gilsum by following State Highway 10 southward for 0.35 mile to a gravel road on the right. Follow the gravel road southwestward and then northward for 0.8 mile. A dirt road continues northward for 0.25 mile to an intersection. Take the right fork for 0.1 mile to another dirt road on the right. Follow this road for 150 feet to the mine.

The property is owned by the New Hampshire Mica & Mining Co., Keene, N. H. Prior to June 1944 a cut about 120 feet long, 10 feet wide, and 15 feet deep was opened. The New Hampshire Mica & Mining Co. operated the mine for 6 weeks beginning June 15, 1944, and about 150 tons of rock was moved. The mine was mapped by A. H. McNair, J. H. Chivers, and R. P. Brundage in May 1943 (fig. 45) and was visited by J. J. Page in June and July 1944.

The pegmatite is about 290 feet long and has an average strike of N. 35° E. The dip is extremely varied. In general, it is steeply east, but in places it is vertical or even westward. The pegmatite is poorly exposed southwest of the opencut, but apparently pinches out within 60 feet. It is 10 to 20 feet wide in, and southwest of, the opencut. Northeast of the cut, it widens to about 65 feet and then abruptly splits into two narrow parts that pinch out northeastward. The pegmatite-schist contact between these two parts dips 50° southward. Rolls in the east wall of the pegmatite at the southwest end of the cut appear to plunge about 35° northward.

The wall rock is poorly foliated, medium-grained, feldspathic biotite gneiss. The strike of the foliation ranges from N. 15° W. to N. It has an average dip of 70° E. The gneiss is overlain comformably by fine-grained quartz-mica-sillimanite schist. The schist exhibits a well developed lineation that plunges 40° SE.

The pegmatite consists of plagioclase, quartz, perthite, and muscovite with accessory black tourmaline and garnet. An indistinct zonal arrangement of the minerals was not mapped. At the east wall a border zone 4 inches thick consists of quartz, scrap muscovite, and plagioclase. It seems to be absent where the west wall is exposed. A discontinuous and indistinct wall zone consisting of plagioclase, quartz, and muscovite lies along the east wall. It is similar in composition to the border zone but has a coarser texture. The footwall part of this zone appears to consist only of plagioclase and quartz The core consists of coarse-

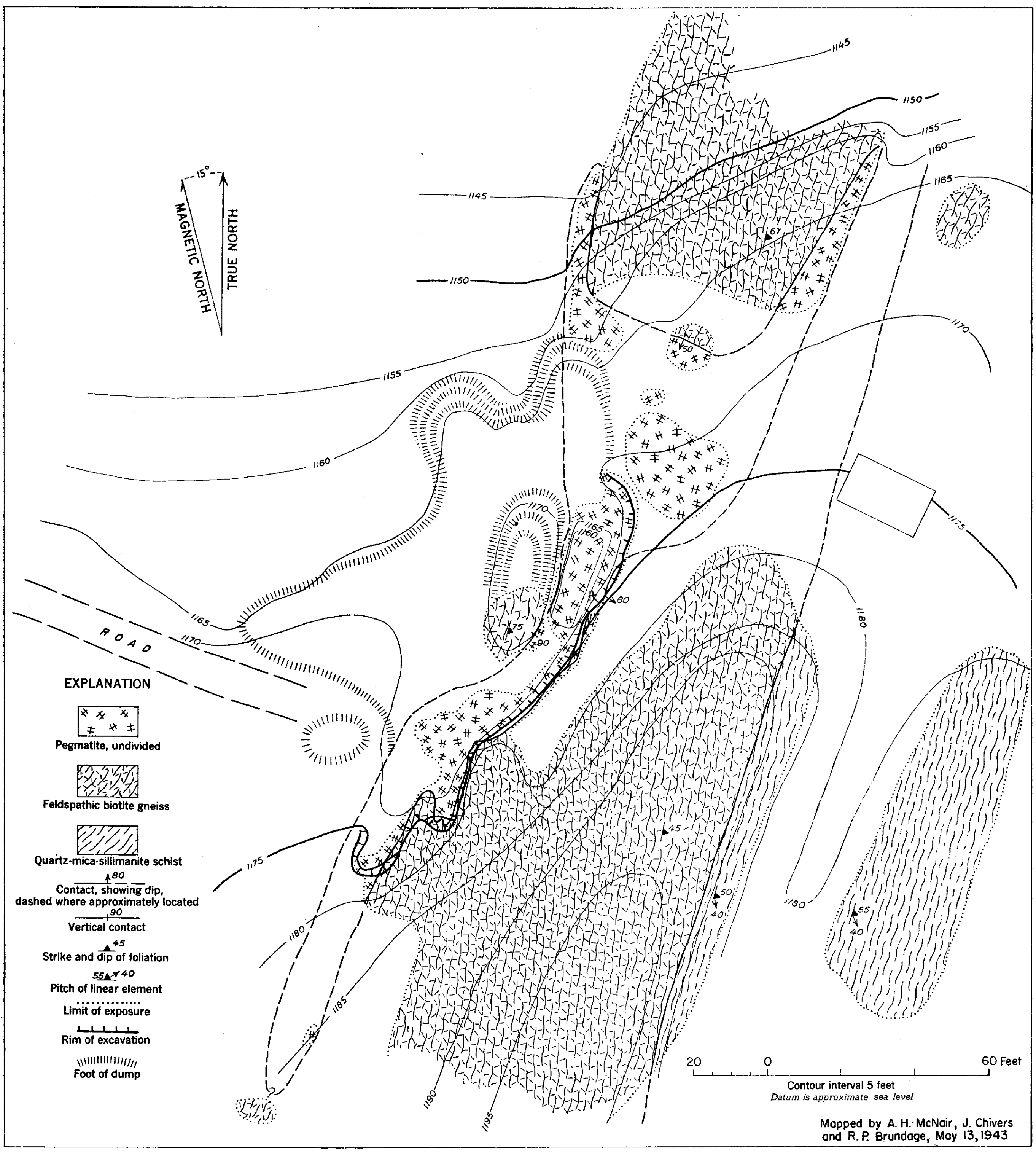


FIGURE 45.—Geologic map of the Kirk No. 2 mica mine, Gilsum, N. H.

grained perthite, quartz, plagioclase, and small amounts of muscovite in small books.

Sheet muscovite is obtained from books disseminated throughout the pegmatite. The sheet-mica content of the poorly developed wall zone does not appear to be much higher than that of other parts of the pegmatite. The narrow northeast tongue of pegmatite is quartz-rich and contains numerous mica books, but probably they are not large enough to yield a satisfactory percentage of sheet. Mica recovered during operations in 1944 was ruby, clear, hard, mostly free-splitting, and small. Black tourmaline is commonly intergrown with the mica. The yield of mica is difficult to determine because some of the 1944 recovery was from the waste rock of earlier operations, but it is estimated that about 1 percent mine-run mica was recovered from rock mined in 1944.

The record indicates that this mine probably would yield little sheet mica in proportion to rock mined.

LYMAN MINE

The Lyman mica mine (pl. 2, no. 7) sometimes known as the Granite State Mica Co.'s mine, is in the town of Alstead, 1.4 miles S. 7° E. of East Alstead village. From East Alstead, follow a gravel road northward for 1.0 mile to a right fork. Turn right and drive for 0.5 mile to the mine, which is to the right of the road.

The property is owned by Rollin Craig of Alstead, N. H. It was operated by the Granite State Mica Co. for several years prior to 1914, at which time the workings consisted of an opencut about 250 feet long and 15 to 90 feet deep (Sterrett, 1923, p. 108). It was worked for short periods in 1918 by Rollin Craig and in 1927 by E. E. Smith of Canaan, N. H. Operations by George A. Craig of Alstead, N. H., began in October 1942 and continued until January 1945. The mine was visited several times during 1942-43 by D. M. Larrabee, studied by A. H. McNair, J. H. Chivers, and R. P. Brundage in May 1943, and mapped by J. J. Page and N. K. Flint in June 1944 (fig. 46).

The workings extend 360 feet N. 50° E. from the road separating the Lyman from the Fitzgibbon mine. The northeast cut, which is about 100 feet long and 70 feet wide, is partly filled with water. There is a 40-foot shaft in the floor of the cut and a 30-foot drift that extends northeastward from the bottom of the shaft. The central opencut consists of three more or less separate workings. The northeastern working is 60 feet long, 10 to 20 feet wide, and 20 feet deep. It is partly filled with water. Southwest of this is an opencut about 50 feet long and 40 feet wide. It passes downward into an inclined stope that is at least 65 feet long and 10 to 15 feet wide. The maximum depth from the rim of the cut to the floor of the stope, measured down dip, is said to be 90 feet. The water was about 40 feet deep in the stope in June 1944.

The southwest opening in the main cut consists of an incline 45 feet long and 20 feet wide driven down dip in 1943–1944. From the bottom of the incline, a drift extended 60 feet southwestward along the pegmatite in June 1944. The drift was as much as 15 feet high and 20 feet wide. A new opencut was begun in 1943 in the part of the pegmatite between the incline and the road separating the Lyman and Fitzgibbon properties. The cut was 40 feet long, as much as 20 feet wide, and about 20 feet deep. This cut and the drift from the incline are reported to have been connected after the mine was mapped.

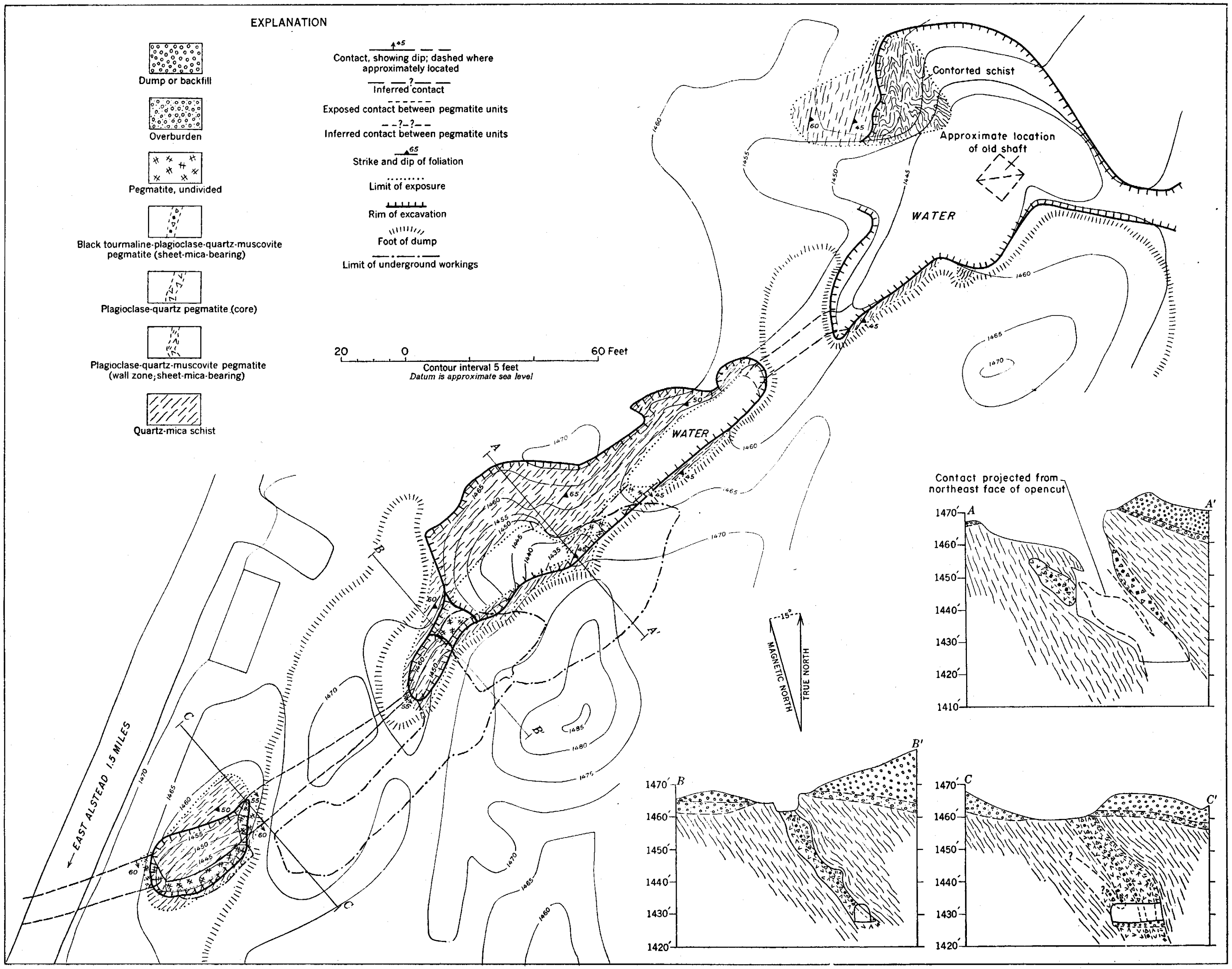
The pegmatite strikes N. 50° E., has an average southeastward dip of 55° and is generally conformable to the wall rock. The pegmatite apparently consists of several roughly lenticular, interconnected bodies that pinch and swell along strike and down dip. In places, lenslike offshoots of pegmatite extend into the footwall schist. There are many small outward rolls of the pegmatite, so that the hanging wall is irregular. The pegmatite ranges from 2 to 18 feet in thickness, probably averaging about 6 feet.

The wall rock consists of medium- to coarse-grained quartz-mica schist. Near the footwall of the pegmatite it commonly is a coarse-grained crenulated mica schist that is injected by pegmatitic material and contains small black tourmaline crystals. In places it is more gneissic in texture near the hanging wall than near the footwall. Small lenses and irregular quartz bodies occur in the schist.

The pegmatite consists chiefly of plagioclase, quartz, and black tourmaline, with small quantities of muscovite and green apatite. The plagioclase is commonly white, but some is colored or stained green, blue, brown, or gray. Black tourmaline is very abundant and locally makes up half of the rock.

The pegmatite exhibits a zonal structure. Most of the sheet mica at the mine was obtained from a discontinuous wall zone that is thickest and richest along the hanging wall. It is apparent presently locally along the footwall. It contains plagioclase, quartz, muscovite, and minor quantities of tourmaline and green apatite. The zone ranges from less than 1 foot to 3 feet in thickness. It is thickest in outward rolls of the hanging wall. The mica is most highly concentrated along the upper parts of the rolls where the hanging wall flattens in dip.

The core of the pegmatite commonly contains plagioclase, quartz, and minor quantities of black tourmaline and apatite. Green muscovite is present as flakes or books of wedge mica associated with narrow transecting quartz veins.



Mapped by J. J. Page and N. K. Flint, June 1944

FIGURE 46.—Geologic map and sections of the Lyman mine, Alstead, N. H.

In addition to the zones a tourmaline-plagioclase-quartz-muscovite unit is present. It has no consistent position within the pegmatite. In some places it occurs against the hanging wall or the footwall, or in the center of the pegmatite. It consists of black tourmaline, colored or stained plagioclase, quartz, and scattered books of muscovite from which sheet mica is obtained. The unit is as much as 3 feet thick.

Most of the sheet mica has been obtained from the hanging-wall part of a wall mica zone, but some sheet has been recovered from books in the tourmaline-plagioclase-quartz-muscovite unit. The muscovite is rum, mostly flat and free-splitting, and hard, and little of it shows mineral staining. It is not ruled, but some books have "A" structure. The yield of mine-run mica from rock mined during 1942–44 was moderately high. It is believed that a satisfactory recovery of sheet mica was obtained.

The workings made in 1942–44 extend down dip about half as far as those in the old stope. This suggests the possibility that considerable quantities of mica-bearing pegmatite that could be removed profitably under conditions comparable to those of 1942–44 remain in the deposit.

NICHOLS MICA MINE

The Nichols mica mine (pl. 2, no. 17), sometimes known as the Keene Mica Products Co.'s mine, is in the town of Gilsum, 1.3 miles N. 30° W. of Gilsum village. To reach it from Gilsum follow the Gilsum-East Alstead road northward for 1.2 miles to a mine road on the left. Follow this road westward for about 0.4 mile to the mine.

Early operations for mica were carried out by the Keene Mica Products Co., Keene, N. H. Sterrett (1923, p. 114) reported the irregular opencut as 60 feet long, 10 to 50 feet wide, and 15 to 25 feet deep. The cut is backfilled except for the northern part. A short stope was driven northward from its northeast corner. Other work for mica consisted of a short inclined shaft 180 feet north of the cut. Some work for feldspar was done in the opencut in the 1930's.

The property is owned by Mrs. Bertha Nichols, Gilsum, N. H., and was operated steadily from May 1943 to about May 1945 by Arthur Whitcomb, Keene, N. H. The mine was mapped by A. H. McNair, J. H. Chivers, and R. P. Brundage in May 1943, then remapped by J. J. Page and V. E. Shainin in December 1943, and by Page and N. K. Flint in June 1944 (pl. 18). Maps and sections were brought up to date as of January 1945 by Page and F. H. Main. Several visits were made between November 1943 and January 1945 by Shainin and Page.

Five main and several smaller openings have been made in the Nichols pegmatite. The no. 1 opening extends northward from an old stope at the northeast corner of the opencut developed prior to 1943. It is worked from a partly timbered shaft 70 feet deep. An irregular stope 5 to 30 feet wide was driven 95 feet northward from the shaft. Its floor is about 60 feet below the surface. It ranges from 35 feet high near the shaft to 8 feet high at the north end. South of the shaft, there are backfilled workings 8 feet high. From the bottom of the shaft a drift extends 50 feet northward. About 2,200 tons of rock was mined from the no. 1 working from July 1943 to January 1, 1945.

The southernmost or no. 2 opening is an opencut made partly during early operations, partly during 1943–45. It has a maximum depth of 55 feet. A drift 10 to 15 feet high and 4 to 15 feet wide was driven 45 feet southward from the bottom of the cut and about 1,250 tons of rock was mined between June and October 1943.

The no. 3 working was begun as an opencut at the west side of the old cut and was driven 25 feet northward. An irregular stope as much as 25 feet wide and 15 feet high was driven 45 feet farther north. These workings broke through to overburden and caved. A 30-foot timbered shaft was then sunk through the caved material to the former floor, and short drifts were then run along the walls. This shaft was deepened to 45 feet and a wide crosscut was driven eastward to the schist wall. A drift about 10 feet wide and 10 feet high extends 50 feet southward from the crosscut toward the no. 1 workings and the backfilled workings developed prior to 1943. About 2,200 tons of rock was mined from the no. 3 opening between May 1943 and January 1945.

The no. 4 opening is an inclined open stope as much as 10 feet wide, 20 feet along strike, and 25 to 30 feet down dip. It was partly flooded at the time of mapping. The rock mined amounted to about 350 tons. A small prospect pit was made 80 feet north of the no. 4 opening along the hanging wall of the pegmatite.

The no. 5 cut is 55 feet long, 35 feet wide, and as much as 25 feet deep. A drift 65 feet long and 10 feet wide was driven along the pegmatite wall on the east side of the cut. The north end of the drift broke through to an old inclined shaft 40 feet deep between the nos. 4 and 5 workings. About 1,200 tons of rock had been mined in the no. 5 working to January 1, 1945.

The pegmatite has an average strike of N. 25° W. and, in general, dips 50° NE. Its strike length exceeds 450 feet. The pegmatite is irregular and shows extreme variations in the dip of its walls. Its thickness ranges from 3 to more than 50 feet. In the old opencut south of the nos. 1 and 3 workings, the pegmatite splits into two parts. The eastern part extends northward under schist and has been worked in the no. 1 opening; the western part continues northward under overburden and has been mined in the nos. 3, 4, and 5 workings. Between these two parts of the pegmatite is a wedge of schist that tapers downward. Contacts of pegmatite and schist are very irregular, and many schist wedges extend downward into the pegmatite. The true east wall of the pegmatite is exposed in only a few places.

The wall rock is quartz-mica schist of the Littleton formation in which biotite is the most abundant mineral and sillimanite is present in some layers. The rock is gneissic in places near the pegmatite, particularly near the hanging wall. Tourmaline is common at the pegmatite contact. The foliation of the schist strikes N. 15°–20° W. and dips 50°–60° NE. Linear elements in the schist plunge 35°–55° SE.

Both the pegmatite and the wall rock have been sheared. Most of the movement apparently was parallel to foliation and took place along the pegmatite contacts and in the nearby schist, but some shears cut the pegmatite. No systematic arrangement of the shears that cut the pegmatite has been determined. Some intend downward into the pegmatite from the points of the small schist wedges. The broken wall rock resulting from shearing increased mining difficulties. Water from the swamp above the workings seeped into the shear planes, so that the no. 1 opening required almost constant pumping.

Practically all the workings are openings along the schist walls, so that the internal structure of the pegmatite is not well exposed. There are at least two zones—a quartz-plagioclase-muscovite zone (sheet-mica-bearing) and a plagioclase-quartz zone. At the south end of the no. 2 cut, a perthite-quartz-plagioclase unit, probably a third zone, seems to lie in the central part of the pegmatite, but elsewhere it is in contact with the sheet mica-bearing zone. The only quartz pegmatite unit large enough to map is a tabular fracture-controlled body that cuts almost across the pegmatite, nearly at right angles, at the north end of the no. 5 cut.

The quartz-plagioclase-muscovite zone (sheet-mica-bearing) occurs against the schist walls. The part of the mica zone mined in the no. 1 opening is against the east side of the irregular schist wedge. At the nos. 3, 4, and 5 openings, most of the mining was done in the part of the zone against the eastward-dipping west side of the wedge. In the no. 2 opening and in the no. 3 opencut, mica was obtained from the footwall of the pegmatite. Exceptionally rich pockets of mica were found in narrow pegmatite "fingers" between the small schist wedges and below their points. The mica zone at most places is two to three feet thick and apparently is present along almost every part of the schist wall. The zone contains gray quartz, plagioclase, and muscovite in about equal proportions, and minor amounts of green apatite, black tourmaline, and green beryl.

The plagioclase-quartz zone forms the bulk of the pegmatite inside the mica zone. Quartz is somewhat more abundant at the north and south ends of the mine than near the middle. The plagioclase is white to cream-colored and in many places is iron-stained. The quartz is gray to white. Perthite is a minor constituent of the zone. Accessory minerals are greenish muscovite of scrap quality, green apatite, and green beryl.

Small irregular bodies of perthite, quartz, and plagioclase occur in the pegmatite. Some are in the center of the pegmatite and some are adjacent to the wall mica zone. Exposures are too poor to indicate the relation of the bodies to the zonal structure of the pegmatite. Perthite and quartz are the most abundant minerals in them.

The quartz body at the north end of the no. 5 cut appears to have filled a fracture late in the formation of the pegmatite. The quartz is milky to clear and has no visible mineral impurities. A few books of greenish scrap mica were found at its south contact.

Sheet mica was obtained from the wall zone. Mine-run mica recovered amounted to about 4.2 percent of the rock moved during operations from May 1943 to January 1, 1945. The mica is rum to ruby, flat, free-splitting, and mostly clear. It is commonly ruled and cracked, but a high percentage of sheet was obtained from it during 1944 and 1945.

Possibilities for future production of sheet mica at the mine are good. Considerable reserves of mica have been blocked out between the no. 1 workings and the nos. 3 and 5 workings. The true hanging wall of the pegmatite, lying an unknown distance east of the no. 1 opening, has not been worked during current operations and appears to offer the most favorable location for future prospecting.

GEORGE PORTER MINE

The George Porter mica mine (pl. 2, no. 9), in the town of Alstead, is 1.0 mile N. 20° W. of Alstead Center. To reach it from Alstead Center follow State Highway 12A northward for one mile to a left fork. Turn left on a gravel road, proceed for about 100 yards to a wood road on the left, and follow this road about 250 yards southwestward to the mine.

The property is owned by Charles Porter of Alstead. The earliest work was done about 1937, when a part of the steep pegmatite cliff was blasted into the valley to the north. The mine was operated by John H. Terry, Jr., Farrhill Mica Co., Westmoreland, N. H., from May to September 1943. The mine was mapped by D. M. Larrabee, W. M. Hoag, W. H. Ashley, and H. R. Morris in May 1943, and remapped by J. J. Page and F. H. Main in October 1944 (fig. 47) to include new development work.

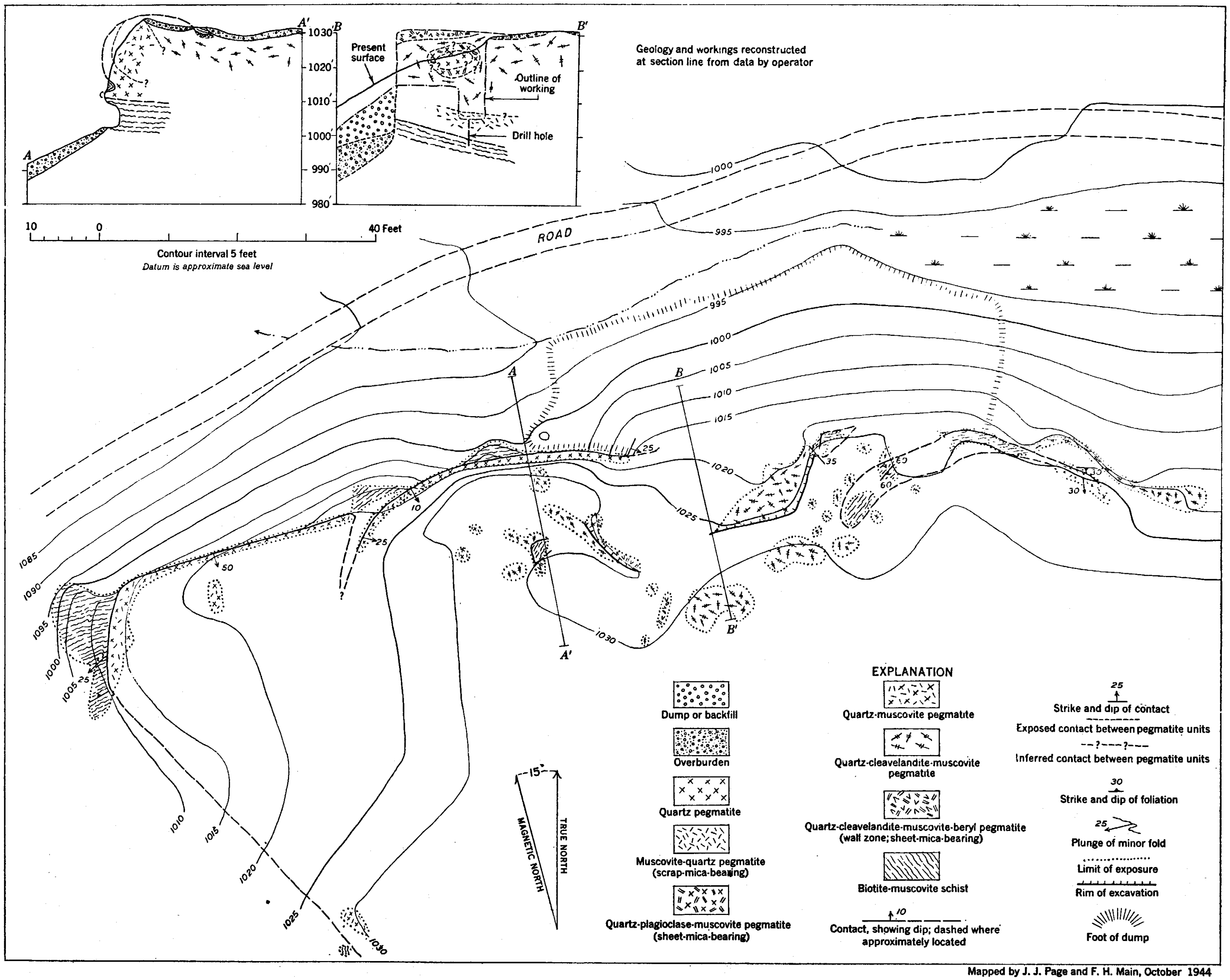


FIGURE 47.—Geologic map and sections of the George Porter mine, Alstead, N. H.

Mining was done at and near the top of a northward-facing pegmatite cliff. A bench approximately 60 feet long and 15 feet deep was driven southward for about 25 feet from the edge of the cliff, and a test pit was sunk for exploratory purposes at one point on the bench. About 2,500 tons of rock was mined during these operations. Much of the cut has been filled with waste.

The wall rock is biotite-muscovite schist that is locally gneissic and is highly folded and contorted at most places near the pegmatite. Its foliation strikes northeast and has a varied southeast or south dip, probably averaging 30°. The footwall schist within 10 inches of the pegmatite contact is heavily tourmalinized.

The pegmatite is a sheetlike body striking east-northeast and dipping approximately 25°–30° S. It is generally concordant with the foliation of the wall rock, but is locally discordant. The pegmatite crops out over an east-west distance of 425 feet and is at least 120 feet wide. Its maximum exposed thickness is 22 feet, but its true thickness may be as much as 30 feet.

Light-gray, "sugary" quartz is the most abundant mineral in the pegmatite. Cleavelandite is the dominant feldspar, but massive plagioclase and a little perthite also are present. Small books of green or rum muscovite, too small to yield sheet, are present in much of the pegmatite. Accessory minerals include beryl, black tourmaline, biotite, apatite, and manganotantalite.

An indistinct zonal arrangement of the minerals is visible in the vicinity of the bench (fig. 47). A wall mica zone as much as 2½ feet thick is present against the hanging wall. It consists essentially of quartz, plagioclase, and muscovite. Most of the muscovite is in small books and scales, but sheet mica was recovered from some books. Another mica zone 1½ to 2½ feet thick is reported to have been followed along the margin of a quartz pod enclosed in quartz-cleavelandite-muscovite pegmatite. White to yellowish-green beryl crystals, 2 inches in average length and 1 inch in average diameter, are present in the zone. Crystal counts made by Larrabee in 1943 indicate that the wall mica zone contains approximately 0.35 percent beryl. Three hundred and seventy-two crystals, having a surface area of 4.85 square feet, were seen in 1,362 square feet of pegmatite.

The zones shown in the sections cannot be traced in the western part of the pegmatite. Outcrops consist largely of quartz and scrap mica, though south and east of the bench quartz, cleavelandite, and minor scrap mica crop out. Mr. Terry reported that a small body consisting almost entirely of diversely oriented books of scrap muscovite was present in the bottom of the test pit.

Green to rum sheet muscovite was obtained from the wall zone and from the margin of the quartz pod. Many of the mica books were small, reeved, and cracked, so that sheet recovery was low. Mica recovered from the zone adjacent to the quartz pod was of higher quality than that found in the wall zone. Approximately 0.91 percent mine-run mica was recovered from rock mined in 1943.

The low rate of recovery of sheet and the low ratio of mica to rock indicate that further operation would be feasible only during a period of exceptionally high prices for small-sized mica. The beryl content is too low to permit recovery under present conditions except as a byproduct of mica operations.

PROVENCHER MICA PROSPECT

The Provencher prospect (pl. 2, no. 6) is in the town of Alstead 1.9 miles N. 5° W. of East Alstead village. To reach it from this village, drive 1.05 miles north to a fork, passing a crossroad; then follow the northwest branch 0.7 mile to an old logging road that leads northeast 0.2 mile to the prospect. A 13-foot shaft was sunk prior to 1942. Donald Provencher, Westmoreland, who operated the deposit under lease for several months in 1942, excavated an opencut south of the shaft. This cut is 30 feet long, 7 feet wide, and 5 feet deep. The deposit was mapped in November 1942 by D. M. Larrabee and G. H. Brodie (fig. 48).

The pegmatite is about 100 feet long and 5 to 10 feet wide. It trends northeast and dips 45°–77° SE., parallel in general to the enclosing garnetiferous quartz-biotite schist of the Littleton formation. The north end of the pegmatite is chiefly granular quartz containing books of muscovite from ¼ to 1 inch in diameter. This is the core of the pegmatite. Along the contact at the northeast end of the outcrop, the border zone is aplite and contains black tourmaline and small garnets. Inward from the border zone is a wall zone composed of medium-grained quartz, plagioclase, perthite, muscovite, and apatite. Pegmatite exposed in the workings is similar, in general, to this medium-grained rock, which contains a lean, poorly defined shoot of larger books of muscovite below the northeast or hanging wall.

The mica occurs in ruby books that are as much as 10 inches in diameter and are strongly warped, sharply crumpled, ruled, and characterized by "A" structure. Clay, magnetite inclusions, and limonite stains are common. Owing to the poor quality and small quantity of mica in the exposed parts of the pegmatite, the mine was abandoned after the work of 1942.

SURRY DAM PROSPECT

The Surry Dam mica prospect (pl. 2, no. 21) lies in the town of Surry 0.6 mile N. 57° E. of Surry village. To reach the prospect from the east end of the flood control dam on the Ashuelot River, 1.75 miles S. 25° E. of Surry village, walk northward for about one-half mile

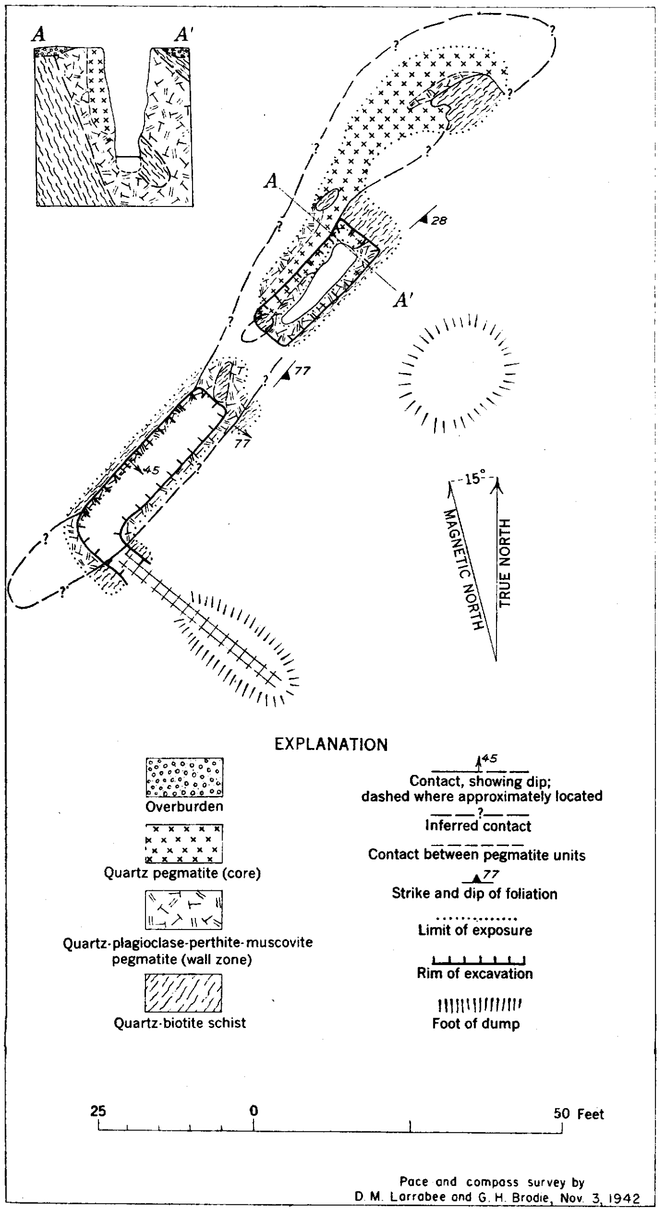


Figure 48.—Geologic map and section of the Provencher mica prospect, Alstead, N. H.

to a power transmission line. Follow the power line northward for 0.4 mile to its intersection with a wood road on the left. Continue northward on the wood road for 1 mile to an old house on the right. The prospect lies 150 feet north of the house, and above the level of water impounded by the dam.

The property is on the Federal reservation surrounding the dam. Several small pits were opened prior to 1944. In the early summer of 1944, a small prospecting crew from Colonial Mica Corporation worked the largest pit for a week, moving 20 tons of rock. The prospect was mapped by J. J. Page and F. H. Main in October 1944 (fig. 49).

Workings consist of one small opencut and five prospect pits. The cut is 50 feet long and 40 feet wide and has a maximum depth of 25 feet. One hundred feet N. 15° W. of this cut is a pit 20 feet long, 15 feet wide, and as much as 7 feet deep. The rock in the pit consists of large blocks of pegmatite and schist that are believed to be nearly in place. Two small pits, respectively 50 feet south and 70 feet S. 20° E. of the cut, were opened but apparently did not reach bedrock. Two other small pits were opened in pegmatites 150 and 200 feet S. 15° E. of the main cut.

All workings appear to have been opened either in a single pegmatite or in search of it. The strike length of this pegmatite is at least 300 feet, and its maximum exposed width is 20 feet. It seems to strike N. 15° to 20° W. The dip is eastward, but the walls are so irregular that the average dip cannot be determined. The pegmatite is broadly conformable to the foliation of the enclosing quartz-mica schist. The foliation of the schist strikes N. 20° W. and is nearly vertical.

Essential minerals in the pegmatite are quartz, plagioclase, biotite, and muscovite. Minor accessories are black tourmaline, green beryl, and perthite. An irregular zonal arrangement of the minerals within the pegmatite is seen at the northeast face of the main cut. Adjacent to the footwall is a wall zone consisting of quartz, plagioclase, and muscovite, but the zone seems to be lacking along the hanging wall. Much of the face of the cut shows a biotite-bearing, plagioclase-quartz-muscovite outer intermediate zone that lies inside the wall zone on the footwall side of the pegmatite, but is adjacent to the schist on the hanging wall side. Biotite occurs as small strips or books, but otherwise the mineralogy is similar to that of the wall zone. A thin middle intermediate zone consisting of plagioclase, quartz, and muscovite is also present. It contains less muscovite than the wall zone and is bordered on both sides by the biotite zone. Inside this zone lies an inner intermediate zone having a maximum thicknes of 1½ feet and consisting of plagioclase, quartz, and sheet mica-bearing muscovite. It surrounds the central quartz pod. Other quartz pods occur in the pegmatite, but none shows a marginal mica zone.

Beryl is found only in loose quartz blocks in the north pit. One crystal measured at least 4 by 12 inches.

Muscovite containing sheet mica is most abundant in a narrow zone surrounding one of a number of quartz pods. It is ruby to rum and mostly clear, but some is bent and slightly stained. Small books of muscovite also are found throughout the biotite-bearing and quartz-plagioclase-muscovite zones. The books are smaller than those near the quartz, but is very hard and

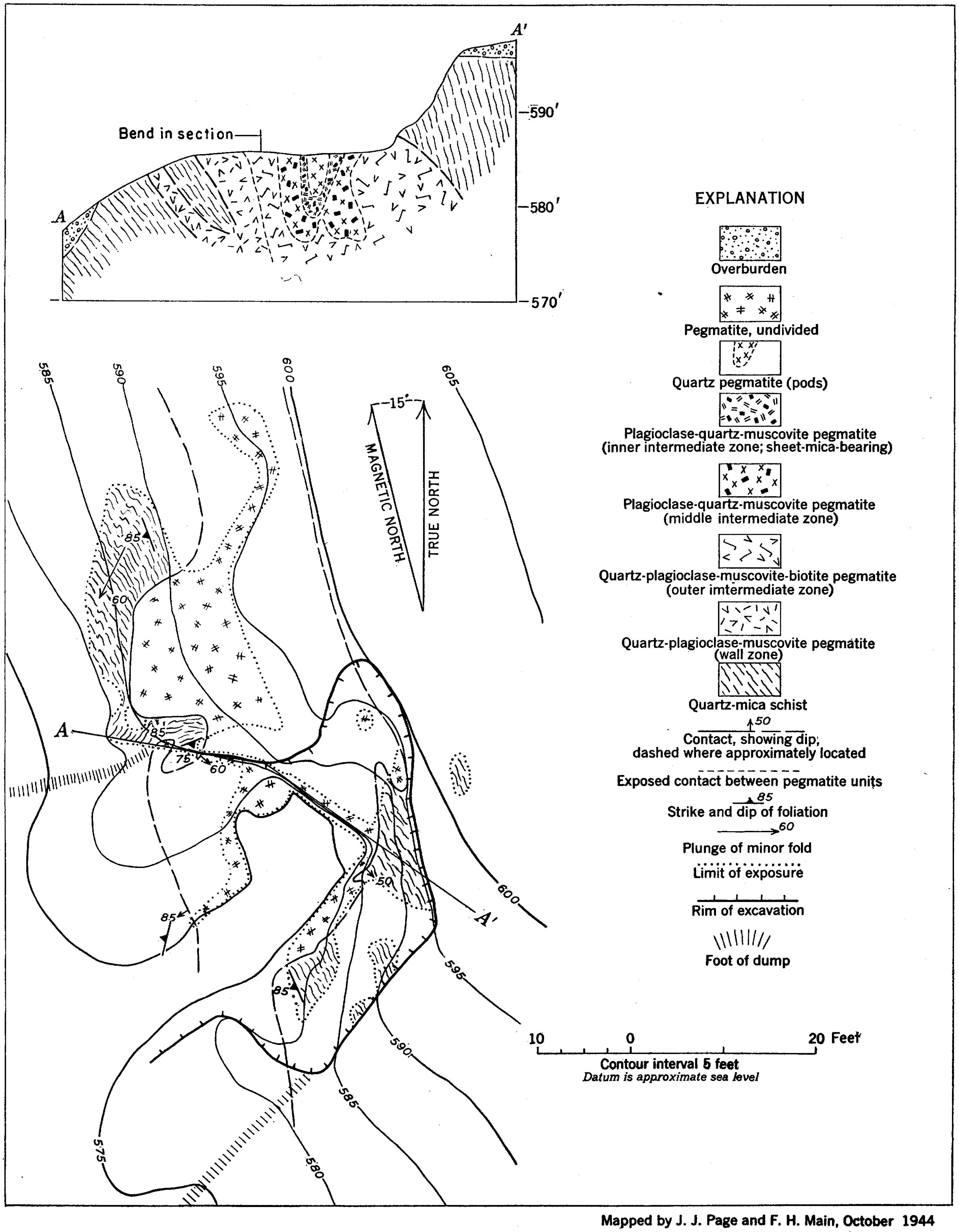


FIGURE 49.—Geologic map and section of the Surry Dam prospect, Surry, N. H.

clear ruby. A high recovery of sheet mica was obtained during prospecting. Approximately 2.5 percent mine-run mica was recovered from the rock moved in 1944.

The high sheet recovery and satisfactory ratio of mica to rock indicate that this prospect could probably support a small-scale sheet-mica operation under conditions comparable to those of 1943–44.

JEHIAL WHITE MICA MINE

The Jehial White mine (pl. 2, no. 20) is in the town of Gilsum, 1.0 mile S. 12° W. of Gilsum village. To reach it from Gilsum follow Route 10 southward for 1.2 miles, turn left and drive 100 feet to the mine. Mineral rights are owned by Jehial White of Gilsum and were leased in 1942–43 by Arthur Whitcomb of Keene.

Two small pits not exceeding 15 feet in depth were made before 1942. In 1942–43 the pits were cleared of debris and the northern pit was enlarged until it was 110 feet long, 35 to 60 feet wide, and 15 to 25 feet deep. A cut 40 feet long, 20 feet wide, and 5 to 10 feet deep was made northwest of the larger cut, and several prospect trenches were dug in an attempt to find a northward extension of the pegmatite. The mine was mapped by H. M. Bannerman and G. B. Burnett in August 1942 and remapped by A. H. McNair, J. H. Chivers, and R. P. Brundage in May 1943 (fig. 50), following cleanup development.

Several small pegmatites crop out at the mine. Two small stringers, ½ to 2 feet thick and trending N. 30° E. are exposed along the edges of the southern cut. The pegmatite in the largest cut is 2 to 8 feet thick. It strikes north in general and dips 40°–55° E. The pegmatite in the northern cut strikes north to N. 10° E. and dips 60° E. The pegmatites are exposed only in the vicinity of the cuts, as the areas between the cuts have a thick overburden.

The wall rock, quartz-mica schist of the Littleton formation, strikes north in general and dips 40°–60° E. It is minutely crumpled and contains contorted stringers of pegmatite.

The pegmatites are similar mineralogically, containing plagioclase, quartz, perthite, and muscovite, and

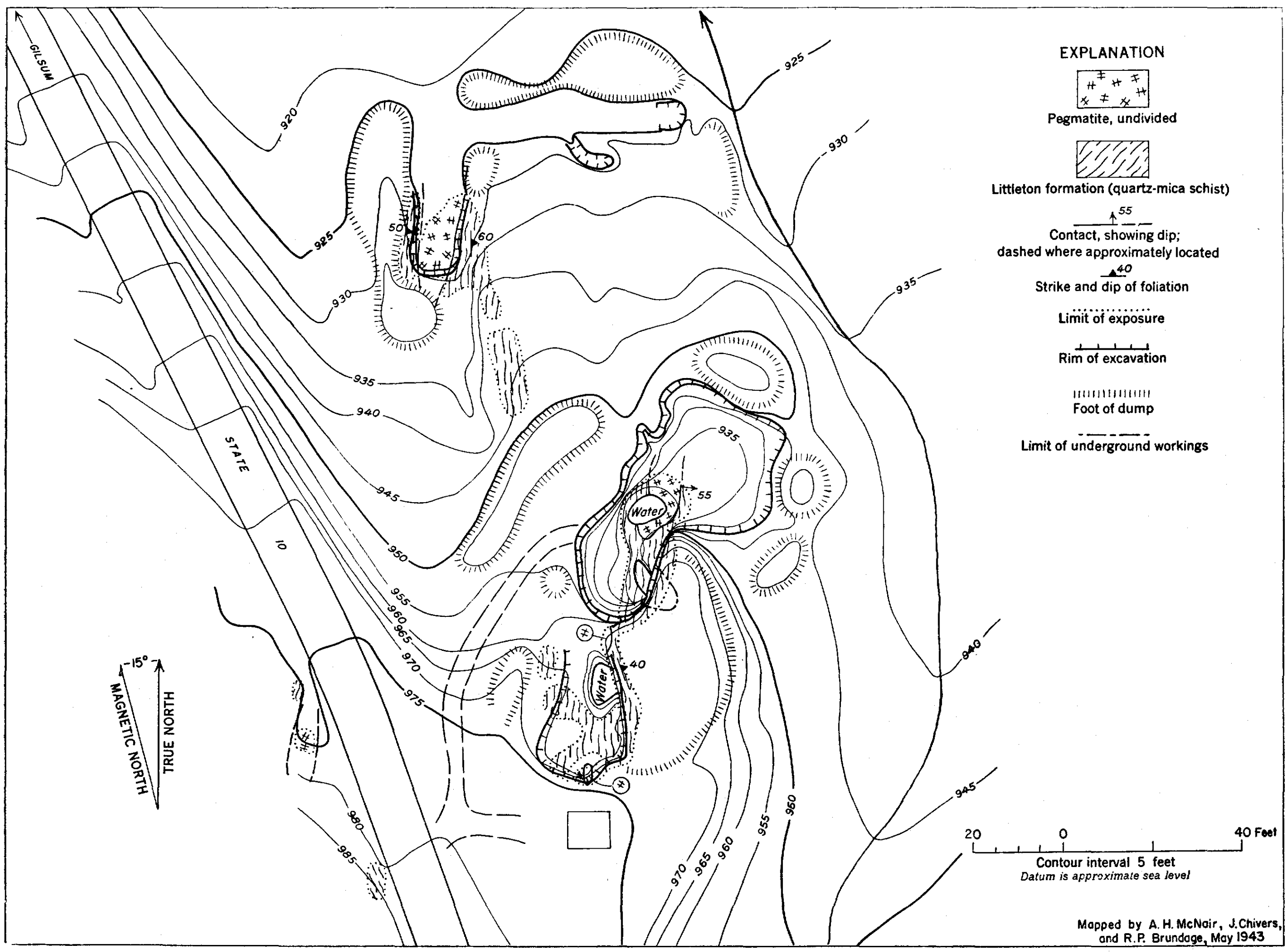


FIGURE 50.—Geologic map of the Jehial White mica mine, Gilsum, N. H.

accessory black tourmaline, greenish apatite, beryl, and garnet. Muscovite is not abundant in any of the bodies. The pegmatites exposed in the northern and largest cuts yielded the most mica in 1942–43. The mica content appears to be highest adjacent to the hanging wall in both pegmatites. No zonal structure, other than that shown by the slight increase in muscovite content along the hanging wall, has been recognized.

The muscovite is amber to ruby, hard, free-splitting, somewhat ruled and reeved. Most of the books are smaller than 4 by 5 by 2 inches. It is believed that a satisfactory percentage of sheet was obtained from them.

Several prospect trenches made in glacial drift did not reveal a northward extension of the pegmatite exposed in the larger cut. Unless the northern part of the pregmatite contains a considerably higher mica content than the part exposed in the vicinity of the cut, it would not yield large amounts of muscovite. Work at the mine was discontinued in 1943 because of low rate of recovery of mica.

COOS COUNTY

FISCHER MICA PROSPECT

The Fischer prospect is in the town of Shelburne, on the knoll 0.25 mile west of Artist Rock. It is 0.7 mile S. 25° E. of the highway bridge in the village of Shelburne. To reach the deposit from Shelburne, follow the logging road south along the east side of Clement Brook 0.4 mile to a fork to the southeast, on the same side of the brook. Follow this old road 0.4 mile to a poorly defined trail leading north 0.1 mile from the road to the prospect, which lies between the knob and Artist Rock. The land is owned by F. C. Fischer, Shelburne, who has stripped moss and shallow overburden from several outcrops between the gully and the knob. The prospect was examined September 4, 1942, by D. M. Larrabee and I. S. Fisher.

Pegmatite, fine-grained biotite granite, and quartz-biotite schist occur in outcrops scattered over 300,000 square feet of surface. Alternate bands of fine- and medium-grained granitic pegmatite, associated with fine-grained biotite granite, are present on top of the knoll. These bands trend west, about parallel to foliation of the wall rock. The foliation strikes N. 80° E. to N. 80° W. and dips 65°–82° N. Contacts of pegmatite to wall rock are not exposed, and the shape of the pegmatite could not be determined. The intrusive appears to be large, and may be part of the larger pegmatite on Artist Rock. Much of the pegmatite exposed is fine-grained, composed of grains 1/16 to 1/4 inch in diameter. This feature suggests that the body has not been deeply eroded.

Inward from the fine-grained border zone, the pegmatite is medium-grained, and consists of quartz, pale flesh-colored perthite, plagioclase, biotite, and muscovite. Isolated pods of coarser-grained perthite and quartz, containing books of muscovite in part intergrown with biotite, occur in the medium-grained pegmatite. The perthite crystals rarely exceed a few inches in diameter. The mica books in the pods and near the inclusions are rum to ruby, less than 4 inches in diameter, have "A" structure, and are commonly ruled. Because of the poor quality and erratic distribution of the mica the property was not operated during the war period.

GRAFTON COUNTY

ACME MICA PROSPECT

The Acme prospect (pl. 1, no. 16) is 2.1 miles N. 13° E. of Dorchester. From Dorchester follow the Cheever road northeastward 2.4 miles to a left fork; take the fork 0.8 mile to another fork; proceed southwestward on foot along a wood road 0.16 mile to the prospect.

The property is owned by John Hanley of Cheever, N. H., and was leased and prospected by the Acme Mica Co. of West Rumney, N. H., during May and June 1944. Two small opencuts were made. The lower cut is 30 feet long, 13 feet wide, and 2 to 5 feet deep. The upper cut is 80 feet long, 5 to 10 feet wide, and 3 to 15 feet deep. The prospect was mapped by A. H. McNair and A. H. Chidester in July 1944.

The Acme pegmatite, exposed for 130 feet, is 1 to 7 feet thick. It strikes N. 85° W. and dips 55° to 75° S. It is roughly parallel to the strike of the foliation but is discordant to the dip. It appears to terminate eastward in the lower cut. The wall rock consists of massive, poorly foliated biotite gneiss. Its foliation strikes N. 63° to 90° W. and dips 60° to 85° NE. Pegmatite-gneiss contacts are sharp and regular.

The pegmatite consists of glassy white perthite, greenish-buff andesine (An_{26}), gray quartz, and minor quantities of biotite and muscovite. The pegmatite does not appear to have a zonal structure. It contains coarse-grained (2 to 12 inches) interlocking anhedral crystals of uniform size from wall to wall. No fine-grained border zone was found.

Muscovite is not abundant in the pegmatite, but it occurs as irregular "nests" or patches that extend across the dike and also as disseminated books in parts of the pegmatite. The books are most abundant on the easternmost glaciated outcrops, a few feet from the edge of the lower cut. The muscovite is amber to rum, ruled, and intergrown with biotite.

The results of prospecting in 1944 were not encouraging. The small size of the pegmatite and the sporadic occurrence of the mica, together with the small size and poor quality of sheet mica obtained from the books, indicate that little commercial mica could be obtained.

AFRICAN MICA MINE

The African mine (pl. 1, no. 42) lies in the town of Orange, three-fourths mile nearly due east of the school at Orange village. From Canaan, follow State Highway 118 northeast for 0.5 mile to the junction with an asphalt road. Turn east and follow this road (part gravel) for 2.85 miles to the bridge over Orange Brook. Turn north and proceed 0.15 mile to the mine entrance.

The property is owned by Will Shepard, Canaan. According to Shepard, the mine was first opened about 1885 by Allen Diamond, but has been worked briefly by several lessees since. Shepard and A. W. Bennett operated the mine intermittently during the fall and winter of 1942–43, recovering a small quantity of mica. In the summer of 1943, the property was leased and prospected by the New Hampshire United Mica Co. of Andover.

In October 1943, the mine consisted of a northwest-trending opencut 95 feet long, 10 to 30 feet wide, and 10 to 25 feet deep. A stope is said to have been driven downward into the southwest side of the cut, in the course of early operations, until inflow of water made further mining impractical. This stope was concealed at the time of inspection. In 1943 a bulldozer was used in an attempt to clean out the cut and expose the pegmatite more fully. The mine was studied by C. S. Maurice and J. B. Headley in August 1942, and by E. N. Cameron, J. Chivers, and V. E. Shainin during two visits in September and October 1943 (fig. 51).

The pegmatite is poorly exposed. The principal outcrops are at the head of the cut, where a tabular body 2 to about 6 feet thick can be traced for about 70 feet along strike. In general, the pegmatite walls strike N. 45° E. and dip 40°–65° E. In the southwest corner of the cut an irregular offshoot of the main body cuts across the footwall (fig. 51, sec. BB′) and connects with pegmatite poorly exposed along the base of the cut. According to Shepard, pegmatite was found at intervals along the cut to the entrance, where there is a small outcrop in the bank on the north side, next to the road. Probably the body as a whole consisted of small connected lenses whose trends are similar to that of the tabular body exposed in the headwall, and that these plunged southwestward beneath schist. One small outcrop occurs near the presumed entrance to the filled stope.

The pegmatite cuts quartz-mica schist of the Littleton formation. The foliation of this rock strikes N. 15°–30° E. and dips 70°–75° E. Both schist and pegmatite are cut, in the headwall, by a branching sinuous normal fault, adjacent to which the rocks are shattered. A reverse fault cuts the pegmatite about 30 feet northeast of the headwall. Displacements along both faults appear small, but the broken condition of the rock and uncertainty as to the position and extent of the faulted segments in depth have complicated prospecting.

Apart from a thin border zone, the pegmatite consists of medium- to coarse-grained plagioclase, quartz, and muscovite, accessory tourmaline, and a few small beryl crystals. In places mica is concentrated along one or the other wall of the tabular body, but no persistent zones have been detected. The pegmatite is essentially a disseminated mica deposit.

Mica recovered from the head of the cut in 1943 was clear, light ruby muscovite, hard, flat, and free-splitting. Ruling was the most conspicuous defect, but cross-fracturing and "A" structure were shown by some books. The books seen ranged from 1 to 10 inches broad and one-half to 2 inches thick. The faulting has broken and severely ruled the mica so that not much sheet could be obtained.

The results of prospecting in 1943 were discouraging. The broken condition of the rock, the low percentage of sheet in the crude mica recovered, the failure to uncover any large, persistent pegmatite, and the large quantity of schist that had to be mined because of the irregularity of the deposit, led to abandonment. It is extremely doubtful that further prospecting would be warranted.

ALGER NO. 1 MICA MINE

The Alger No. 1 mine (pl. 1, no. 68) is in the town of Grafton, 1.3 miles due west of Grafton Center. From Grafton Center follow the gravel road leading up the valley of Manfeltree Brook for 1.2 miles. Here the road branches. Follow the left-hand branch for 0.8 mile to the mine. The road is impassable to ordinary motor vehicles.

The ownership of the mine was not investigated. A well-known source of large beryl crystals (Hubbard, 1852, p. 264–265; Hitchcock, 1878, p. 90; Clarke, 1885, p. 907; Flint, 1919, p. 21–22), it was first worked by Francis Alger in the 1850's. According to Sterrett (1923, p. 145) the mine was worked about 1875 by J. E. Martin, J. B. Page, and later by the Grafton Mica Co. At the time of Sterrett's visit in 1914 no work had been done for nearly 30 years. The workings were an opencut 120 feet long, 30 to 45 feet wide, and 5 to 30 feet deep, with a room and stope on the north side and two small cuts on the south and southwest. Between 1914 and 1944 the cut was extended about 40 feet west-northwest. In August 1944, the mine was leased by W. Shepard and A. W. Bennett, of Canaan, who operated it until September and produced a small amount of sheet mica. The mine was mapped and studied by

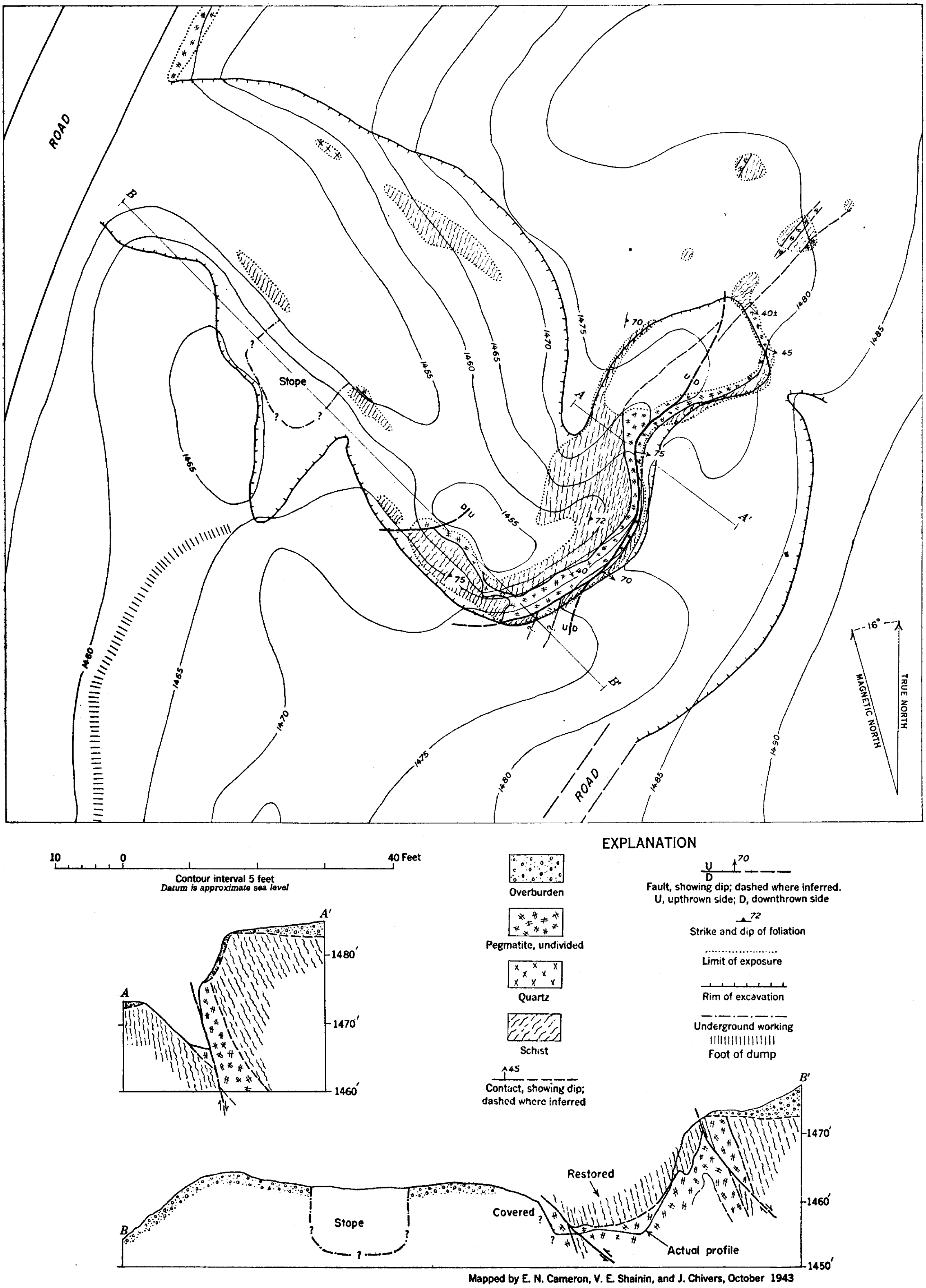


FIGURE 51.—Geologic map and sections of the African mica mine, Orange, N. H.

E. N. Cameron and P. W. Gates in August 1944 (fig. 52).

The Alger No. 1 pegmatite is an irregular body roughly resembling a dumbbell in plan. Its long axis trends about N. 80° W., and it is about 150 feet in length, and 55 to 100 feet in outcrop width. The walls are extremely irregular, with moderate to steep dips. Outcrops of wall rock in the floor of the pit suggest that it may consist of two connected bulbous parts.

The wall rocks are fine-grained biotite-muscovite granite (Concord granite?) and quartz-mica, quartz-mica-sillimanite, and amphibole-biotite schist of the Littleton formation. The foliation of the schists strikes in general between N. 12° W. and N. 13° E. and dips 60° E. to 78° W. The granite is a discordant intrusive ranging from massive to gneissic. The gneissic parts have a foliation parallel to that of adjacent schists and may be the result of granitization of the schist. The pegmatite is discordant to both rocks, cutting both the foliation of the schists and contacts between schists and granite. In places the schists have been soaked by pegmatitic material and converted to coarse gneiss, and adjacent to contacts with the pegmatite the granite in places contains tourmaline-rich masses surrounded by rock free of biotite.

The pegmatite consists of a border zone, a wall zone, an outer intermediate zone, a core-margin zone, and a discontinuous core. The border zone, ½ to 2 inches thick, consists of fine-grained quartz, plagioclase, and muscovite. The wall zone, best exposed on the north wall of the opencut and the small drift beneath it, is 2 to 3 feet thick and consists of medium- to coarse-grained plagioclase with subordinate quartz and sparsely scattered books of muscovite ranging from 4 by 4 by 1½ inches to 18 by 8 by 3 inches. Accessory tourmaline is present. Along the footwall at the base of the pillars this unit is barren of book muscovite.

In other parts of the pit the wall zone is difficult to trace because it contains little mica and on weathered surfaces is not easily distinguished from the intermediate zone. It is present along the north wall to the northwest corner of the cut and likewise along the southeast wall, but it cannot be traced south of the cut. Along the southeast wall, part of the wall zone has been removed but it seems to have been lean.

The outer intermediate zone is 2 to 5 feet thick and consists of quartz and plagioclase (cleavelandite in part) with scattered masses of perthite and books of mica. In places in the opencut this zone is much thicker and contains numerous small books of muscovite.

The core-margin zone, 1 to 2 feet thick, consists of plagioclase (cleavelandite), quartz, and wedge mica books up to 6 by 12 by 18 inches. A lens of quartz, 1 to 2 feet thick, is exposed for about 10 feet in the pillar (fig. 52). This is probably the remnant of a larger lens or a segment of the discontinuous core.

In the south wall of the quarry the outer intermediate zone contains xenoliths of alaskite and schist, some granitized. Along the southwest margin of the opencut there is a large body of quartz containing sparsely scattered perthite crystals as much as 4 by 4 feet, and molds indicate that still larger crystals have been removed. The large beryl crystals of the early days of mining probably came from this unit, which is interpreted as a second segment of the core. It is bordered by a core-margin zone, 1 to 3 feet thick, composed of plagioclase, quartz, and scrap mica, but the plagioclase here (unlike that bordering the quartz body of the pillar) appears to be largely massive. The two segments of the core differ in that the one in the pillar carries no perthite. However, the part of this segment remaining is small, and the perthite crystals in the core were evidently widely scattered.

Mica from the wall zone is light ruby, hard, cracked, reeved, and somewhat wavy. Only a few books could be inspected, however, and the sheet content of the crude product could not be estimated. The scattered books in the intermediate zone are cracked, show an approach to "fish-scale" structure, and appear to contain little sheet material. Mica from the core-margin zone is greenish, wedge, and has "A" structure. It appears to be entirely of scrap quality. Beryl was not seen in place, but Bennett and Shepard recovered a few crystals during mining in the western part of the cut.

The only obvious source of sheet-mica, the wall zone, is varied in mica content, but the average is less than 1 percent of mica. Mica from other zones is largely or entirely scrap. Little beryl is in sight, and there is no direct evidence of the distribution of the large crystals said to have been extracted in the past. Reserves of high-grade feldspar in sight are very small.

ASHLEY MICA PROSPECT

The Ashley mica prospect (pl. 1, no. 14) is in the town of Rumney, about 2.5 miles west of Rumney Depot. To reach the deposit, follow State Highway 25 for 2.2 miles west from Rumney Depot. At this point, almost opposite the town tool yard, a wood road turns west from the highway along the south side of a small stream. The road leads about 4,500 feet to the deposit, which is situated on a high spur of Bailey Hill. The road is poor and steep and is passable only by tractors.

The prospect is owned and operated by H. A. Ashley, Dorchester, N. H., who worked it intermittently from December 1942 to 1945. Production was small. The property was examined several times during the winter of 1942–43 by D. M. Larrabee, and was examined and mapped by E. N. Cameron and J. Chivers on August 2, 1943 (fig. 53).

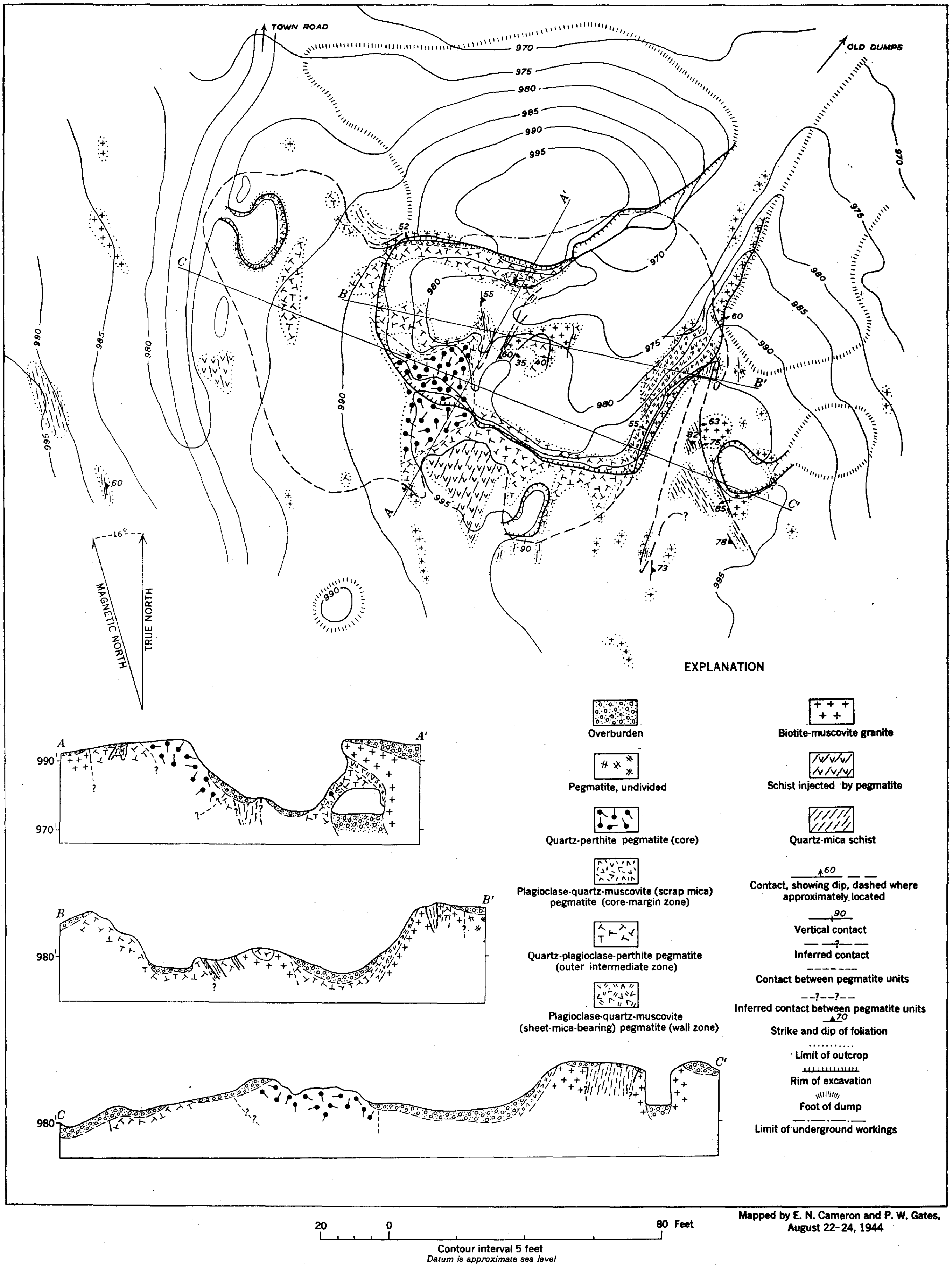
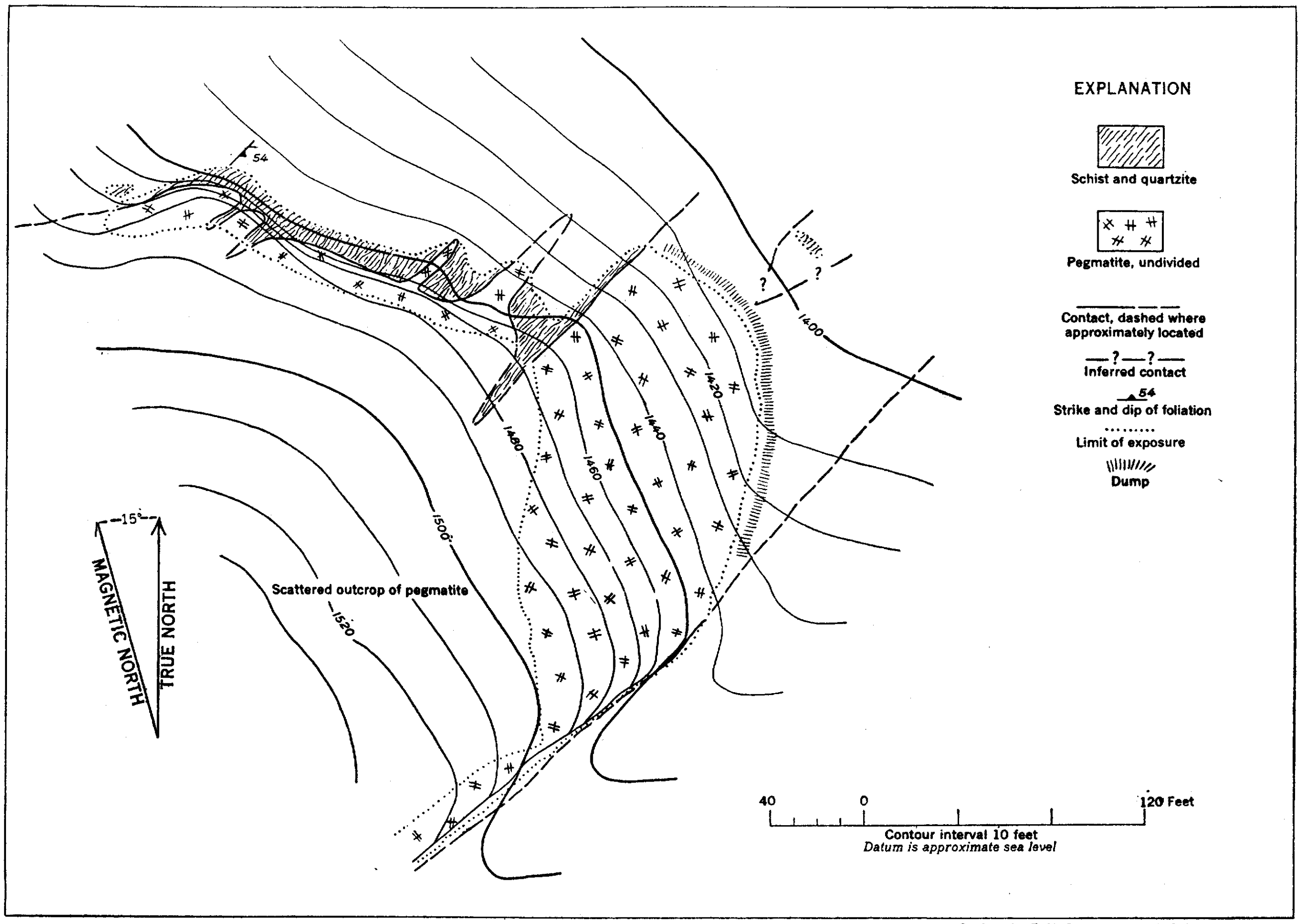


FIGURE 52.—Geologic map and sections of the Alger No. 1 mica mine, Grafton, N. H.



Geology by E. N. Cameron and J. Chivers, July 1943

FIGURE 53.—Sketch map of the Ashley mica prospect, Rumney, N. H.

The prospect is in a pegmatite that trends about N. 45° E. and is enclosed in interbedded quartz-mica schist and mica quartzite of the Littleton formation. The southeast contact of the pegmatite dips steeply southeast, parallel in general to the foliation of the wall rocks. The northwest contact is irregular and determined partly by the foliation of the wall rocks, partly by joints that cut sharply across the foliation. The mass is evidently large, extending southwest beyond the area mapped.

The pegmatite is a poorly zoned body consisting of quartz, plagioclase, perthite, graphic granite, and muscovite, with accessory tourmaline and garnet, and scattered small crystals of beryl. Along the walls there is a narrow, fine-grained border zone composed of quartz, small scrap mica books, and subordinate plagioclase. The rest of the pegmatite is an extremely thick wall zone enclosing unevenly distributed pods composed of coarse quartz, perthite, and subordinate muscovite. The muscovite books are as much as 12 inches broad and 2 inches thick. The sheet-bearing mica mined has been obtained almost entirely from the pods, which range from a few feet in length and width to 20 feet in length. No deposit of sheet mica has been found along either wall, though the walls are exposed in several places. Mica is present throughout the pegmatite, but except around the quartz masses it is small and entirely scrap.

The mica is clear, hard, rum muscovite. Books are marred by all the common types of structural defects, but sheet of good quality was obtained from some books.

Though unfavorably located, the deposit is so situated topographically that the cost of moving rock was low. Material blasted out of the steep face at the northeast end of the pegmatite exposures fell directly to the base of the slope, leaving the working faces clean. Despite this, the deposit was a marginal operation, for the average yield of mica from the pods was low. Further mining would require removal of large quantities of barren pegmatite to uncover more pods. Experience with this type of deposit indicates that the ultimate percentage of mica recovered from rock moved would be less than 1 percent.

The pegmatite contains potash feldspar of good quality, but its extraction would require mass mining, and treatment on a large scale. It seems unlikely that it could compete with other similar pegmatite deposits more favorably located.

ATWOOD MICA MINE

The Atwood mine (pl. 1, no. 11), formerly known as the General Electric Co's. mine, is in the town of Rumney, 0.5 mile N. 75° W. of the village of West Rumney (Swainboro Station). To reach it from West Rumney follow State Highway 25 northwest for 0.4 mile to a woods road on the left; turn left and follow the road about 0.2 mile southwest to a point below the mine.

Mineral rights are owned by the town of Rumney. The mine was originally owned and operated by the General Electric Co. of Schenectady, New York. Operations began in 1911 and continued for some time after Sterrett's visit in 1914 (Sterrett, 1923, p. 118–121). The main working was an open pit extending 100 feet down dip of the pegmatite. Stopes and drifts were made eastward and westward along the pegmatite from the pit. The stopes were backfilled to the 60-foot level. Pits 8 to 10 feet deep were dug east of the main workings. From July 1943 to July 1944 the mine was operated by the Granite State Mica Corp. of Wentworth, N. H. Open stopes were extended eastward from the old pit and a short adit was run along the strike of the pegmatite about 60 feet below the rim of the pit. Small opencuts and prospect trenches were made east and west of the main workings, and part of the backfill was removed from the west end of the old working. The mine was operated during August 1944 by William A. MacLeod, 50 Court Street, Boston, Mass. Most of the rock was left in the floor of the workings.

The mine was studied in July 1943, prior to reopening, by E. N. Cameron and J. Chivers and was mapped in June 1944 by Glenn W. Stewart and Norman K. Flint (pl. 19; fig. 54). Periodic visits were made between October 1943 and July 1944 by Cameron and Stewart.

The main pit is 160 feet long and 20 to 30 feet wide. It connects with two large open stopes. The northeast stope is about 50 feet long, 5 to 10 feet wide, and 20 to 25 feet high. Its floor is about 40 feet below the rim of the pit. The main stope is inclined and is connected to the northeast stope by a crosscut tunnel. The main stope is about 60 feet long, 20 to 40 feet deep, and 10 to 16 feet wide. The floor slopes about 15° northwestward toward the tunnel. About 60 feet below the rim of the pit, there is a drift about 10 feet long, 5 feet wide, and 7 feet high. Most of the workings are now flooded.

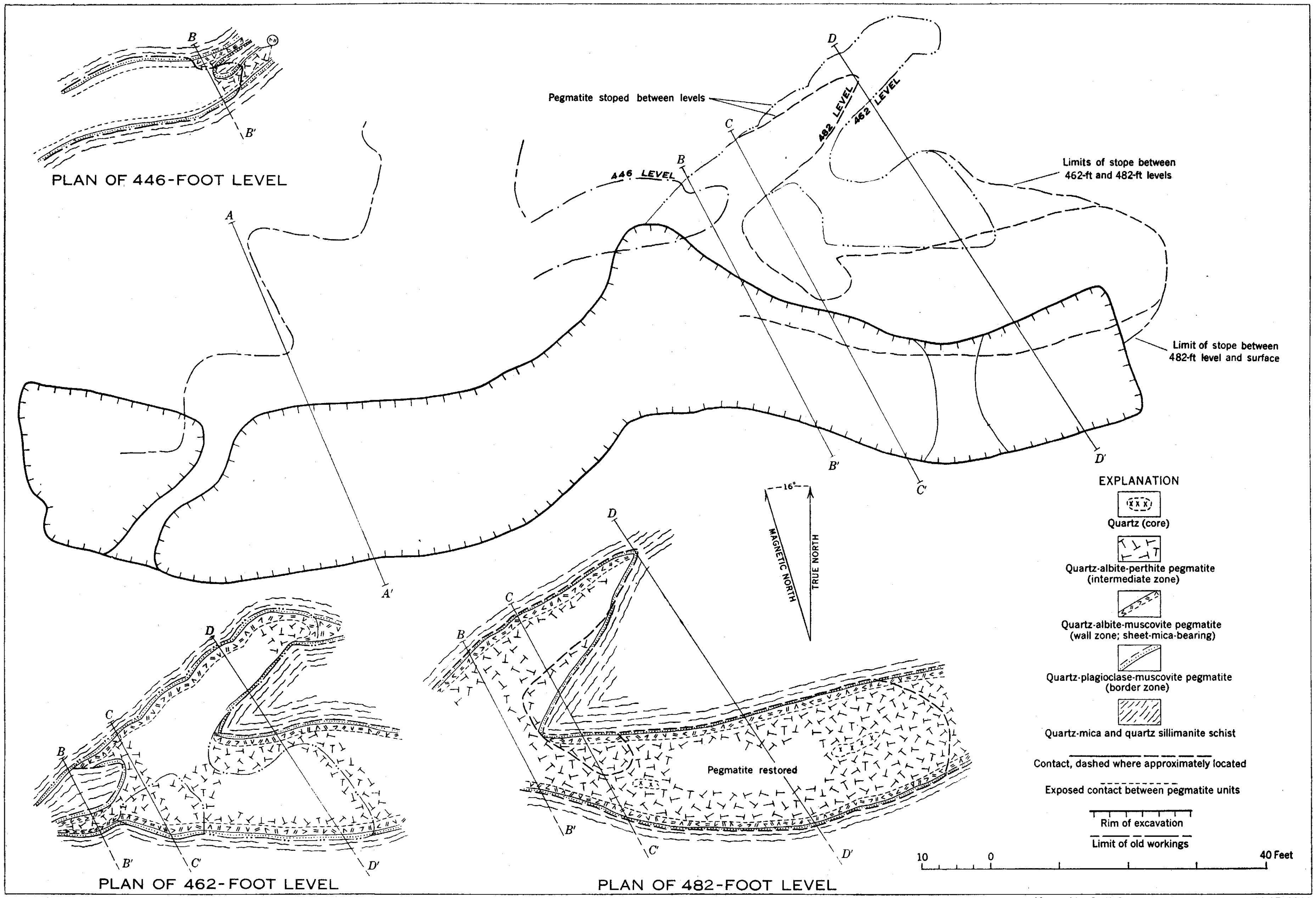
Both overhand and underhand stoping were done, and waste rock was removed by a derrick. About 2,500 tons of rock was mined between July 1943 and July 1944 and about 2 percent of this amount was recovered as mine-run mica.

The pegmatite is exposed for about 340 feet along strike and is 3 to 20 feet thick. It strikes irregularly eastward, dips from 30°–90° N., and probably plunges northeast. It is essentially parallel to the foliation of the wall rock, but in places it is sharply discordant. An offshoot that strikes approximately N. 40° E. extends from the pegmatite near the center of the main cut. The keel of the schist wedge separating the offshoot from the pegmatite plunges N. 30°–35° E. at an angle of 40 degrees. The crest of the offshoot is exposed in the roof and northeast face of the northeast stope, where it plunges 30° to 60° NE. Sharply defined rolls occur along the hanging wall of the offshoot and in the old working along the main pegmatite. Rolls occur also on the footwall but except for a deep roll in the small open pit are less pronounced. The plunge of the rolls along the hanging wall varies with the dip of the pegmatite, from approximately 40° in the old workings to 90° in the northeast stope. The plunge of the rolls is generally between 60° and 70°, but the plunge of the rolls of the footwall is much lower. One roll near the northeast end of the northeast stope has a plunge of only 30°. No well-defined rolls occur in the east end of the main stope, and there seem to be no rolls west of the old workings.

The wall rock is quartz-sillimanite schist of the Littleton formation. Northwest of the main workings the foliation strikes N. 35° W. and dips 50° NE., but in the vicinity of the workings it strikes N. 35° E. to east and dips 65° SE. to 60° NW.

The pegmatite has a well defined zonal structure. The border zone, 4 to 12 inches thick, is composed of fine- to medium-grained quartz, albite (An_9), muscovite, and accessory garnet and tourmaline. In places the component minerals are arranged in thin layers. Some of the muscovite books in this zone are 2 by 2 inches.

The quartz-albite-muscovite wall zone, 6 inches to 3 feet thick, is discontinuous. It is composed of sheet-bearing muscovite, medium-grained quartz and albite (An_4), and accessory garnet. This zone is 1½ feet thick in the hanging wall part along the western face of the old workings; 1 to 3 feet thick, according to Sterrett in the old workings and 1 to 2 feet thick in the offshoot. In places, it surrounds the crest of the offshoot, but extends only for a short distance along the footwall. It is present at the junction of the offshoot and the main pegmatite and apparently extends eastward to the prospect trench at the foot of the hill. The footwall part of this zone is 1 to 2 feet thick. It apparently is continuous throughout the exposed length of the main pegmatite, but both the hanging and footwall



Mapped by G. W. Stewart and N. K. Flint, June 11-17, 1944

FIGURE 54.—Plans of underground workings of the Atwood mica mine, Rumney, N. H.

part of the zone are indistinct in the easternmost prospect trench.

The intermediate zone, 1 to 12 feet thick, is composed of quartz, albite (An_4), small quantities of perthite, and accessory tourmaline and beryl. The core is 2 to 3 feet in maximum thickness. It is discontinuous, consisting of isolated quartz pods, 1 to 4 feet long, in the central part of the pegmatite. Some of this quartz is intergrown with albite (about An_4). Muscovite books are unevenly distributed along the margins of the quartz pods.

Most of the sheet muscovite is light to medium rum, hard, ruled, and slightly stained. The books average 4 by 5 inches, but occasionally books 1½ by 1½ feet are recovered. Muscovite is unevenly distributed in both the hanging wall and footwall parts of the wall zone, but is most abundant in the hanging-wall part, where the muscovite content is highest in shoots parallel to the rolls in the hanging wall. Several shoots were mined during the excavation of the northeast stope, and obviously the old workings followed the rolls and shoots down dip. The distribution of the muscovite in the footwall part of the wall zone is uneven, and no definite shoots were observed. The muscovite books associated with the margins of the small isolated quartz pods were larger and yielded a better quality of sheet muscovite than those obtained from the wall zone. Isolated clusters of books occur in the intermediate zone in patches rich in quartz. Muscovite recovered in the main open stope, directly beneath the open pit excavated during 1911–14, yielded poor sheet mica. The poor quality may be due to shattering of this part of the pegmatite during early operations, which permitted water to percolate into the pegmatite and soften and stain the mica. The mica exposed in the accessible parts of the old workings is very hard, flat, and apparently less ruled, although the books are slightly smaller. The quality appears to be better. Some of the muscovite recovered from the backfill in the old workings yielded sheet mica of satisfactory quality.

Considerable quantities of muscovite probably remain in the pegmatite. The pegmatite could be explored by continuing the small drift at the 446-foot level eastward beneath the northeast stope and by enlarging the main stope downward and eastward along the plunging keel of the schist wedge. Even though the mica content in the prospect pit at the bottom of the hill is low, it might be worthwhile to explore the pegmatite westward. Good quality muscovite is present in the accessible parts of the old workings. The westward extent of the pegmatite is unknown, but the pegmatite seems to thin toward the west end of the main working.

BELDEN MICA MINE

The Belden mine (pl. 1, no. 10) lies in the town of Rumney, 0.5 mile N. 15° E. of the village of West Rumney (Swainboro Station). To reach it from West Rumney, follow a graded gravel road northward for 0.5 mile across the Boston & Maine Railroad and the Baker River to a road on the right; take the right fork 100 feet to a lane on the left; follow the lane northeast about 0.2 mile to the mine. The property is owned by Edward I. Moses of West Rumney, N. H. Mineral rights are leased by William B. Wood, Warren, N. H.

Prior to July 1944 the workings consisted of a pit about 30 feet long, 18 to 25 feet wide, and 5 to 30 feet deep. A drift 35 feet long, 10 to 13 feet wide, and 7 to 10 feet high extended northeast along the strike of the pegmatite. Between July 1944 and January 1945, the pit was extended northeast along the west contact. This extension is 20 feet long, 5 to 10 feet wide, and 5 to 20 feet deep. An inclined stope 15 feet long was extended northeastward from the bottom of the pit along the west wall. A considerable thickness of backfill remains in the bottom of the open pit. The mine was mapped in October 1944 by Glenn W. Stewart and Karl S. Adams (pl. 20).

The main pegmatite is exposed for about 140 feet along strike. It is 20 to 50 feet wide, strikes N. 20° E., and dips irregularly southeast. A probable offshoot to the east strikes N. 30° W., dips 30°–40° NE., and is about 20 feet wide. It can be traced for 80 feet along strike. The main pegmatite is essentially parallel to the foliation of the wall rock but is locally discordant to the foliation near the southeast end. Several xenoliths of wall rock occur in the main pegmatite and its offshoot. The longer dimensions and foliation of the xenoliths are parallel to the foliation of the wall rock.

A silicified shear zone, 6 to 8 inches wide, cuts the western edge of the pegmatite and forms the west wall of the open pit. It strikes N. 15°–25° E., dips 73°–76° SE., and can be traced for nearly 30 feet along strike. The feldspar along the shear zone has been strongly fractured and pulverized, and in some places appears to be partially kaolinized. Small grooves and striations on the silicified surface plunge 20° N. near the entrance of the small inclined stope and 12° S. near the entrance of the open pit, but the relative displacement along the shear zone is unknown.

A vertical basic dike about 2 feet thick cuts the main pegmatite and strikes N. 40° E. It is exposed for 10 to 12 feet at the northeast corner of the open pit, and forms the southeast face of the large drift. A dike 1 foot thick is exposed in the northeast face of the large drift, 2 feet northwest of the larger dike. It appears to have a strike similar to the first but dips 65° NW. Several smaller basic dikes, 1 to 3 inches thick, are exposed in the large drift.

The wall rock is quartz-mica-sillimanite schist of the Littleton formation. Its foliation strikes north to N. 20° E. and dips 65°–80° SE. Locally, the schist contains aggregates of small black tourmaline crystals, and several lenses and sill-like bodies of gneissic granite, 5 to 25 feet thick, occur in it. In places the gneissic granite is the wall rock of the pegmatite. The foliation of the granite is essentially parallel to the foliation of the schist and the contacts are generally gradational.

The main pegmatite has well-defined zones. The border zone, 2 to 5 inches thick, is composed of fine-grained muscovite, quartz, albite (An_6), and accessory tourmaline and garnet. The wall zone, 0 to 15 feet thick, is composed of quartz, albite (An_2), small quantities of perthite, disseminated muscovite, and accessory tourmaline, garnet, and apatite. The small inclined stope was excavated in this zone. The intermediate zone, 10 to 35 feet thick and exposed for 140 feet along strike, is composed of coarse anhedral to subhedral perthite and quartz, small quantities of albite (An_2), and sparsely disseminated muscovite. Some of the crystals of perthite are 2 by 4 feet. This zone is adjacent to the footwall part of the border zone northeast of the pit. The core is composed of several isolated quartz pods in the central part of the pegmatite. Remnants of the largest quartz pod in the roof of the large adit indicate that it was 10 to 15 feet long and 3 to 6 feet wide, but other pods measure 3 by 5 feet or less. The offshoot of the main pegmatite was not examined in detail.

Most of the muscovite is hard, flat, slightly ruled, and nearly free from mineral stains, but small crystals of tourmaline are embedded in some books. The muscovite is mostly medium to dark rum, but some is ruby. The books average 3 by 3 inches are are very sparsely disseminated in the wall and intermediate zones. In general they are more abundant in the wall zone, but there are numerous books in the quartz-rich parts of the intermediate zone.

Only small quantities of small sheet mica of good quality were recovered between July 1944 and January 1945. The crude mica recovered amounted to 1 percent of the rock moved. Prospecting in the old workings yielded little mica, and future prospecting in other parts of this pegmatite would probably have similar results.

BROWN MICA MINE

The Brown mine (pl. 1, no. 4) lies in the town of Wentworth, on the north slope of a prominent hill, 0.75 mile S. 10° E. of Wentworth village. To reach the mine from Wentworth follow a hard-surface road south 0.8 mile to a farmhouse; walk 0.4 mile east through a wooded slope to the mine.

The mineral rights are owned by C. H. Brown of Wentworth, who reports that a small prospect pit was made on the property about 1885. The Granite State Mica Corp. of Wentworth leased the mine, deepened the pit to 25 feet, and made two small opencuts during the winter of 1943–44. The pegmatite in which the cuts were made was mapped by A. H. McNair and A. H. Chidester in June 1944 (fig. 55).

The Brown pegmatite is exposed for 160 feet along strike. It is 2 to 10 feet thick, strikes N. 50° W. and dips 36°–50° NE. It is thickest in the vicinity of the pit, where it plunges southeast at an angle of approximately 25°. A second pegmatite, the keel of which is exposed on the southeast face of the cut, also plunges southeast. It is not exposed southeast of the cut.

Bethlehem gneiss forms the wall rock. Its foliation strikes N. 25° W. and dips 45° E. and is crossed by strong northwest-trending joints that control the pattern of the gneiss outcrops. The pegmatites are sharply discordant to the foliation of the wall rock.

Three basic dikes cut the pegmatite. An 18-inch dike in the walls of the shaft strikes east and dips 75° N. It consists of a fine-grained material containing irregular feldspar phenocrysts. A dike 38 feet wide cuts the pegmatite northwest of the cut. It strikes N. 45° E. and dips 75° NW. The third dike, 3 to 5 feet thick, is is exposed at the southeast end of the northernmost cut, and it strikes northeast to east.

The northwestern pegmatite consists of plagioclase, perthite, quartz, muscovite, and minor garnet. It has a well-defined zonal structure. An ill-defined border zone, 1 to 4 inches thick, contains fine-grained mica, plagioclase, and quartz. It grades into the wall zone, which is composed of medium-grained quartz, muscovite, and plagioclase and is thickest and most clearly defined along the hanging wall. The wall zone is 18 inches thick along the hanging wall in the pit and 4 to 12 inches thick along the footwall. An intermediate zone, 6 inches to 6 feet thick, lies within the wall zone and consists of plagioclase, quartz, perthite and minor scrap muscovite and garnet. A discontinuous quartz core as much as 4 feet in thickness occurs in the central part of the pegmatite near the inclined shaft and in the northwestern part of the pegmatite.

The southwestern pegmatite is similar mineralogically and contains equivalent zones, except that no quartz core is exposed.

The mica obtained from the deposit in 1943–44 was small, excessively ruled and reeved, greenish rum muscovite. The quality was so poor that little, if any, was rifted or trimmed. The mica in the northwestern

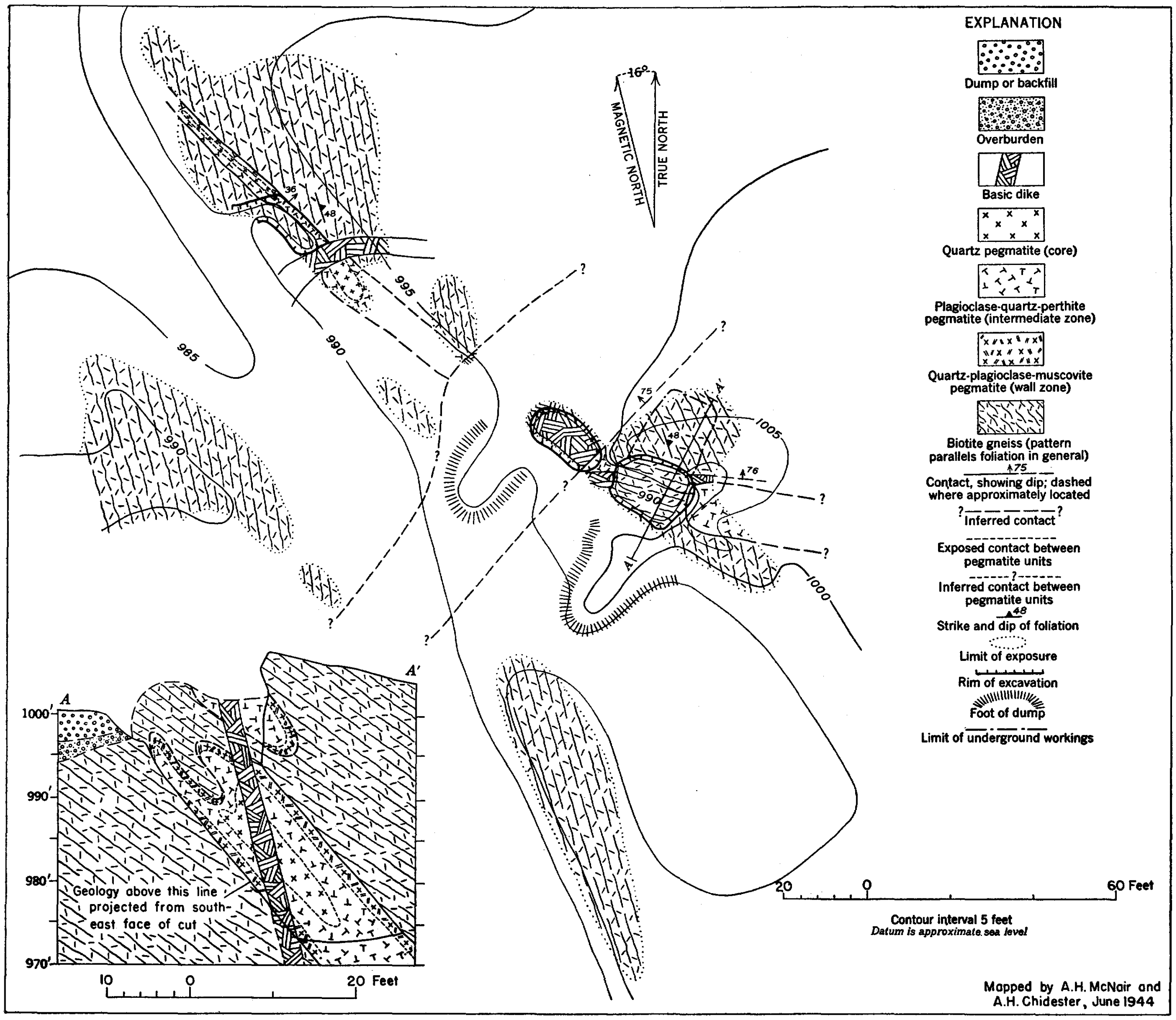


FIGURE 55.—Geologic map and section of the Brown mica mine, Wentworth, N. H.

pegmatite is most abundant in the deep pit near the largest basic dike. It appears that both the dike and the deformation that produced fractures in the pegmatite are partly responsible for the poor quality of the mica. The southeastern pegmatite has not been prospected. It appears doubtful that it contains mica of high quality southeastward away from the basic dike.

BROWN LOT MICA MINE

The Brown Lot mica mine (pl. 1, no. 32) is in the town of Groton, 1.7 miles N. 68° E. of Bucks Corners. To reach the deposit from Bucks Corners, go northward 0.2 mile along State Route 118, a gravel road, to an intersection. Turn east for 1.4 miles to the junction with another gravel road leading east across the South Fork of Baker River. Follow this road about 1.2 miles to the mine, which is about 600 feet northeast of the Brown Lot No. 10 feldspar mine.

The mine is owned by Golding-Keene Co. of Keene. It was opened many years ago and, according to local report, has been operated several times for mica or feldspar. The workings are three opencuts and two test pits. The westernmost cut is largely filled with waste and the two inclines on its east wall are now largely flooded and filled with waste. These are said to have been sunk steeply eastward to depths of about 90 feet. The middle cut, partly flooded, gives access to a short forked adit driven into its northeast wall. The east cut is little more than an enlarged test pit. The mine was mapped and briefly studied in September 1943 by E. N. Cameron, J. Chivers, and V. E. Shainin (fig. 56).

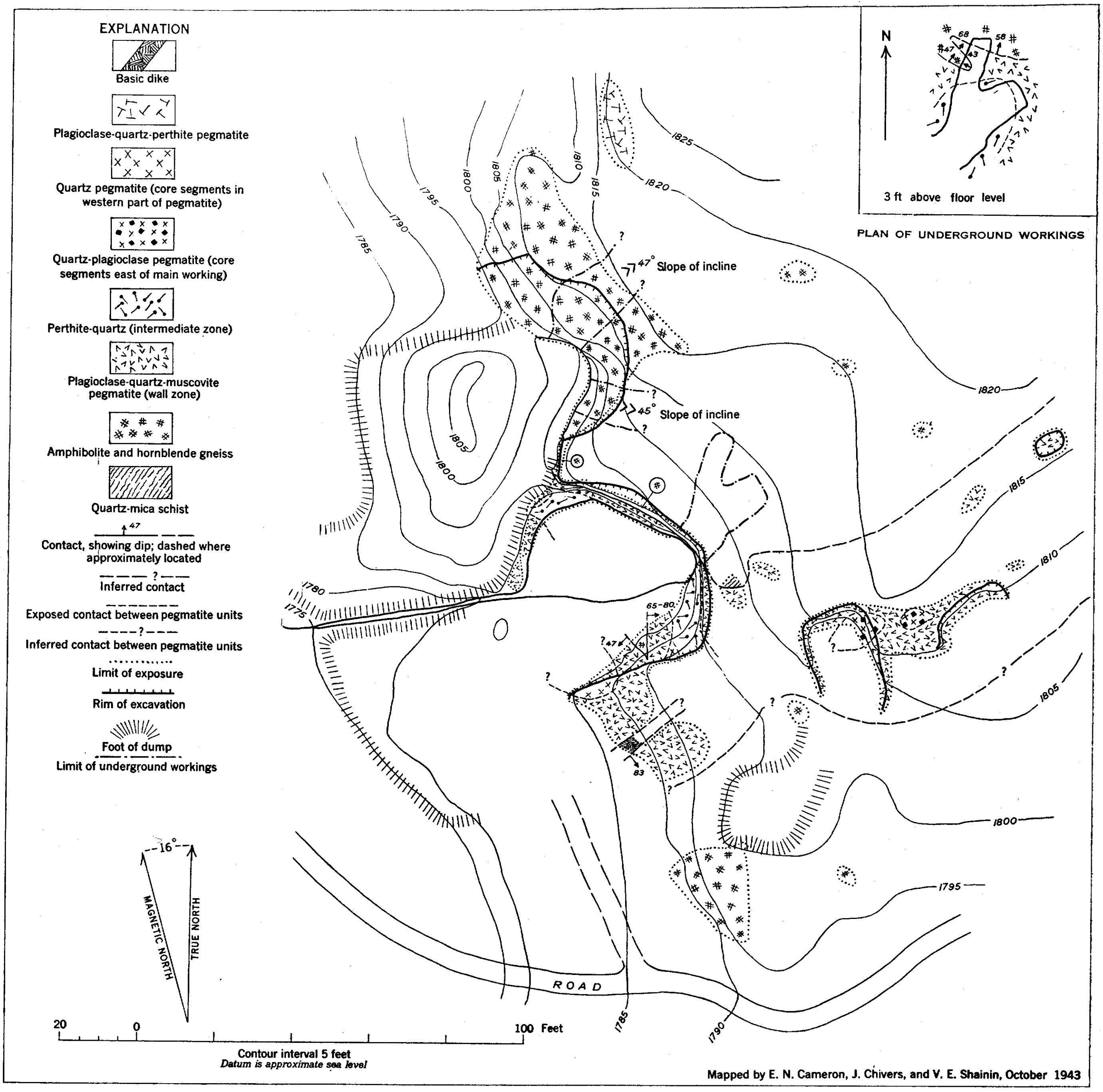


FIGURE 56.—Geologic map and plan of the Brown Lot mica mine, Groton, N. H.

The mine is in a pegmatite that is poorly exposed but appears to be an irregular lens, crescentic in outcrop plan. The footwall is concealed. The hanging wall has the form of an irregular trough that plunges in a direction between N. 30° E. and N. 45° E. The axis of the trough passes through the western part of the headwall of the middle cut. In detail the hanging wall is uneven and rolling. In the west cut it strikes north-northeast in general and dips easterly. The north incline follows a pronounced upward roll of the hanging wall that plunges N. 20° E. at an angle of about 27°. At the junction of the west and middle cuts the strike of the hanging wall changes abruptly to east-southeast, and the dip east of this point is in general to the north. East of the middle cut the strike apparently veers to east-northeast.

The pegmatite is intruded into massive amphibolite, hornblende gneiss, and biotite gneiss containing patches

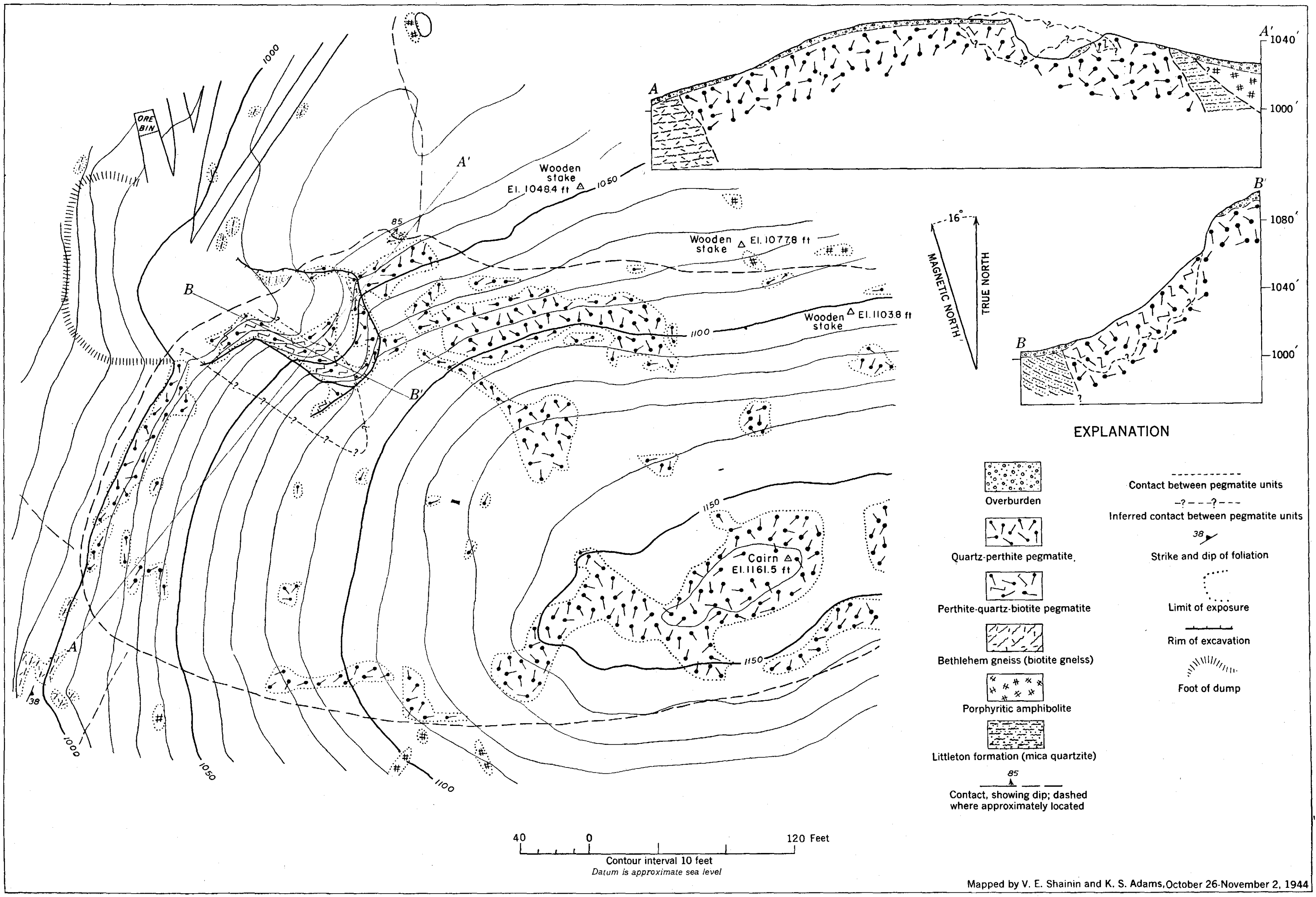


FIGURE 57.—Geologic map and sections of the Brown Lot No. 10 feldspar quarry, Groton, N. H.

of quartz-mica schist. Near the middle working it is cut by a steeply dipping basic dike that strikes N. 53° E. and dips 83° SE.

The pegmatite is zoned, consisting of a border zone, a plagioclase-quartz-muscovite wall zone, a perthite-quartz intermediate zone, and a quartz-rich core. The border zone, 1 to 5 inches thick, consists of quartz and muscovite, with varying quantities of plagioclase. The wall zone, 2 to at least 15 feet thick, is composed of medium- to coarse-grained plagioclase, quartz, and muscovite, with accessory garnet. The intermediate zone is composed largely of perthite and quartz, in part graphically intergrown. Perthite forms crystals as much as 2 by 4 feet in cross section. This zone appears to pinch out irregularly in the northwest wall of the cut. East of this point, in the headwall, the zone is exposed for 5 to 7 feet above water level. As the pit is more than 10 feet deep in places and is said to have yielded potash feldspar, the total thickness is probably much greater. This zone was followed underground in the forked adit and forms most of the walls of the stem and east branch of the adit, but the wall zone forms the roof and face of the east branch. In the west fork of the adit the pegmatite interfingers with amphibolite and the wall zone occurs at the contacts.

In the southeast wall of the middle cut, the full sequence of zones is exposed between the hanging wall of the pegmatite and a wedge of hornblende gneiss. A quartz body, interpreted as a segment of a discontinuous core, is exposed (see map, fig. 56) under the perthite-quartz zone. The part of the plagioclase-quartz-muscovite zone underlying the quartz body wraps around the top of the wedge, and separates it from another segment of the core exposed to the southwest. The perthite-quartz zone is not present adjacent to this segment nor around the third core segment that is exposed in the east cut. Between the wedge and the hanging wall the perthite-quartz zone is only 7 to 8 feet thick and appears to be pinching out. East of the middle cut the wall zone forms the bulk of the pegmatite, but in the east cut there is a quartz body that appears to be another core segment though it contains scattered plagioclase crystals up to 10 inches in diameter. A similar body lies between it and the test pit to the east. Books of muscovite are scattered along the margins of these bodies.

Scattered mica books as much as 10 by 8 by 2 inches occur in the hanging wall of the middle cut, along the upper margin of the perthite-quartz zone, in a poorly defined zone. West of the middle cut the pegmatite could be seen only at a point in the north incline; there the upper part of the wall zone is exposed, and contains a few muscovite books.

Mica from the deposit is light-rum to light-ruby, clear muscovite. The few books available for inspection were hard but marred by ruling, reeving, and cracking. They appear to contain little sheet mica. The book mica occurs mainly along the upper margin of the intermediate zone in the middle cut and in the wall zone. The average mica content of these units seems to be low. Perhaps more book mica was found in the wall zone in the inclines, but it is doubtful that the expense of cleaning and draining the inclines would be justified. Any reserves of potash spar remaining in the intermediate zone is probably confined to the middle cut, for the zone is thin at both ends of the cut.

BROWN LOT NO. 10 FELDSPAR QUARRY

The Brown Lot No. 10 quarry (pl. 1, no. 33) lies in the town of Groton, 2.1 miles N. 59° E. of Bucks Corner. To reach it from Canaan follow State Highway 118 northeastward to Bucks Corner; take the right fork 0.2 mile to a gravel road leading eastward across the South Fork of the Baker River. This road leads directly to the mine, a distance of about a mile.

The property is owned by the Golding-Keene Co., Keene, N. H., who operated the quarry for short periods from 1942 to 1944. An opencut 90 feet long, 60 feet wide, and 5 to 70 feet deep was blasted into a steep knoll and then partly backfilled. The property was mapped by V. E. Shainin and K. S. Adams in November 1944 (fig. 57).

Neither the external nor internal structure of the pegmatite can be determined accurately from the exposures. In plan the body is roughly oval, with its long axis striking east. The south wall is probably vertical or steeply dipping, and the north wall may have a moderate to steep northward dip. The pegmatite may be a lens whose upper contact coincides roughly with the western and northern slopes of the knoll. The pegmatite has a strike length of at least 500 feet and an outcrop width of 270 feet. It is discordant to the foliation of the enclosing mica-quartzite, dark-green porphyritic amphibolite, and Bethlehem gneiss.

Despite poor exposures, four fairly distinct units can be recognized: quartz-plagioclase border zone, quartz-perthite-plagioclase-muscovite wall zone, perthite-quartz-biotite unit, and quartz-perthite unit. The structural relations of the last two units are unknown.

The border zone, about 5 inches thick, consists of fine-grained quartz and plagioclase with accessory muscovite and garnet. Irregular patches of fine-grained pegmatite, interpreted as border zone remnants, occur as capping layers on widely scattered pegmatite outcrops on the northern and western slopes of the knoll. The attitudes of these cappings, which are too mall to be shown on the accompanying map, coincide roughly with the topographic surface, suggesting that the present surface of the knoll lies close to a contact from which the wall rock has been eroded.

The wall zone, 2 to 8 feet thick, contains medium-grained quartz, perthite, plagioclase, and muscovite. It is exposed in the north wall of the quarry and forms scattered outcrops on the northern and western slopes of the knoll. It is not shown as a separate unit in figure 57.

The perthite-quartz-biotite unit is a poorly exposed body with a length of at least 90 feet. It is exposed in the opencut, where it appears to overlie quartz-perthite pegmatite. The essential minerals are perthite, quartz, biotite, and muscovite. Accessories are green apatite and black tourmaline. Perthite occurs in salmon-colored anhedral masses 1 inch to 6 feet in diameter. Graphic granite appears to be less common in this unit than in the quartz-perthite unit. Biotite occurs in diversely oriented blades up to 10 feet long, 4 feet wide, and 2 to 3 inches thick, many of which are slightly curved. The biotite is badly fractured and intergrown with muscovite. In the eastern face of the opencut three large biotite blades occur along joint surfaces with their cleavage parallel to the walls of the joints. Muscovite, in ruby-colored books averaging 3 to 4 inches in diameter, is disseminated sparsely through the unit.

The quartz-perthite unit constitutes most of the exposed pegmatite. It may be a zone that envelops an unexposed core or might be the core of the pegmatite. It consists of quartz and perthite with accessory garnet, tourmaline, muscovite, and small quantities of biotite. Perthite occurs in subhedral to anhedral masses as much as 8 feet in length. Graphic granite is common as irregular aggregates that average 6 feet in length and are composed of inch-sized grains of quartz and perthite. Small parts of the unit consist of books of muscovite ¼ to ½ inch in diameter. These are disseminated in quartz with subordinate perthite.

The perthite-quartz-biotite unit contains abundant perthite. However, the feldspar appears to be more fractured and iron-stained than that in the quartz-perthite unit and, in addition, biotite is so abundant that its separation from perthite would be difficult. The perthite in the quartz-perthite unit appears to be fresher and less friable than that in the biotite-rich unit, but most of the perthite contains quartz in graphic or other intergrowths even though there are many large masses of nearly pure feldspar in the unit. The composition, texture and mineral relations of the unit in outcrops outside the quarry are somewhat obscured by weathering and a thin veneer of lichens and moss, but the feldspar appears to be no better than that exposed in the opencut.

BUFFUM MICA MINE

The Buffum mine (pl. 1, no. 62) is in the town of Grafton, approximately 3.4 miles S. 28° E. of Canaan village. To reach it from Canaan follow U. S. Highway 4 west 0.5 mile to a road on the left; turn left across the bridge over the Indian River and Boston & Maine Railroad; continue southeast 1.5 miles to a crossroad; continue southeast on the same road 1.4 miles to a fork, passing a side road on the right. At the fork, turn right on a woods road and travel about 0.6 mile to another woods road and then about 0.7 mile to the mine.

The property is owned by Pearley Hanna, Canaan, N. H. Between August 1943 and May 1944 the mineral rights were leased and the mine operated by Arthur L. Albee, 4 Liberty Square, Boston, Mass. Prior to August 1943, a small prospect pit had been made in pegmatite no. 2 (pl. 21) and during 1943–44 several opencuts and prospect pits were made in the northern half of pegmatite no. 1. The area between cuts A and B has been partly mined and backfilled. Approximately 1,400 tons of rock was mined from cuts A and B and yielded 2.1 percent of mine-run mica. Only small quantities of mine-run mica were recovered from cuts C and D. The pegmatites were mapped in November 1943 by Glenn W. Stewart and Norman K. Flint, and in July 1944 the workings in the northeastern half of the pegmatite were remapped by Stewart and Flint. Periodic visits were made by E. N. Cameron and Stewart between December 1943 and May 1944.

Pegmatite no. 1 is exposed for 620 feet along strike and is 6 to 140 feet wide. The narrow western half strikes east, in general, whereas the eastern half strikes east-northeast to northeast. The walls of the pegmatite dip 50°–85° SSE., and it appears to plunge northeast. Pegmatite no. 2 is exposed for 85 feet along strike and is 5 to 40 feet wide. It strikes N. 45° E., dips 35°–60° SE., and probably plunges 35° NE. Pegmatite no.3 is exposed for 250 feet along strike and is 85 to 140 feet wide. It strikes N. 40°–45° E. and dips steeply northeast. All the pegmatites are essentially concordant to the wall-rock foliation.

The wall rock consists of aplite and quartz-mica schist of the Littleton formation. The foliation of the schist strikes N. 40° E. to E. and dips 60° SE. to vertical. The aplite is confined mainly to the northeast ends of Pegmatites no. 1 and no. 3. In both pegmatites the aplite bodies have an irregular crescent shape, are wrapped around the crests of the pegmatites, and seem to extend a greater distance along the hanging walls than along the footwalls. The aplite has a uniform, fine-grained texture and is composed of quartz, albite

(An_{7-9}), sericite, minor quantities of microcline, and accessory garnet.

A complex zonal structure is present in the northeastern part of pegmatite no. 1. The border zone varies in thickness and composition with the type of wall rock with which it is in contact. At the schist contacts it is 3 to 18 inches thick and is composed of fine-grained quartz, oligoclase (An_{10-12}), muscovite, and accessory garnet, tourmaline, and apatite. At the aplite contact the border zone is 1 to 2 inches thick and contains more oligoclase, less quartz, and small amounts of fine-grained muscovite. The sharply defined border zone at the aplite and pegmatite contact indicates that the aplite is older than the pegmatite.

The discontinuous, sheet-bearing wall zone, 1 to 2 feet thick, is most persistent along the footwall. It is composed of albite-oligoclase (An_{9-11}), quartz, sheet-bearing muscovite, and accessory tourmaline, apatite, and garnet. This zone appears to have extended along the aplite hanging wall for a short distance.

The outer intermediate quartz-albite-perthite zone, 10 to 28 feet thick, is discontinuous. It is best exposed at the extreme northeast end of the pegmatite in cut A and along the footwall. It is composed of quartz, albite (An_{5-7}), perthite, minor sheet-bearing muscovite, and accessory tourmaline, garnet, and apatite. In the vicinity of cut A it contains inclusions of aplite as much as 3 feet long and 1 foot thick. The perthite and the sheet-bearing muscovite books are unevenly distributed through the visible parts of the zone.

The inner intermediate perthite-quartz (or core-margin) zone is 25 to 50 feet thick and is exposed for 120 feet along the strike. It is composed of coarse-grained perthite, quartz, graphic granite, minor albite (An_{5-7}), muscovite, and partly chloritized biotite. Accessory minerals are tourmaline, garnet, apatite, and pyrite. There is a textural change in this zone between cuts B and D. Cut B, in the outer (upper) part of the zone contains coarser grained material than cut D, which is in the lower, inner part of the zone.

The core consists of milky and rose quartz. It is reported that quartz covered a large area of the floor near the entrance of cut B before it was backfilled.

A replacement body transects the quartz-albite-perthite zone on the east and west faces of cut A. It is a lens-shaped body that strikes E., dips 65° S., has an average width of 1½ feet, and an exposed length of 25 feet. It is composed of quartz, albite, sheet-bearing muscovite, and accessory tourmaline and garnet.

The muscovite is light rum, soft, badly ruled, reeved, cracked, and contains mineral inclusions. The average dimension of the books is 5 by 5 inches, but many are 10 by 12 inches, and some are 2 to 3 inches thick. The muscovite is confined mainly to the footwall part of the wall zone and to the replacement body, but scattered books are present in the intermediate zones. Many wedge-shaped books, containing herringbone structure, are scattered in the quartz-perthite zone, and a few are marginal to the quartz core. In cut C some muscovite occurs as strips along joint planes in the quartz-perthite zone.

Operations during 1943-44 were reported unprofitable primarily because of the low recovery of sheet mica. This was due to the softness and numerous structural defects of the mica. Several hundred tons of feldspar of good quality could be recovered from the quartz-perthite zone, and at least 15 to 20 tons of mica of poor quality remains in the unmined parts of the footwall mica zone. The quantity of recoverable mine-run mica present in the replacement body is unknown.

BURGESS PROSPECT

The Burgess prospect (pl. 1, no. 13) is in the town of Rumney, about 1.1 miles south-southeast of West Rumney post office. To reach it, follow State Highway 25 for 2.2 miles west from the turn-off to Rumney village. At this point, almost directly opposite the Rumney town tool yard, a wood road turns south. Follow this road for about 3,500 feet to the deposit, which is high on a spur of Bailey Hill. The road is steep and impassable for trucks.

The property is owned by H. A. Ashley, Dorchester. A pit 25 feet long, 8 to 15 feet wide, and 4 to 8 feet deep was opened prior to 1942. Ashley prospected the pegmatite on the property during 1943–44, and 1945, and recovered small quantities of mica and beryl. The deposit was examined briefly by E. N. Cameron and J. Chivers in August 1943 and again by A. H. McNair in February 1945.

The pit is near the northeast margin of a poorly exposed pegmatite body, probably a large thick lens with a northwest trend. The northwest wall of the pegmatite in the vicinity of the pit is uneven, but in general dips steeply east and northeast. The limits of the body were not fully determined. Its strike length is more than 500 feet and its width more than 150 feet.

The pegmatite is composed essentially of medium- to coarse-grained quartz, plagioclase, perthite, and muscovite. A border zone and indistinct pods are present. A fracture-controlled body 4½ feet thick extends 28 feet along the north rim of the pit. It strikes about N. 80° E. and has a steep dip. A similar body extends 30 feet N. 33° E. from the east rim of the pit. The fracture fillings consist of coarse quartz, perthite, accessory book mica, and scattered beryl crystals, as much as 9 inches long and 3½ inches in diameter. The mica books are 1 to 8 inches broad and up to 2 inches thick. The mica is hard, clear, rum muscovite, marred by ruling, "A" structure, cross fracturing, and tanglesheet. Some books, however, contain flat sheet of good quality.

Apart from the two fracture-controlled deposits the pegmatite is virtually barren of book mica. Prospecting has served to confirm the fact that such deposits rarely support mining operations.

CARPENTER MICA MINE

The Carpenter mica mine (pl. 1, no. 70) is in the town of Grafton, 3.5 miles S. 77° W. of Grafton village. From Grafton take a graded road southwestward 2.3 miles to Robinson Corner. Follow the right fork northeastward, passing two left forks, for 2.0 miles to a crossroad. Take the left fork over a newly constructed mine-access road for 0.9 mile to a right fork. Proceed on the right fork, 0.2 mile to the next fork, take the right fork, and continue to the end of the road. The mine lies about 200 yards northeast of the road cut.

The mineral rights are owned by the Whitehall Co., Inc., of New York. Francis Carpenter of Grafton Center first opened the mine in 1930 and operated it intermittently until 1933. An opencut 30 feet wide, 50 feet long, and from 5 to 20 feet deep was made. Freedom Mines, Inc., of Grafton leased the property and worked it from July through December 1943 and from May to September 1944. The opencut is 30 feet wide, 70 feet long and 5 to 30 feet deep. Mining was done by benching. Waste rock was removed by a drag line with a wooden skip. About 1,100 tons of rock was mined from the main opencut after July 1943. A small cut 120 feet northeast of the large cut was made in another pegmatite. The mine was studied by G. W. Stewart, R. P. Brundage, and J. Chivers in June 1943, by E. N. Cameron and F. H. Main in May 1944, and by A. H. McNair and A. H. Chidester in July 1944 (fig. 58).

The Carpenter pegmatite is a stock-like body having a shield-shaped outcrop pattern. It is 120 feet long, has a maximum width of 110 feet, and appears to have a steep attitude. It is concordant in general to the foliation of the wall rock on its west and east sides, but it is discordant at its north and south ends. The northern contact, exposed at the entrance of the cut, dips 35°–75° S.; the other contacts are poorly exposed. Several small areas of schist occur along the eastern edge of the opencut. These may be inclusions or, possibly, rolls in the wall. The east and west walls of the opencut are formed by north-trending vertical joints.

The pegmatite consists chiefly of perthite, quartz, muscovite, and biotite with accessory green apatite and traces of autunite and torbernite. No zonal arrangement of minerals is apparent. Parts of the pegmatite exposed show irregular blocks of perthite and graphic granite that are crossed and intersected by unevenly spaced irregular bodies of gray quartz and scrap muscovite. Crystals of muscovite and biotite in parallel intergrowth occur within the quartz and scrap mica. Most of the muscovite-biotite intergrowths are oriented parallel to the long dimensions of the quartz-rich bodies, so that the quartz forms podlike envelopes around the mica. Mica and quartz are scattered throughout the pegmatite. There are no concentrations of mica near the small irregular schist areas on the east side of the cut or along the north wall at the entrance of the cut.

Many of the intergrown crystals of muscovite and biotite are 3 feet long, but most are less than one-half inch in thickness. Sheet mica can be obtained from scattered crystals that have a thickness exceeding one-half inch and contain little intergrown biotite. Large clear areas of muscovite are not common, and sheet production from most of the muscovite would contain an unusually high percentage of the smaller sizes. The mica is rum, hard,somewhat stained, and ruled.

Although the Carpenter Mine has characteristics of both disseminated and pod mica deposits, it does not conform closely to either type. It appears best to consider it an unusual pod. Muscovite is present in small amounts throughout the pegmatite exposed in the opencut, but the books are widely scattered, and the rate of yield would be low. The muscovite is intergrown with biotite and only the larger and thicker crystals would yield sheet mica—mostly small sheets, because of ruling, staining, and intergrowth with biotite. Although a considerable tonnage of muscovite remains in the deposit, the low average content and the low yield of sheet would probably prevent the deposit from being a large producer of sheet mica at 1942–44 price levels—unless low-cost mining methods could be devised.

A small opencut was made in the pegmatite cropping out east of the Carpenter pegmatite in 1944. Mineral associations and mica occurrence in the cut are almost identical with those at the larger cut.

CLEMENT PROSPECT

The Clement (Wood) prospect (pl. 1, no. 1) is in the town of Warren, 0.6 mile S. 4° W. of the Common in Warren village. To reach the prospect from Warren follow State Highway 25 southward for 0.55 mile Turn right on a gravel road, cross the Baker River, then turn right on a wood road midway between the bridge and an old mill and proceed westward for about 800 feet to the prospect.

The property is owned by Mrs. Nettie P. Brown, and mineral rights are held by the heirs of Daniel Clement.

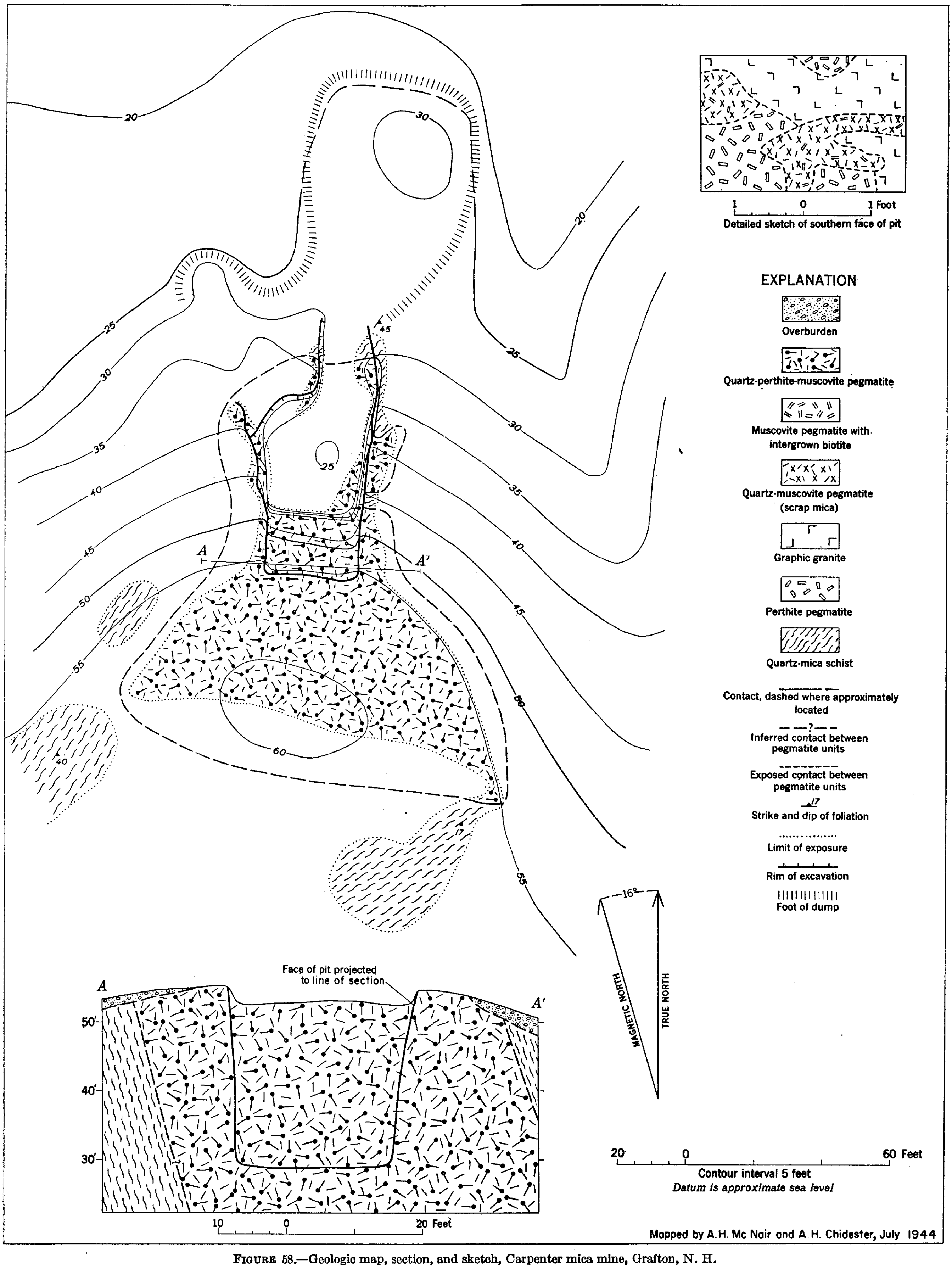


FIGURE 58.—Geologic map, section, and sketch, Carpenter mica mine, Grafton, N. H.

W. D. Wood operated the prospect intermittently for about a year, beginning in November 1942. All the people named above live in Warren. In July 1943, the prospect was mapped by E. N. Cameron and J. H. Chivers. It was revisited by J. J. Page and F. H. Main in November 1944.

The workings are 3 narrow cuts in 2 nearly parallel pegmatites that are connected by a cross-dike at the east end of the workings. The south cut is 75 feet long, 5 to 10 feet wide, possibly 16 feet deep in places, and is partly back filled. The north cut is 15 feet long, 6 feet wide, and 4 feet deep. The cut opened on the cross-dike is 10 feet long and 6 feet wide. It is almost completely filled with waste.

The pegmatite in the south cut strikes east and dips about 65° N. It is exposed along strike for about 85 feet and ranges from 2½ to about 6 feet in thickness. The second dike, 12 feet north of the first, strikes N. 85° E. and dips about 70° N. It is 4 feet thick and is exposed for 20 feet on strike. The cross-dike is almost completely concealed by waste, but its footwall strikes N. 23° E. and dips about 50° E. Its hanging wall is not exposed, but the dike is probably not more than a few feet thick.

The wall rock is coarse-grained biotite-plagioclase gneiss (Bethlehem gneiss). The composition of the plagioclase is An_{30}. The foliation strikes N. 35° W. and dips 45° NE. It contains small schlieren of fine-grained biotite gneiss and is muscovitized adjacent to the pegmatite contact.

The pegmatites consist of quartz, perthite, and muscovite with accessory plagioclase, garnet, tourmaline, pyrite, and beryl. Aside from thin quartz-perthite-scrap mica zones adjacent to the walls, little segregation of the constituents is evident. Plagioclase (An_{20-22}) is a minor accessory. Muscovite occurs as small green or greenish-rum colored books and scales disseminated throughout the pegmatite. Larger books were obtained, apparently from the center of the dike. The mica is badly ruled and cracked, and much is tanglesheet. No sheet mica was seen although the operator reports that a very small percentage of mica of fair quality was recovered. Crack mica recovery during work in 1943–44 was approximately 0.4 percent of rock mined. About 100 pounds of light-green to golden beryl in crystals 8 inches in maximum length and 3 inches in maximum diameter were recovered.

The operation was abandoned when it became clear that neither the quality nor the quantity of mica in the prospect warranted further operation at prices then current. The beryl content was very low.

COLEMAN MICA MINE

The Coleman mica mine, sometimes known as the New Hoyt Hill or South Hoyt Hill mine (pl. 1, no. 94), lies in the town of Orange, 3.2 miles S. 72° E. of Canaan village. To reach the mine from Canaan follow U. S. Route 4 for 2.9 miles to a gravel county road leading southeast; follow the gravel road 0.9 mile to a left fork, take the left fork 1.4 miles to the first farm house past Orange Pond; and from this point walk northeast 0.75 mile on a logging road to the southern summit of Hoyt Hill. The present owner, Robert B. Coleman of Canaan, operated the mine during the fall, winter, and spring of 1942–43 and enlarged an old prospect pit into an opencut 65 feet long, 35 feet wide, and 10 to 20 feet deep. The lower part of the cut is flooded. Waste was removed by a derrick and a short track with a dump car. The property was visited by C. S. Maurice and D. M. Larrabee during 1942–43 and was mapped by A. H. McNair and P. W. Gates in August 1944 (fig. 59).

The Coleman pegmatite has an irregular shape. In the vicinity of the cut it is lens-shaped and about 45 feet thick. At the south end of the cut, vertical offshoots 2 to 9 feet wide extend southward from the thickest part of the body. The pegmatite, exposed for about 220 feet, strikes, in general, N. 10° W. and dips vertically.

The wall rock is fine-grained Concord granite and quartz-mica schist of the Littleton formation. The granite, intruded into the schist, is tabular in shape and contains oligoclase, perthite, quartz, and biotite. It is discordant to the foliation of the schist, which strikes N. 45° E. and dips 60°–80° E.

The pegmatite in the cut contains numerous blocks of granite and schist. The granite blocks have many pegmatite stringers extending into them. The schist blocks are tabular, and in general are parallel to the strike of the pegmatite. The foliation in them is contorted and is discordant to the pegmatite and to the foliation of the wall rock.

The pegmatite is composed of perthite, quartz, and minor plagioclase, green apatite, muscovite, biotite, and black tourmaline. Graphic intergrowths of black tourmaline and quartz and intergrown crystals of muscovite and biotite are common.

The pegmatite has a quartz-rich, fine-grained border zone, 1 to 4 inches wide, consisting of quartz, perthite, plagioclase, and muscovite. A discontinuous scrap-mica unit, composed of perthite, muscovite, quartz, and plagioclase is present in places near the wall rock or along the sides of the larger inclusions. Most sheet-

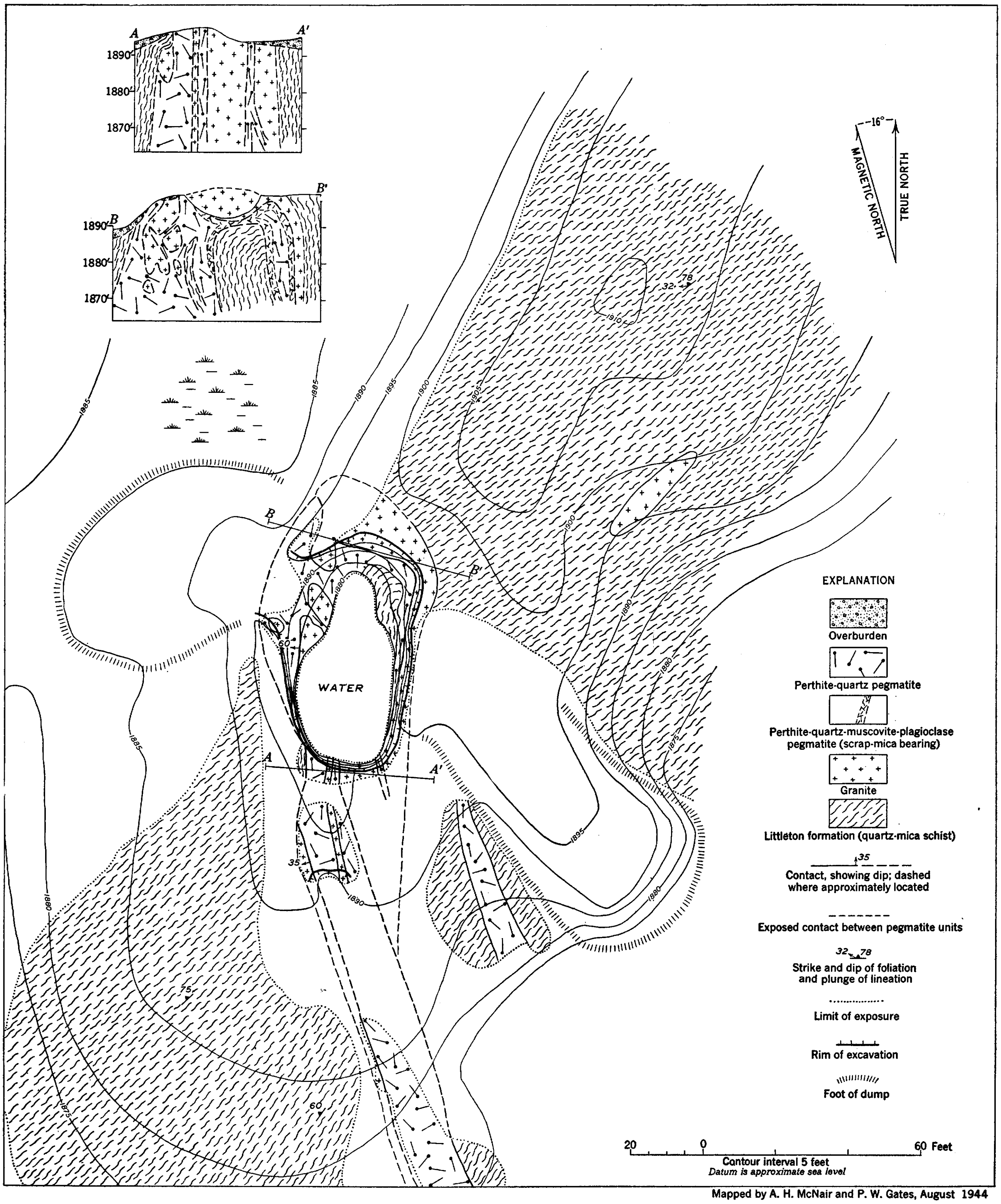


FIGURE 59.—Geologic map and sections of the Coleman mica mine, Orange, N. H.

mica-bearing books occur in this unit. The central part of the pegmatite consists of perthite, quartz, and scattered crystals of muscovite.

Mica obtained from the cut in 1942–43 was rum-colored, hard, and free from staining or structural defects and yielded a relatively high percentage of fair-sized sheet. The books were of medium size and were not abundant in any part of the pegmatite. The rock moved in 1942–43 yielded about 1 percent mine-run mica.

The leanness and small size of the pegmatite indicate that the mine could yield only small amounts of sheet mica.

COTTON PROSPECT

The Cotton mica prospect (pl. 1, no. 2), sometimes known as Tilly's Last Chance prospect, lies in the town of Warren, 1.1 miles S. 14° W. of the Common in Warren village. To reach the prospect from Warren, follow a gravel road westward for 0.25 mile to a left fork. Follow the gravel road up Beech Hill for about 1.4 miles to two farmhouses. From these houses, a wood road leads eastward for one-half mile to the edge of a steep hillside. The prospect is near the top of the slope.

The prospect is reported to be partly on land owned by Mr. Ralph Cotton and partly on land owned by Charles Berry, both of Warren. Mineral rights are held by the landowners. In the summers of 1943 and 1944, W. D. Wood of Warren operated the prospect intermittently. It was visited by J. J. Page and F. H. Main in November 1944.

The face of a 6- to 8-foot cliff has been blasted off, exposing pegmatite for about 35 feet on strike. Only the hanging wall of the pegmatite is exposed. It strikes N. 70° W. and has a nearly vertical dip. Its thickness is unknown, but is probably only a few feet. The country rock is coarse-grained biotite-plagioclase gneiss with a foliation striking N. 35° W. and dipping 25° NE. The pegmatite consists of perthite, quartz, moscovite, and plagioclase with accessory garnet and pyrite. The part of the dike adjacent to the gneiss wall is rich in quartz and contains muscovite and plagioclase. Perthite appears to make up the central part of the dike.

Muscovite occurs in small ruby-colored books, some of it flat and hard, but most of it soft, ruled, and tangle-sheet. Mica is most abundant against the gneiss wall, but some occurs adjacent to the perthite.

Owing to the poor quality and small quantity of mica, and the small size of the pegmatite, it seemed unlikely that the deposit would long sustain operations at 1943–44 price levels, hence work was not carried past the prospecting stage.

CRAYLIP MICA PROSPECT

The Craylip mica prospect (pl. 1, no. 26) lies in the town of Groton, 1.1 miles S. 65° E. of North Groton. To reach it from North Groton follow a graded gravel road eastward for 0.5 mile to an obscure right fork, follow the right fork, an ungraded woods road and trail, for 0.7 mile to the prospect.

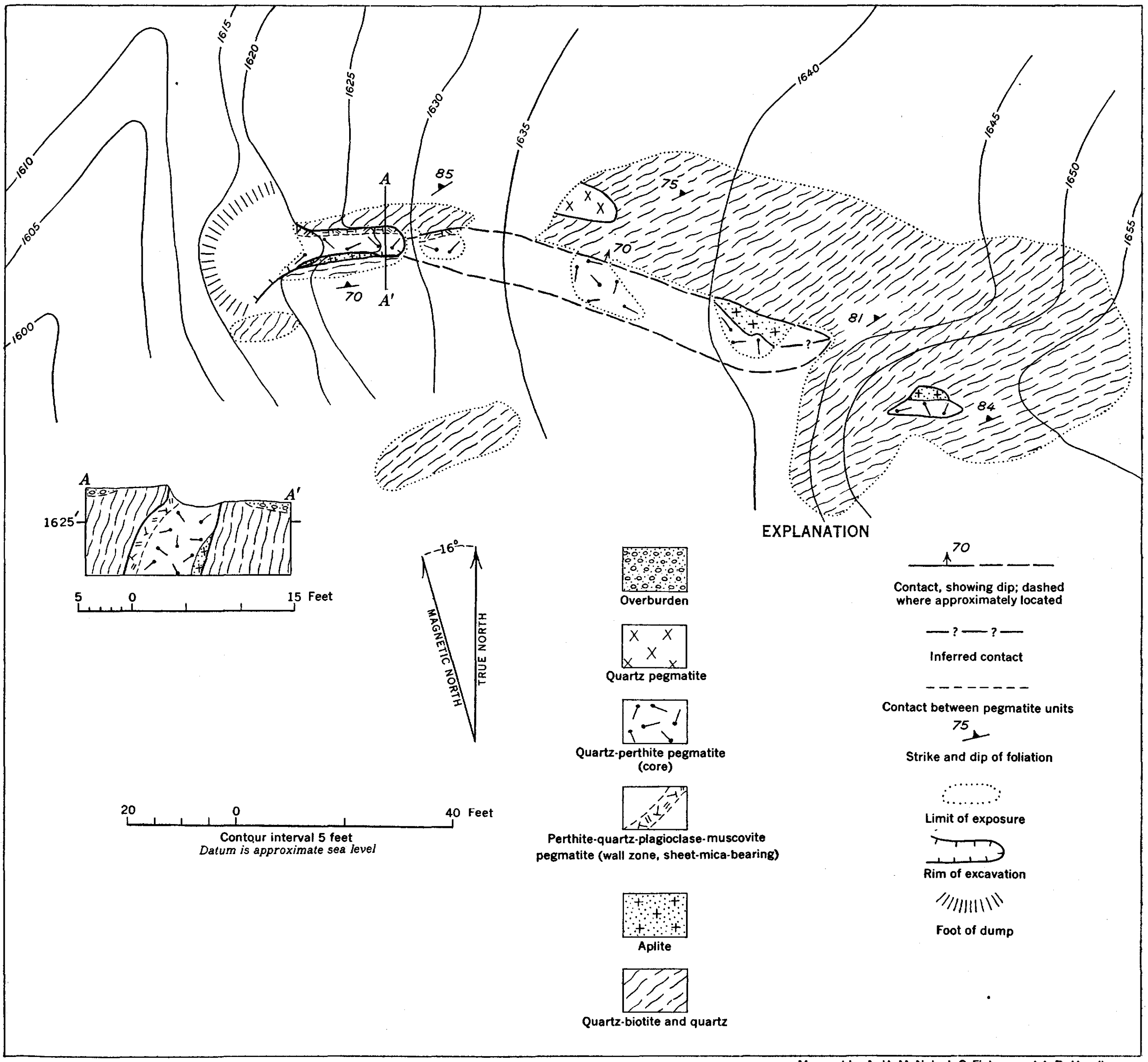
The mineral rights are owned by Rene Latoulip of North Groton. An opencut 20 feet long, 6 feet wide, and from 2 to 10 feet deep was made by Mr. Latoulip during prospecting operations in the summer of 1942. A tape and compass survey of the prospect was made by A. H. McNair, J. B. Headley, Jr., and I. S. Fisher in October 1942. (fig. 60).

The Craylip pegmatite is a lens that is discordant to the wall rock over most of its length. It is 4 to 12 feet wide, strikes N. 70° W. in general, and dips about 70° NE. The body appears to terminate abruptly at the foot of a small cliff 80 feet east of the face of the cut, but a small isolated pegmatite outcrop a short distance farther east may indicate that the pegmatite extends beyond the cliff beneath a thin capping of schist. The western part is covered. The wall rock is interbedded quartz-biotite and quartz-sillimanite schist. The sillimanite is partly altered to sericite. The foliation of the schist strikes N. 50° E. and dips northwestward about 80°.

Aplite, composed of equigranular quartz, muscovite, feldspar, and garnet, occurs in three places at the margins of the pegmatite. In the largest exposures, near the east end of the body, irregular stringers of the aplite extend into the wall rock. The exposure shows an inclusion of schist, highly impregnated with quartz and feldspar. It lies 3 feet from the contact but has a relict foliation parallel to that of the neighboring wall rock. The contact between the aplite and schist is gradational over a width of 4 inches.

Perthite, quartz, plagioclase, muscovite, and biotite compose the pegmatite. The minerals are arranged in three poorly defined zones: a border zone, a wall zone and a core. The border zone is thin and discontinuous. It is thickest (2 to 4 inches) near the central area of aplite, and less well defined where the pegmatite is in contact with schist. Near the aplite it is slightly finer grained than the other zones. Small inclusions of aplite are abundant in it near the contact and short fingerlike projections of the zone extend into the aplite.

The wall zone contains most of the muscovite that can be seen in the deposit. It is about 18 inches thick along the hanging wall, but is indistinct or absent along the footwall. It consists of perthite, quartz, plagioclase, and muscovite. Muscovite seems to be most abundant in parts rich in granular gray quartz. The core consists of perthite, quartz, minor intergrown muscovite and biotite, and small irregular bodies of graphic granite.



Mapped by A. H. McNair, I. S. Fisher, and J. B. Headley.
Tape and compass survey, October 17, 1942

FIGURE 60.—Geologic map and section of the Craylip mica prospect, Groton, N. H.

Most of the muscovite obtained from the opencut during prospecting was small, stained, and somewhat ruled. It was rum, hard, and free splitting, and (as most of the staining consisted of iron oxide and organic material), mica of higher quality should be present below the zone of weathering. The muscovite content of the zone near the hanging wall ranges from 5 to 15 percent but, because considerable quantities of nearly barren core would have to be mined with the wall zone, the yield of mica per unit of rock moved would be considerably less.

The deposit seems to be small, but mining may reveal extensions of the pegmatite. Mica is not abundant in the pegmatite, and most of the mica obtained from the opencut was small. The mica obtained was not rifted and trimmed, so little is known concerning its quality.

CRYSTAL MICA MINES

The Crystal mica mines lie in the town of Campton on the south slope of Campton Mountain, about 2.6 miles and 2.4 miles N. 67° and 73° E. respectively of the village of Campton Hollow. To reach them from Campton Hollow follow a graded gravel road eastward approximately 2.1 miles to the Beebe River logging road (an old abandoned logging railroad bed); turn left and follow the logging road northeast 0.9 mile to a trail on the left; follow the trail about 0.4 mile to the Lower Crystal Mine on the right. Follow the trail 0.3 mile farther up the slope to the Upper Crystal Mine. The properties, owned by the Draper Corporation, Hopedale, Mass., are leased by William A. MacLeod, 50 Court Street, Boston, Mass.

The mines were visited periodically during 1942–43 by D. M. Larrabee, and were mapped in July 1943 by E. N. Cameron and J. Chivers (fig. 61). Progress maps of the upper mine were made by Glenn W. Stewart and Norman K. Flint during subsequent visits.

Lower mine—The lower mine is reported to have been prospected prior to December 1942, when mining began. The main working is an opencut, 40 feet long and 10 to 18 feet wide, largely filled with waste rock. It is probably not more than 10 feet deep. About 450 tons of rock was moved.

Neither the form nor the extent of the pegmatite can be satisfactorily determined, because it is poorly exposed. The pegmatite is at least 75 feet long, 30 feet wide, and probably strikes N. 30° E. Its dip is unknown. The poor exposures of the pegmatite at the northeast corner of the opencut are mostly massive quartz with scattered crystals of coarse plagioclase. For about 12 feet southeast along the rim from the northeast corner of the cut abundant books of mica are intergrown with quartz and plagioclase. In the west wall a quartz-plagioclase-muscovite zone containing sheet mica seems to have been mined, but neither its extent nor its attitude is known. It is possible that the pegmatite may consist of a border zone, a quartz-plagioclase-muscovite zone, and a quartz-plagioclase core.

The muscovite books are as much as 12 inches broad and 3 inches thick. They are heavily stained by limonite, ruled, have "A" structure, herringbone structure, and cross fractures. Wedging and tanglesheet are also conspicuous defects, but some flat, flawless sheet could be recovered from parts of many books. The rock mined in 1942–43 did not yield sufficient quantities of sheet-bearing muscovite to warrant further exploration.

Upper Mine—The upper mine was opened in January 1943 and worked until July 1944. The principal working is an irregular opencut about 160 feet long, 10 to 30 feet wide, and 5 to 25 feet deep. Five to 10 feet of backfill covers most of the floor. A narrow drift 10 feet long extends south from a point near the center of the south face of the cut. During the last few weeks of mining a small prospect pit was excavated near the southwest limits of the pegmatite and a crosscut trench, 20 feet long, 15 feet wide, and 5 to 15 feet deep was made northward near the northeast end of the main working. About 3,200 tons of rock was moved from all the workings and about 1.65 percent of this was mine-run mica. Two other prospect pits, northeast of the main working, exposed only a thin pegmatite sheet.

The pegmatite is exposed for at least 360 feet along strike and is 20 to 70 feet wide. It strikes about N. 50° E., and dips 50°–70° SE. It is, in general, parallel to the foliation of the wall rock, but locally breaks sharply across the foliation along joints. The pegmatite contains many tabular xenoliths of schist oriented parallel to its walls. Where xenoliths are numerous the pegmatite consists of alternating layers of schist and pegmatite. The small pegmatite exposed in the two prospect pits may be an offshoot of the main body. The main pegmatite seems to terminate to the northeast, probably by interfingering with the wall rock, which is biotite and biotite-muscovite-garnet schist of the Littleton formation. The foliation of the schist strikes N. 15° E. and dips from 70° NW. to 68° SE.

The pegmatite has a poorly defined zonal structure. The border zone, 2 to 10 inches thick, is composed of fine-grained quartz and muscovite, minor plagioclase, and accessory pyrite. The wall zone, exposed only along the hanging wall, is 1 to 2 feet thick. It is composed of medium-grained quartz, plagioclase, and unevenly distributed sheet-bearing muscovite books. The intermediate zone, 17 to 66 feet thick, is composed of medium- to coarse-grained quartz, plagioclase, sheet-bearing muscovite, minor perthite, and accessory pyrite and garnet. Many schist xenoliths, 3 by 5 feet to 8 by 20 feet are irregularly distributed in this zone. The core is represented by quartz bodies that are scattered in the intermediate zone.

Muscovite books are sporadically disseminated in the widest part of the pegmatite, but the chief source of mica has been the wall zone along the hanging wall. Mica has also been found near the schist xenoliths and along the margins of the quartz bodies. The muscovite is rum to ruby, hard, usually free splitting, and clear except for some limonite stain. Ruling, cross fracturing, "A" structure, and tanglesheet are the principal structural defects. Most of the books average 3 by 4 inches.

Although most of the mica occurred along the hanging wall side of the pegmatite, its distribution was very uneven, and no single persistent deposit was discovered. Finding of large volumes of pegmatite containing little mica led to unsuccessful attempts to find mica in other parts of the pegmatite. Despite the uneven distribution of the mica, however, the average yield of all rock moved was 1.65 percent and the percentage of sheet recovered appears to have been satisfactory.

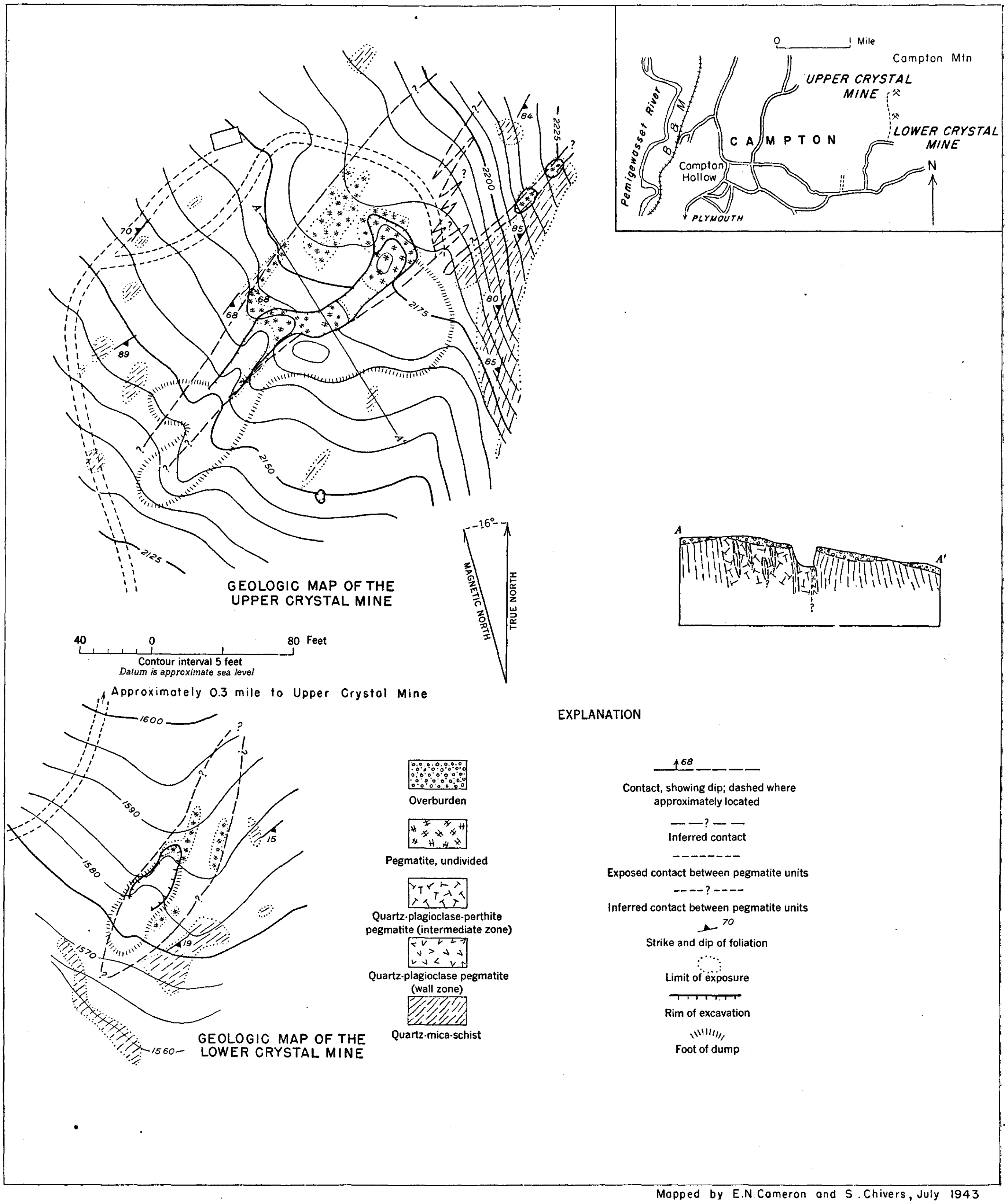


FIGURE 61.—Geologic map and section, Cyrstal mines, Campton, N. H.

In future operations, it may be desirable to mine the entire hanging wall side of the pegmatite rather than to attempt selective mining. If this were done, perhaps operations might be carried on profitably under economic conditions similar to those of 1943–44. The difficulty of access to the mine, however, would undoubtedly add to the cost of operation.

CHARLES DAVIS MICA MINE

The Charles Davis mica mine (pl. 1, no. 24) is in the town of Groton 0.7 mile N. 73° W. of the village of North Groton. To reach it from North Groton follow the North Groton-Cheever road northwest 0.6 mile to a mine access road on the left; follow the access road southwest 0.2 mile to the mine. The property is owned by Paul Glover of Bath, N. H. Mineral rights are leased by the Strafford Mining Co., Bristol, N. H.

An opencut 100 feet long, 12 to 18 feet wide, and 15 feet deep was made prior to 1920. Work by the Strafford Mining Co. began in December 1943 and continued until July 1944. The present opencut is about 150 feet long, 10 to 30 feet wide, and 40 feet deep near the southwest end. The northeastern half of the cut apparently contains considerable backfill. Open-pit mining methods were used and waste rock was removed by a bucket on an aerial tramway. About 1,350 tons of rock was removed from the cut between December 1943 and July 1944. The mine was mapped by Glenn W. Stewart and Norman K. Flint in June 1943 (fig. 62), and periodic visits were made to it by E. N. Cameron and Stewart.

The pegmatite is exposed for about 300 feet along strike. At the southwest end it narrows to 4 inches, but in the main part of the pit it averages 14½ feet thick. It appears to be a lens essentially parallel to the foliation of the wall rock. Minor rolls along the southeast edge suggest that the pegmatite plunges 40°–50° southwest.

The wall rock, part of the Littleton formation, is a quartz-sillimanite schist that strikes N. 35° E. and has a dip ranging from vertical to steeply east. Sillimanite crystals 1 inch long and ¼ inch thick are abundant in it. In some places along the contact the schist contains many small tourmaline crystals but generally a very fine-grained dense band of recrystallized schist, 3 to 4 inches thick, occurs at the contact.

The pegmatite has a well-defined border zone and a core. The border zone, 3 to 8 inches thick, is composed of fine-grained quartz, muscovite, and minor plagioclase, tourmaline, and garnet. The core is composed of plagioclase, quartz, perthite, muscovite, minor biotite, secondary chlorite, and accessory tourmaline, beryl, and pyrite. Small anhedral crystals of lazulite (Sterrett, 1923, pp. 129–130) are scattered in the core. Several quartz bodies, 2 by 7 feet or less, also occur in the core.

Sterrett reported that mica was most abundant near the hanging wall and E. N. Cameron, on his first visit, noted a similar occurrence. However, the mica along the hanging wall was soon mined out and most of the mica recovered in 1944 occurred as disseminated books. The pegmatite adjacent to a small roll near the bottom of the pit, on the southeast wall, had a slightly higher mica content than the central parts of the pegmatite. Mica was also slightly more abundant near the margins of the quartz bodies.

The muscovite has a medium rum color, is ruled, stained, relatively hard, and flat. Most of the books average 4 by 4 inches but a few are 10 by 12 inches. Some are intergrown with biotite. The muscovite contains numerous inclusions of magnetite(?) or pyrite(?) and small tourmaline crystals.

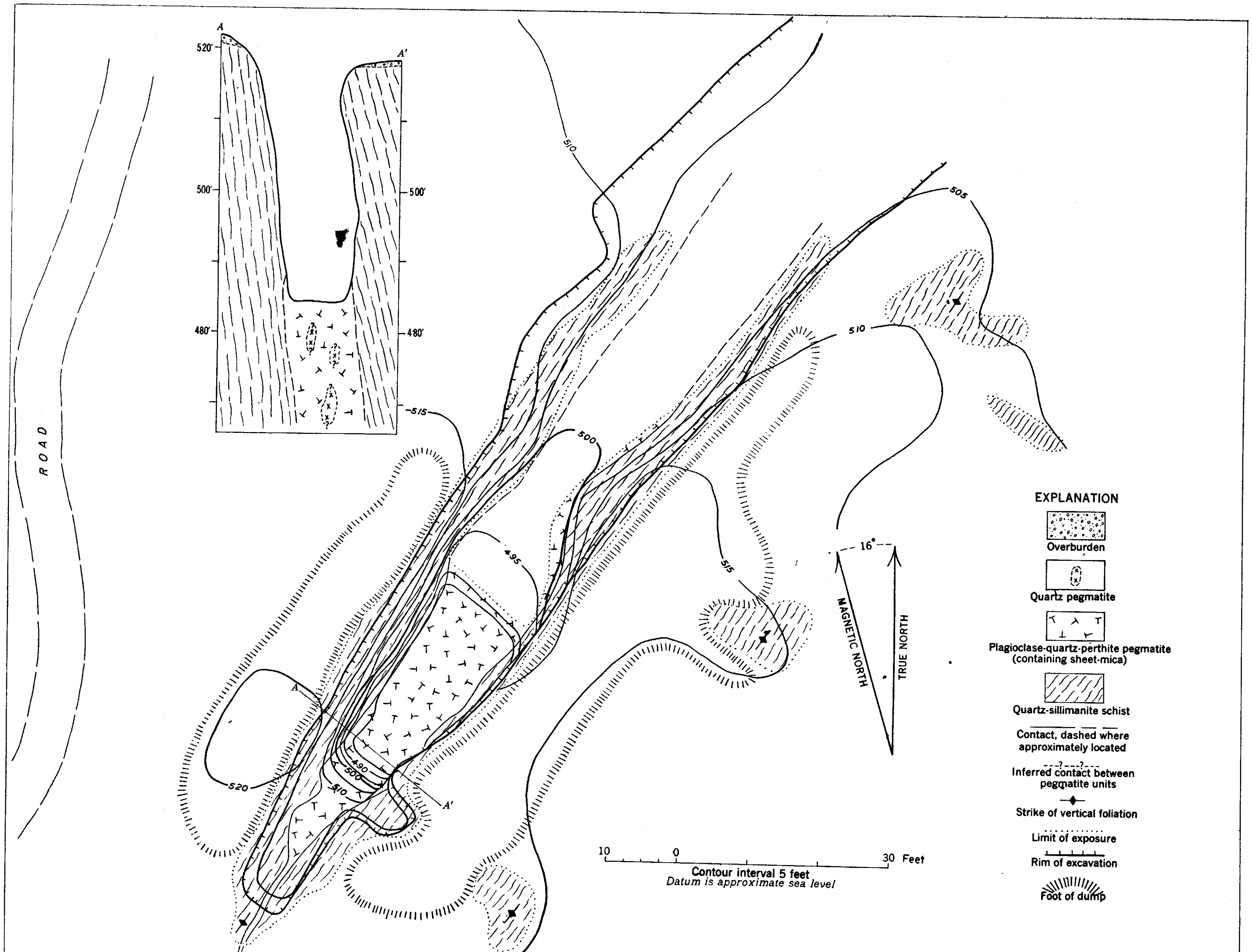
Satisfactory quantities of mine-run mica were recovered during 1934–44, but because of structural defects the mica yielded only small sheet. The mine is still capable of producing considerable quantities of small-sized sheet mica.

DEMOTT MICA MINE

The DeMott mica mine (pl. 1, no. 69) lies 3.0 miles S. 70° W. of Grafton. To reach it from Grafton, follow a graded gravel road southwestward for 2.3 miles to Robinson Corner; follow the right fork 2.0 miles, passing two left forks, to a crossroad. The mine is 200 feet northeast of the crossroad. Mineral rights are owned by Mr. Charles DeMott of Grafton, N. H.

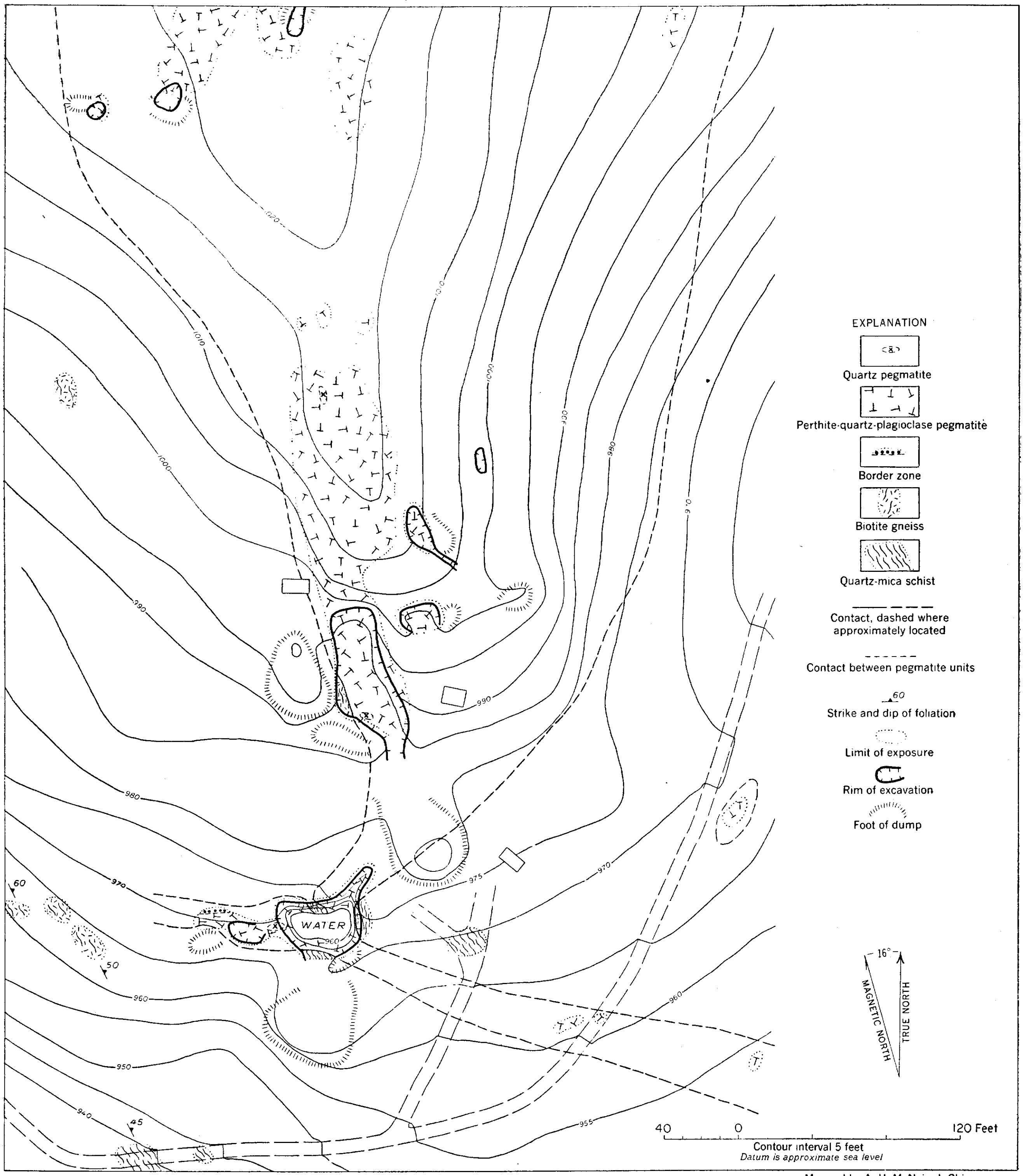
Two small opencuts and six small prospect pits were made prior to 1943. In September and October 1943 the property was leased and prospected by Freedom Mines, Inc., of Grafton and about 85 tons of rock were removed from the southernmost cut. A planetable map of the mine was made by R. P. Brundage and J. Chivers in June 1943 (fig. 63).

The DeMott pegmatite is poorly exposed. Contacts of pegmatite and wall rock can be seen only in a few places in the cuts. The few exposures available for study suggest that the pegmatite has two parts; a northern part extending from the south opencut almost due north at least 800 feet; and a southern part extending northwest and southeast of the south opencut. The northern part is conformable to the foliation of the wall rock, probably dips about 60° E., and is 25 to 380 feet wide at the outcrop. The southern part is discordant to the wall rock and has an irregular, almost vertical dip. It is joined to the other part near the cut and is about 25 feet wide. Quartz-mica schist and biotite gneiss form the wall rock. The foliation strikes N. 25° W., in general, and dips 50° E.



Mapped by G. W. Stewart and N. K. Flint, June 27, 1944

FIGURE 62.—Geologic map and section of the Charles Davis mica mine, Groton, N. H.



Mapped by A. H. McNair, J. Chivers, and R. P. Brundage, June 11-15, 1943

FIGURE 63.—Geologic map of the DeMott mica mine, Grafton, N. H.

Perthite, quartz, white plagioclase, biotite, muscovite, and black tourmaline make up most of the pegmatite. Löllingite, beryl, garnet, graftonite, triphylite, and vivianite are rare constituents. No zonal arrangement of minerals is apparent in the northern part. The southern part of the pegmatite, in the vicinity of the opencut, has an outer wall zone of perthite, plagioclase, and quartz; an intermediate zone relatively rich in quartz and perthite; and a quartz core. The core and intermediate zone were poorly exposed at the time of mapping, but prospecting showed that they extend from the west end of the pit nearly to the east end.

Muscovite occurs in small crystals sparsely disseminated through the pegmatite. It is concentrated locally near the margins of the quartz core in the center of the southern part of the pegmatite and around small scattered quartz pods in the northern part of the pegmatite. Most of the mica obtained during prospecting in 1943 was rum-colored, fairly hard, free-splitting, and unruled. Some of the books, however, had "A" structure, were wedge-shaped, and were tangled. The percentage of sheet recovered was low. Approximately 1.5 percent mine-run mica was recovered from rock moved during 1943.

Beryl occurs sparingly in the body and like the muscovite appears to be restricted to the margins of segments of the quartz core. Neither mineral was found in quantities that would repay mining, even at wartime prices. However, the walls of the pegmatite have not been uncovered except in the southern cut, and it is possible that wall-zone concentrations of muscovite occur in the pegmatite in places where the walls are now concealed.

EIGHT-BALL MICA PROSPECT

The Eight-Ball mica prospect (pl. 1, no. 7) is near the top of the western knob of Willoughby Mountain in the town of Rumney, about 2.3 miles N. 27° E. of the village of West Rumney (Swainboro Station). To reach it from West Rumney, follow a graded gravel road 0.4 mile northward across the Boston and Maine Railroad and the Baker River to a road on the right; continue northward on the same road 1.2 miles to a dilapidated barn on the left, turn right and follow an old logging road and trail to the prospect.

The property is owned by the U. S. Forest Service, Department of Agriculture, Washington, D. C. Mineral rights, owned by the town of Rumney, are leased by Jay LeVanway, West Rumney, and Mrs. Gladys Lovering, Wentworth, N. H. Two small test holes were made prior to 1940, and three prospect pits were made in September and October 1944 by LeVanway. The largest pit is 20 feet wide, 12 feet long, and 2 to 8 feet deep. The prospect was mapped in September 1944 by Glenn W. Stewart and Norman K. Flint (fig. 64) prior to the prospecting by LeVanway. It was examined by Stewart and Karl S. Adams in May 1945.

The pegmatite prospected is an irregular, U-shaped, complex body well exposed on a sloping surface for 100 feet. It is 30 to 55 feet wide. Observed dips along the contacts of a schist screen that divides the pegmatite into an eastern and western part, suggest that the pegmatite has the shape of an anticline that plunges northeast and may be slightly overturned to the west. (See sec. A-A'; fig. 64.) Contacts between the pegmatite and the wall rock in the eastern part are marked by numerous rolls. In some places the pegmatite cuts across the foliation, in others it is parallel. The relations between the pegmatite and the schist screen are similar.

The wall rock is quartz-mica-sillimanite schist of the Littleton formation composed of muscovite, biotite, and numerous clusters of small needlelike sillimanite crystals. The strike of the foliation is variable at the contacts, but away from the contacts it strikes N. 30° E. and dips 80°–85° SE. In most places along the eastern and northern contacts, the wall rock contains abundant black tourmaline crystals, ½ to 1 inch long and as much as ¼ inch n diameter. This tourmalinized aureole is from a few inches to 1½ feet thick. Small irregular patches of blue vivianite, apparently formed by partial replacement of tourmaline and muscovite, occur in the northern part of this aureole. The vivianite was probably derived from triphylite, but no triphylite was found.

The pegmatite has a complex zonal structure that was well exposed before prospecting. The border zone, 4 to 12 inches thick, is fine- to medium-grained and is composed of quartz, muscovite, albite (An_{6-7}), and accessory tourmaline, garnet, and apatite. Muscovite forms individual crystals or tangled aggregates of wedge-shaped books. The aggregates increase in size from less than ½ inch at the contact to 2 to 2½ inches at points 8 to 10 inches from the contact. This feature suggests that the muscovite grew inward from the wall rock.

The wall zone, 10 to 12 inches thick, is discontinuous, but is exposed for 30 feet along the eastern contact. It consists of medium-grained muscovite, quartz, albite (An_{5-6}), and accessory garnet and tourmaline. Most of the muscovite books are wedge-shaped, and the largest are 6 by 3 by 1 inch.

The outer intermediate zone, 1 to 25 feet thick, is largely medium-grained but contains scattered coarse-grained patches. It is composed of quartz, albite (An_{5-6}), minor perthite, triphylite, graftonite, small muscovite books, and accessory tourmaline and apatite. The perthite is unevenly distributed, occurring

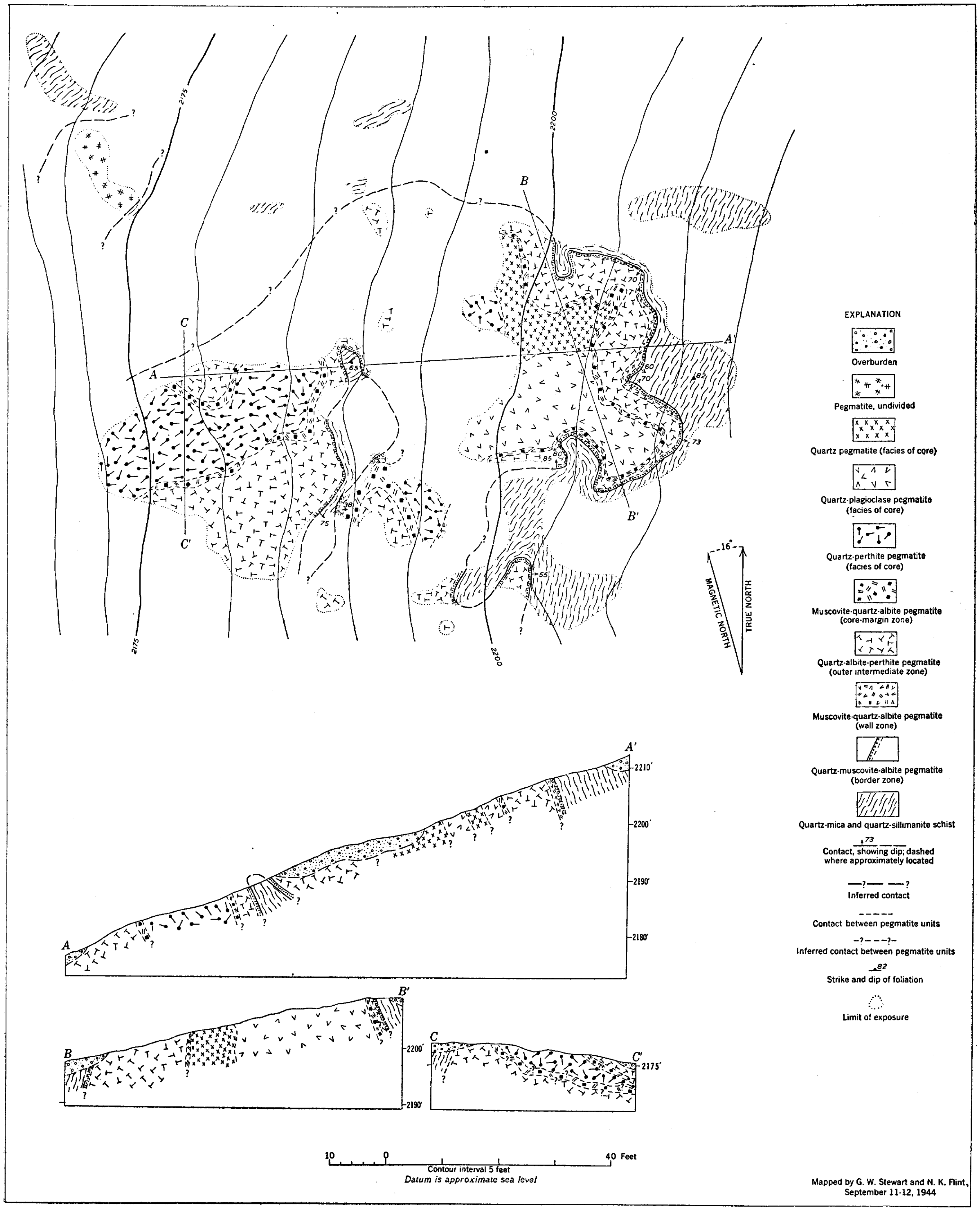


FIGURE 64.—Geologic map and sections of the Eight-Ball mica prospect, Rumney, N. H.

only in the coarse-grained patches. Black, spindle-shaped tourmaline crystals, 2 to 6 inches long and ½ to 1½ inches in diameter occur mainly in the outer 1½ feet of this zone in the eastern half of the pegmatite.

The core-margin zone in the eastern part of the pegmatite is medium-grained, 5 to 7 inches thick, and is composed of 2½- by 2½-inch muscovite books, quartz, albite (An_{5-6}), and accessory garnet and apatite. It is nearly continuous for 100 feet around the margin of the core. It is discontinuous down dip and in places is only 2 to 3 inches thick. In the western half of the pegmatite the zone is medium- to coarse-grained and is 1½ to 2 feet thick. It is exposed for nearly 100 feet along the southeast and eastern margins of the core and for 15 to 20 feet along the northwestern margin. It is composed of muscovite books (3 by 4 inches to 10 by 12 inches), quartz, albite (An_{5-6}), white to pale-green beryl crystals (as much as 5 inches in diameter and 4 to 6 inches long), and accessory garnet and apatite. A similar zone, 2 to 3 feet east of the schist screen, is apparently marginal to a patch of quartz and perthite that is a part of the main core.

The core is coarse-grained and has a varied composition and structure. The eastern half, 38 to 40 feet wide, is composed largely of massive quartz; however, the southern part of it contains an abundance of interstitial albite (An_{5-6}) and muscovite books less than an inch in diameter. The boundary between these two parts is indistinct. The contact of the eastern half of the core is essentially parallel to the irregular contact of the main body of pegmatite, but locally the quartz bulges into the intermediate zone, and at one place a small apophysis of quartz transects the core-margin mica zone and extends a short distance into the intermediate zone. The western half of the core, 10 to 15 feet thick, is exposed for 40 feet. It is composed of coarse-grained quartz, perthite, and small disseminated muscovite books. The anhedral crystals of perthite are as much as 3 by 6 feet, and quartz forms bodies that reach a naximum of 4 by 11 feet. The core and associated core-margin mica zones, exposed in the small prospect pit, appear to dip 35° S. The core may lens out a few feet beyond the south face because it is only 1 foot thick at the edge of the pit. The core-margin mica zone also is thinner and contains less mica southward.

Most of the muscovite books are light green, but a few are light rum. The books in the wall zone are wedge-shaped and have a conspicuous herringbone structure. Most books in the core-margin zone are hard, but generally are badly ruled, reeved, and cracked. Many books contain inclusions of magnetite.

Green to blue-green triphylite and graftonite are present in the intermediate zone in the eastern half of the pegmatite. The triphylite bodies range from 3 by 6 inches to 1 by 1½ feet and are accompanied by vivianite, heterosite, and purpurite—the characteristic alteration products of triphylite. Some of the smaller bodies are embedded in smoky quartz. Most of the larger bodies are partly enclosed in smoky quartz, but are commonly associated with the muscovite books, some of which appear to have been replaced by triphylite along cleavages. Most of the graftonite occurs disseminated in the triphylite bodies as salmon-colored specks, as much as 5 mm. in diameter.

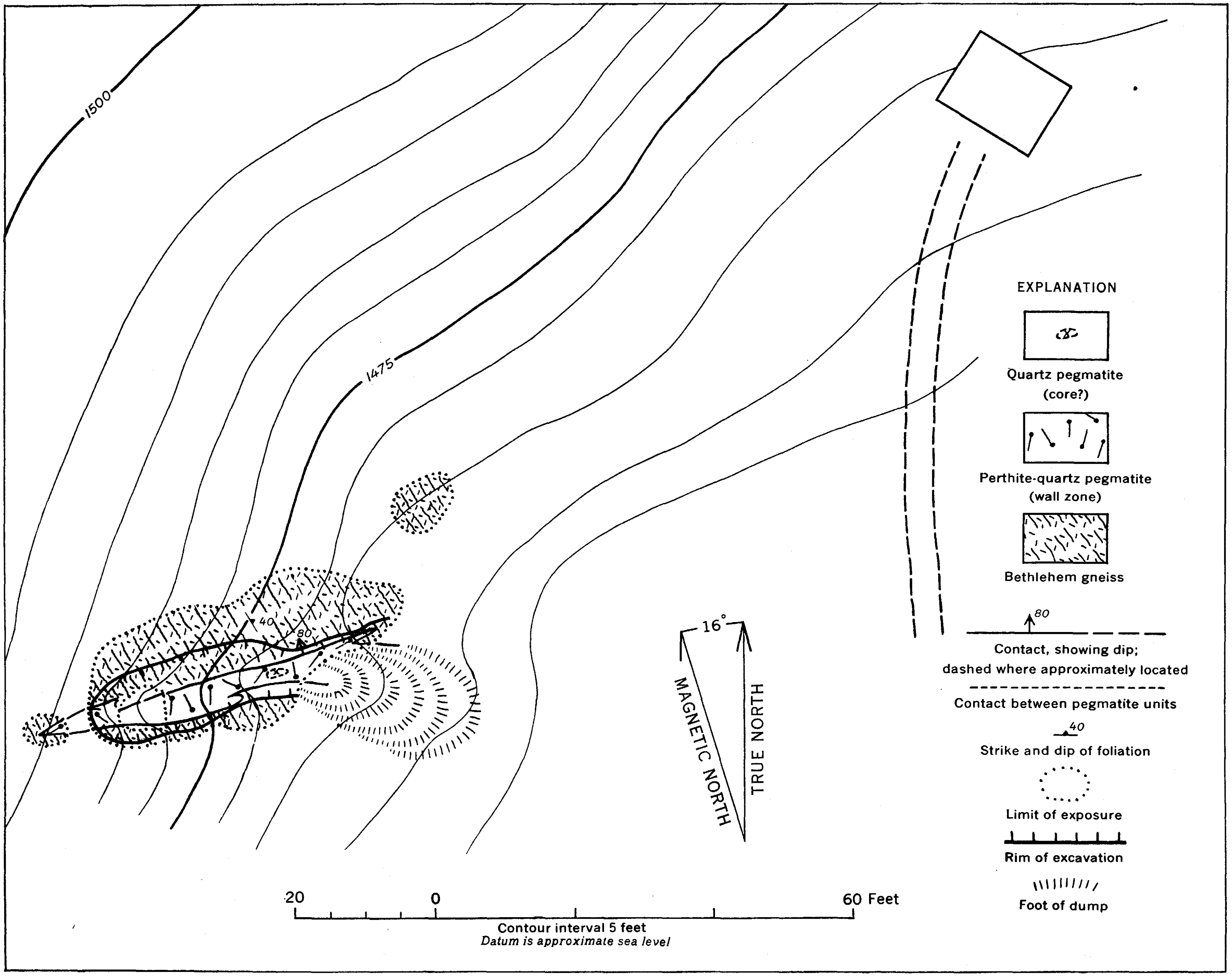
Prospecting in September and October 1944 yielded only a very small quantity of sheet mica. The most promising zone, the core-margin zone, is discontinuous down dip, and the mica books average only 2½ by 2½ inches in the eastern half of the pegmatite. The core-margin zone in the western half dips 35° S. It decreases downward in thickness, mica content, and size of books, and appears to lens out a short distance beyond the south face of the prospect pit. The numerous structural defects, the characteristic green color of the muscovite, and the discontinuity of the mica zones discouraged operations in 1944.

FAIRBURN MICA PROSPECT

The Fairburn mica prospect (pl. 1, no. 17) is in the town of Dorchester, 1.9 miles N. 23° E. of the village of Dorchester. To reach the prospect from Dorchester follow State Highway 118, 2 miles to a dilapidated house on right; turn left and follow a logging road 0.5 mile to the prospect. The property is owned by J. H. Fairburn of Dorchester (R. F. D. West Rumney) but the mineral rights are leased by M. Sidell of Manchester, N. H. A cut about 40 feet long, 7 to 11 feet wide, and 5 to 8 feet deep was excavated into the hillside in December 1942. The prospect was visited in the winter of 1942–43 by D. M. Larrabee and was mapped by G. W. Stewart and Harry Kamensky, August 1943 (fig. 65).

The pegmatite is exposed along strike for 50 feet. It is 2 to 5 feet wide, strikes N. 75° E. and dips 80° NW. to vertical. Eight feet beyond the southwest face of the cut it ends in a crest that plunges southwestward. The contact is sharp but very irregular because of minor "rolls." Small apophyses of pegmatite project into the wall rock. The pegmatite is discordant to the foliation of the enclosing Bethlehem gneiss, which strikes N. 35° W. and dips 48° NE.

The pegmatite is poorly zoned. The border zone, 1 to 2 inches thick, consists of fine-grained quartz and muscovite. The wall zone is composed of perthite and quartz, minor muscovite and biotite, and accessory garnet. The quartz in pods, 1 by 4 feet or smaller, probably represents the core. Some muscovite books 2 by 2 inches are disseminated in the quartz, and slightly



Mapped by G. W. Stewart and H. Kamensky, August 16, 1943

FIGURE 65.—Geologic map and section of the Fairburn mica prospect, Dorchester, N. H.

larger and more abundant books occur near the quartz pods. The muscovite is light to medium rum, hard, slightly stained, cracked, and ruled. The books average 2½ by 2½ inches, and some are intergrown with biotite. The mica deposits in this pegmatite are characteristic of the pod type.

Prospecting in 1942 did not yield enough good muscovite to encourage operations. The small size of the books together with their sporadic occurrence indicate that only a small percentage of sheet mica would be obtained from the pegmatite.

FELLOWS MICA MINE

The Fellows mica mine (pl. 1, no. 3) is 1.8 miles north of Wentworth village. To reach the deposit, follow State Highway 25 for 0.9 mile north to its junction with a gravel road. This leads northward 1.1 miles to the mine.

The property is owned by Carl Fellows, Wentworth. Several small pits were made many years ago. In 1942 the property was leased by the Granite State Mica Corp., and intermittent mining was done until November. Mining was resumed in May 1943 and continued, with brief interruptions, until June 1944. At the time of mapping, July 1943, pits 1 and 2 (fig. 66) were being operated and pit 4 was being prospected. Pit 1 was an opencut 100 feet long, 5 to 25 feet wide, and 3 to 16 feet deep. It was later enlarged slightly and an inclined stope 5 to 7 feet high was carried down dip from its floor. Waste was removed by a scale pan lowered by derrick into the opencut by block and tackle, but as the stope was deepened, this method became increasingly difficult. In early 1944, a shaft was therefore sunk southeast of the pit, but whether this struck the pegmatite is uncertain. Pit 2, in July 1943, was 40 feet long, 20 feet wide, and 14 feet deep. Operations at pits 2 and 4 were discontinued in August 1943.

The mine (fig. 66) was studied by A. H. McNair in August 1942 and by E. N. Cameron and J. Chivers in July 1943. Periodic visits were made by Cameron and G. W. Stewart later in 1943 and in 1944, and the workings at pit 1 were remapped in May 1944 by Stewart.

The mine is in a thin tabular pegmatite that strikes nearly north and dips 20°–30° E. It is 2 to 8 feet thick and is exposed for 500 feet along strike. The south end is covered, but the north end, exposed in pit 1 is a rounded keel that plunges about S. 52° E. at the surface but probably plunges more easterly underground. Sharp changes in the thickness of the dike at a few places correspond to rolls in the walls.

The wall rock is biotite-granite gneiss (Bethlehem gneiss), the foliation of which strikes N. 20°–30° E. and dips 20°–35° SE. The pegmatite is therefore discordant, though nearly parallel to the foliation in sections along the dip. Contacts between pegmatite and gneiss are sharp, but the gneiss within a few inches of the contact has been tourmalinized and in places enriched in muscovite.

The pegmatite consists essentially of plagioclase and quartz, with subordinate muscovite, and accessory garnet, beryl, and black tourmaline. Perthite is present in places. Though thin, the pegmatite is distinctly zoned as follows:

1. Border zone, 1 to 6 inches thick, fine-grained quartz, scrap muscovite, plagioclase, and garnet, in varying proportions, with traces of schorlite. Fine-grained garnet is unusually abundant in places, and particularly along the footwall forms granular aggregates, lenses and layers in the zone.
2. Wall zone, one-half to 2 feet thick, composed of medium- to coarse-grained plagioclase with subordinate quartz and muscovite, and accessory garnet and schorlite. This zone is clearly developed only along the hanging wall. In most places along the footwall it is absent or has so low a mica content as to be indistinguishable from the core.
3. Core, 2 to 6 feet thick, composed of medium- to coarse-grained quartz with subordinate plagioclase, muscovite in small books, and accessory garnet. Some perthite is present. A few scattered beryl crystals as much as 8 by 2 by 2 inches occur in quartz rich parts.

The wall-mica zone, even along the hanging wall, is far from uniform either in thickness or mica content. The zone appears to pinch out in pit 1 (fig. 66), about 25 feet north of the line of section AA′, becoming a few inches thick and then, due to diminution in book mica content, indistinguishable from the core. As the underground workings were carried deeper, the limit of the minable part of the zone was reached progressively farther south. At the south end of the pit, the zone contains little book mica. The shape of the workings apparently reflects the existence of a definite shoot in the wall zone parallel to the apparent plunge of the keel of the pegmatite. Only this shoot repaid mining. The yields of pits 2 and 4 were inadequate, and the pits were shut down in August 1943.

Mica from the wall zone is rum to faintly ruby, hard, clear muscovite. Books show ruling, tanglesheet, cross-fractures, and "A" structure. Ruling is the most common defect. Inclusions of quartz and garnet and films of quartz and plagioclase are present along the cleavages of some books. Despite the defects, a satisfactory percentage of free-splitting sheet mica of high quality was obtained. The yield of crude mica from rock mined in pit 1 in 1943 and 1944 was about 1.3 percent.

Mica produced from the mine is of high quality but the average yield of the mica zone is low, even from the shoot worked in pit 1. Efficient underground mining would be required to operate the deposit profitably, even under conditions comparable to those of 1943–44.

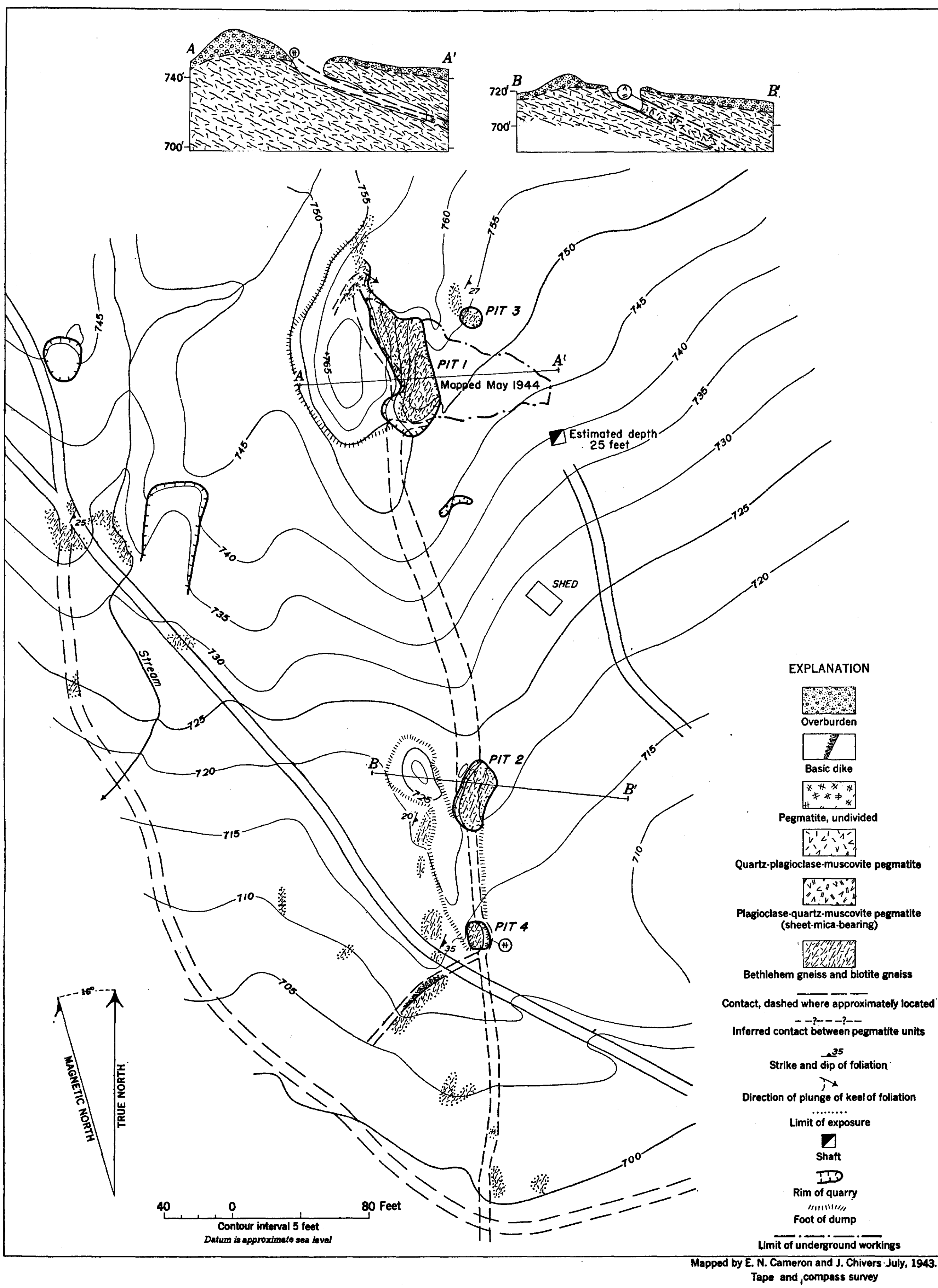


FIGURE 66.—Geologic map and sections of the Fellows mica mine, Wentworth, N. H.

FLETCHER MINE

The Fletcher mica mine (pl. 1, no. 25) is in the town of Groton, 2.15 miles due east of North Groton village. It can be reached from North Groton by following a gravel road northeast toward Rumney Depot for 1.5 miles to a gravel mine-access road on the right. Follow this road southeast 0.8 mile to the second intersection; take the right fork and continue for about 0.5 mile to the mine, which lies on the summit of a narrow ridge.

The property is owned by the town of Groton. According to Sterrett (1923, p. 124–125), the Fletcher pegmatite was discovered shortly after the Valencia mine (1880) and considerable work was done prior to Sterrett's visit in October 1914, when it was about to be worked by the General Electric Co., Schenectady, N. Y. Joseph Rogers of Rumney, N. H., worked the mine for a short time about 1928, and Groton Mines, Franklin, New Hampshire, operated it intermittently from September 1942 to the summer of 1944. The mine was studied by A. H. McNair, G. B. Burnett, and J. B. Headley, Jr., in September 1942 and by J. J. Page and F. H. Main in November 1944 (pl. 22).

Three opencuts have been made. The north cut is separated from the others by a narrow, steep-sided glaciated depression that crosses the summit of the ridge. The north cut is 140 feet long, 40 feet wide, 30 feet deep, and trends N. 20° E. The central opencut extends southward up the hill from the valley for 220 feet. It consists of three narrow, interconnected cuts driven into the hillside at successively higher elevations. The maximum width of the cut is 30 feet and the depth is as much as 20 feet. The south cut is 100 feet long, 20 feet wide, and 15 feet deep to water level. Sterrett (p. 127) states that the depth was about 40 feet in 1914. This cut is entered from the east by a crosscut trench.

The workings seem to be in a single pegmatite at least 600 feet long and as much as 50 feet thick. It strikes N. 15° E., has a variable eastward dip, and is concordant with the foliation of the enclosing medium-grained quartz-biotite-sillimanite schist of the Littleton formation. In the central and south cuts the walls dip 40°–85° E.; the average dip is 55°. In the north cut, rolls in the hanging wall plunge north about 15°.

A very irregular zonal structure is present in the pegmatite. A fine-grained aplitic border zone composed of quartz, plagioclase, and minor small muscovite is present in places, particularly along the hanging wall. The zone ranges from less than 1 inch to as much as 3 feet in thickness. The thickest parts are in small pegmatite apophyses in schist as in the east wall of the central cut where a dikelike offshoot 3 feet thick extends into the schist. This dike strikes N. 60° E. and dips 65° SE. It has sharp contacts and is deeply weathered.

The discontinuous sheet-mica-bearing wall zone is locally as much as 1½ feet thick. Apparently, it was thickest and richest along the part of the hanging wall mined during early operations. Exposed parts of the wall zone are lean or barren of muscovite, but the general shape of the workings suggests that this zone was followed by the miners. It consists of plagioclase, quartz, and muscovite. The footwall of the pegmatite is poorly exposed, but the wall zone is visible along it in a few places. No sheet muscovite was seen in the footwall part of the zone.

The plagioclase-quartz outer intermediate zone constitutes the bulk of the pegmatite. It consists predominantly of plagioclase and quartz with small amounts of muscovite, perthite, and accessory small red garnet. Gray quartz is present throughout the zone, either intergrown with plagioclase or in small irregular bodies—mostly less than 1 foot in width. Some of these bodies contain scrap muscovite and beryl.

A discontinuous middle intermediate zone consisting of perthite with intergrown quartz and minor plagioclase occurs in the thicker parts of the pegmatite. Commonly, it is somewhat closer to the footwall than to the hanging wall. In the north cut, very few strips of biotite are found in this zone.

Centrally located pods of massive to granular quartz as much as 15 feet long are found in the pegmatite. These may be segments of a discontinuous quartz core. Where they are in contact with the perthite-quartz zone, they seem to lie under or along its east side. One large block of perthite lies within the quartz pod at the south end of the central cut. Triphylite, purpurite, and other manganese phosphates and their alteration products also are found within the pods. A core-margin zone that is 2 feet thick and composed of granular to massive gray quartz, abundant small muscovite books, and scattered small green beryl crystals surrounds the quartz pods.

Irregular books of sheet-bearing greenish-rum to ruby muscovite were obtained from the hanging wall part of the wall mica zone and from the quartz-muscovite core-margin zone along the quartz pods. Muscovite is not abundant in exposed parts of the wall zone. Subhedral books of muscovite occur adjacent to the quartz pods, but many of these books are too small to yield sheet. This mica is very hard, flat, and greenish-rum to ruby. It exhibits color zoning parallel to the edges of the books. Sheet muscovite has also been obtained from very narrow pegmatite apophyses in schist.

The extent of the workings at the mine suggests that much sheet mica was obtained during the early operations from the now poorly exposed hanging wall zone.

The parts now visible do not contain abundant mica. Muscovite is more abundant in the zone marginal to quartz pods, but the books are small. The mica of both zones is of good quality. Production data for 1942–44 are lacking, but the low content of muscovite in the unmined pegmatite and the small size of the books indicate that the mine probably would not support further mining operations under conditions comparable to those of 1942–44.

HACKETT MINE

The Hackett mica-feldspar mine (pl. 1, no. 20) is in the town of Groton, 2.0 miles N. 72° E. of North Groton village. From North Groton follow a gravel road northeast toward Rumney Depot for 1.5 miles to a gravel mine-access road on the right. Follow this road southeast for 0.8 mile uphill to the second intersection. Take the left fork and drive for about 0.7 mile to the Valencia mine. The Hackett mine is 300 feet north of the Valencia mine.

The property is owned by the town of Groton. After 40 years of idleness it was reopened in July 1942 by Groton Mica Mines, Franklin, N. H. In 1942, the workings consisted of a cut 60 feet long, 30 feet wide, and 12 feet deep, entered from the northwest by a 65-foot crosscut trench. During intermittent operations lasting until the spring of 1944, the cut was widened 10 feet and lengthened 20 feet. About 650 tons of rock was moved. The Hackett mine was studied by C. S. Maurice and J. B. Headley, Jr., in July 1942 and by J. J. Page and F. H. Main in November 1944 (fig. 67).

The pegmatite appears to be a lens-shaped body, narrowing on the surface at both ends of the cut but widening with depth. Its strike is almost north, parallel to foliation of the wall rock, a quartz-biotite-sillimanite schist. Its dip, in general, is steeply east, although locally the contacts dip west. Small rolls in the schist wall on the east side of the cut plunge N. 15° E. at an angle of 25°. Pegmatite is exposed 115 feet south of the south end of the opencut, midway between it and the Valencia mine.

The irregularly zoned pegmatite consists essentially of perthite, plagioclase (An_6), gray quartz, muscovite, and biotite. Black tourmaline is a common accessory. A fine-grained aplitic border zone, 1 to 4 inches thick, is exposed along parts of the hanging wall contact. It consists of quartz, feldspar, and muscovite. Gouge and shattering of both pegmatite and schist indicate movement along both walls, and the apparent absence of the border zone along parts of the walls may be the result of this movement. The discontinuous sheet-bearing muscovite wall zone is as much as 2 feet thick and consists of plagioclase, quartz, and sheet-bearing muscovite. It is most persistent along the footwall.

Inside the wall zone is a plagioclase-quartz outer intermediate zone that contains minor amounts of muscovite and perthite. It is best exposed at the north end of the cut, where it lies between the schist wall and the perthite-quartz-biotite zone. The perthite-quartz-biotite inner intermediate zone, in which perthite is the dominant mineral, contains biotite in large, weathered books. The perthite-quartz core lies near the center of the pegmatite and is best exposed at the south end of the opencut. Perthite is the dominant mineral in the zone, but small quantities of plagioclase, quartz, and muscovite are present. The muscovite, mostly too small for use as sheet, is associated with small quartz bodies and stringers.

The muscovite content of the footwall part of the wall zone is low, and most of the books are small. The mica occurs as small, hard, free-splitting subhedral books that commonly show green and ruby color zoning parallel to their edges. Larger books are present in the hanging wall part of the zone but are mostly fractured and bent. Scattered books near the quartz bodies and stringers in the perthite-quartz zone are hard and free splitting, but most are stained.

Owing to the small size and scarcity of the muscovite, operations in 1942–44 were unsuccessful. Some potash feldspar is present, but it is stained and does not occur in large, easily minable concentrations.

HALE MICA MINE

The Hale mine (pl. 1, no. 63), on the eastern slope of Isinglass Mountain, is in the town of Grafton, approximately 3.5 miles S. 15° E. of Canaan village. To reach it from Canaan follow U. S. Highway 4 west 0.5 mile to a road on the left; turn left and cross the bridge over the Indian River and the Boston & Maine Railroad; continue southeast 1.5 miles to a crossroad; proceed southeast on the same road 1.5 miles to a fork, passing a side road on the right; follow the right fork 1.1 mile to another fork; turn left; and proceed to the mine.

The mineral rights, owned by the Whitehall Co., Inc., of New York, were leased during June and July 1943 by the Hill Mining Co., Bristol, N. H.

Prior to June 1943, several prospect pits were made by the Whitehall Co., and the Hill Mining Co. operated the mine in June and July 1943. The main open pit is about 50 feet long, 10 to 16 feet wide, and 3 to 15 feet deep. The mine was mapped in July 1943 by Glenn W. Stewart and John Chivers (pl. 23) and was revisited by Stewart in May 1945.

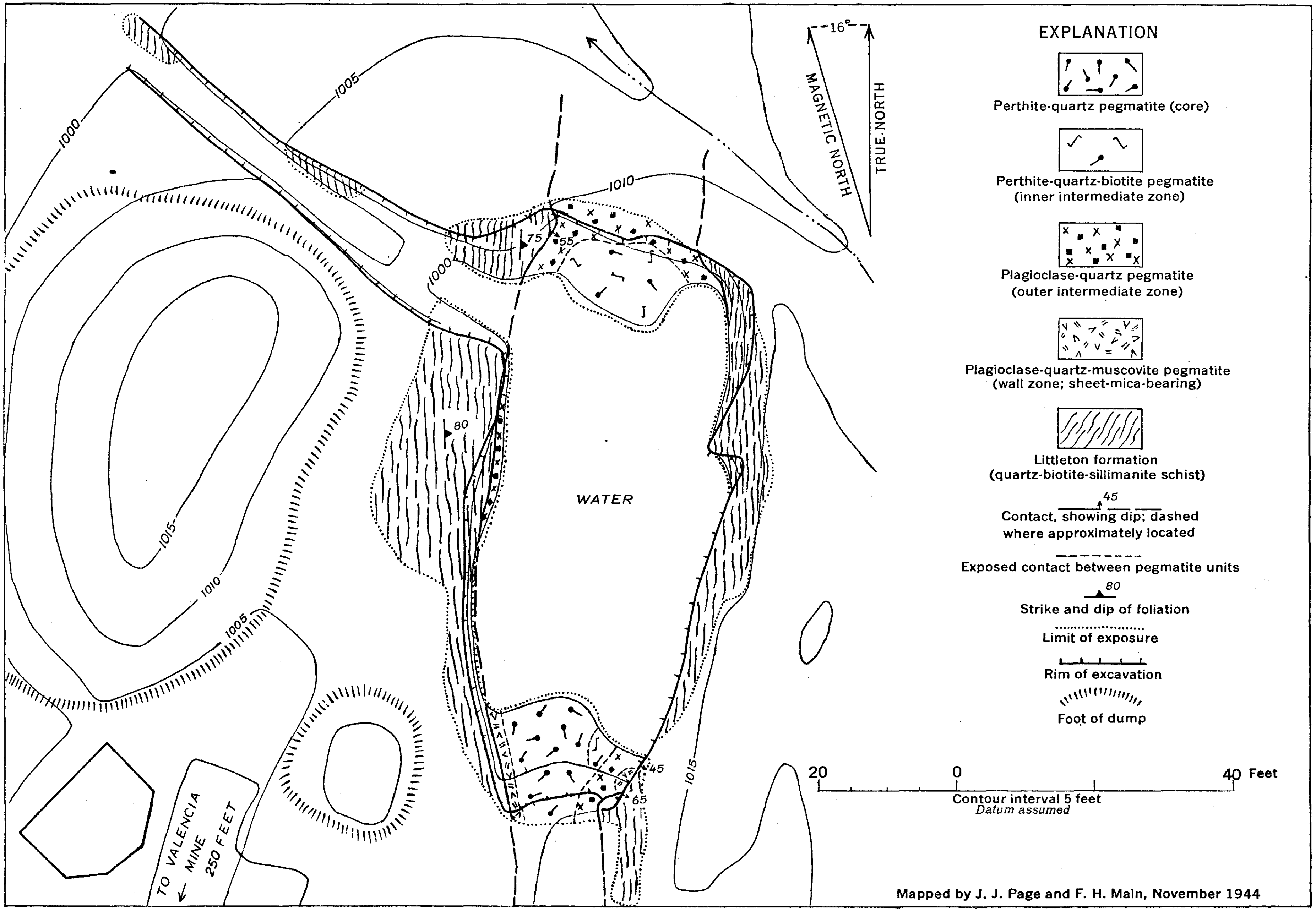


FIGURE 67.—Geologic map of the Hackett mine, Groton, N. H.

The pegmatite is more than 880 feet long. It strikes north and dips 20°–75° E.; the hanging wall contact dips 20°–35° E. Irregularities of the footwall contact suggests that the pegmatite plunges southward. The pegmatite is generally concordant with the wall rock foliation along strike, and cuts across the dip of the foliation in most places. The wall rock is schist of the Littleton formation, the foliation of which strikes N. 10° W. to N. 15° E. and dips 55°–75° E. Garnets as much as 5 mm in diameter and sillimanite crystals as much as 20 mm long locally are present near the contacts.

The border zone of the pegmatite, 1 to 3 inches thick, is composed of fine-grained quartz and muscovite, with small quantities of plagioclase, garnet, and tourmaline. The inner part of the pegmatite is medium to coarse-grained. Associated with it is aplitic rock consisting of albite (An_{5-7}), microcline, sericite, and accessory garnet, tourmaline, and apatite. This material occurs chiefly as irregular patches along the hanging wall of the pegmatite. Elsewhere, the aplitic rock is present as isolated, lenticular patches in medium to coarse-grained pegmatite. Garnet and tourmaline crystals occur in discontinuous bands or streaks in the aplitic rock. It cannot be proved that all the aplitic rock was formed by replacement and recrystallization of wall rock, but the banding, streaking, and fine-grained texture are suggestive of this origin. The aplitic material in the coarse-grained pegmatite may represent xenoliths of wall rock that have been replaced. Tabular xenoliths of wall rock with both sharp and gradational contacts are scattered through the pegmatite. The medium- to coarse-grained pegmatite is mainly in the central and footwall parts of the pegmatite. It is composed of quartz, perthite, plagioclase, and accessory garnet, tourmaline, and apatite. Irregular patches and tabular, fracture-controlled, replacement bodies of coarse-grained albite-quartz-muscovite pegmatite are present in the aplitic rock along the hanging wall and extend into other parts of the body.

The replacement bodies are as much as 50 feet long and 2 feet thick. They are best exposed in the main working and in the prospect pits to the southeast. They tend to parallel the strike and dip of the pegmatite. The largest body exposed strikes N. 20°–30° E. and dips 25°–35° SE. An offshoot of this body has a steeper dip but a strike parallel to that of the main body. The contacts between the replacement bodies and the aplitic rock are sharp in some places and gradational in others. The bodies show discontinuous border units as much as 2 inches thick. These are composed of quartz, fine-grained muscovite, and accessory garnet. Discontinuous bands of garnet, 3 mm thick, occur commonly in the contact zone of this fine-grained pegmatite. Inside the discontinuous border units the replacement bodies are composed of albite (An_{5-7}), quartz, sheet-bearing muscovite, and accessory garnet and tourmaline.

Most of the sheet-bearing muscovite is in the tabular, fracture-controlled replacement bodies. Only scattered books are found in the main pegmatite. The muscovite is light rum, soft, wavy, ruled, reeved, and contains inclusions of magnetite(?). A few of the books are wedge-shaped, many are cross-fractured, and some are much stained. About 1 percent mine-run mica was recovered from 100 tons of rock removed. Mining was abandoned in 1943 when it became evident that the yield of sheet mica was insufficient for profitable operation.

HOYT HILL MICA MINE

The Hoyt Hill mine (pl. 1, no. 43) is in the town of Orange, near the summit of Hoyt Hill, 3.2 miles S. 77° E. of Canaan. To reach it from Canaan, take a hard-surface road west for 3.5 miles to Orange Basin; turn right after crossing Orange Basin bridge; proceed 0.6 mile over a gravel road to the first fork; and take the right fork 1.1 miles to the mine.

The mine is owned by Robert B. Coleman, Jr., of Canaan. It was operated during the First World War and for a short period in 1935–36. An opencut about 70 feet long, 20 feet wide, and 67 feet deep, and a steep inclined stope,extending northward 40 feet below the floor of the cut, were made. The mine was dewatered in 1943 by Mr. Coleman, who operated it intermittently from September 1943 to October 1944. The north end of the opencut and the bottom of the inclined stope were lowered about 15 feet. The mine was mapped by A. H. McNair and A. H. Chidester in August 1944 (fig. 68) and was revisited periodically by McNair during September 1944.

The pegmatite is exposed only in the cut and underground workings. It is an irregular, branching, tabular body that is parallel in general to the long axis of a narrow granite mass. It strikes north, parallel to the walls of the cut, and has an almost vertical dip. It is only 6 inches thick in places in the north end of the cut. At the south end of the cut, where it appears to end against a prepegmatite shear-zone, it is about 12 feet thick.

The pegmatite is in contact with both granite and quartz-mica schist of the Littleton formation. The granite is partly concordant, partly discordant to the foliation of the schist and appears to be a small body related to the larger Concord granite body that outcrops half-mile mile east of Hoyt Hill. The schist strikes in general N. 10° E. and dips approximately 85° W. Lineation in the schist plunges 75° SW. A conspicuous shear surface crosses the schist at the south end

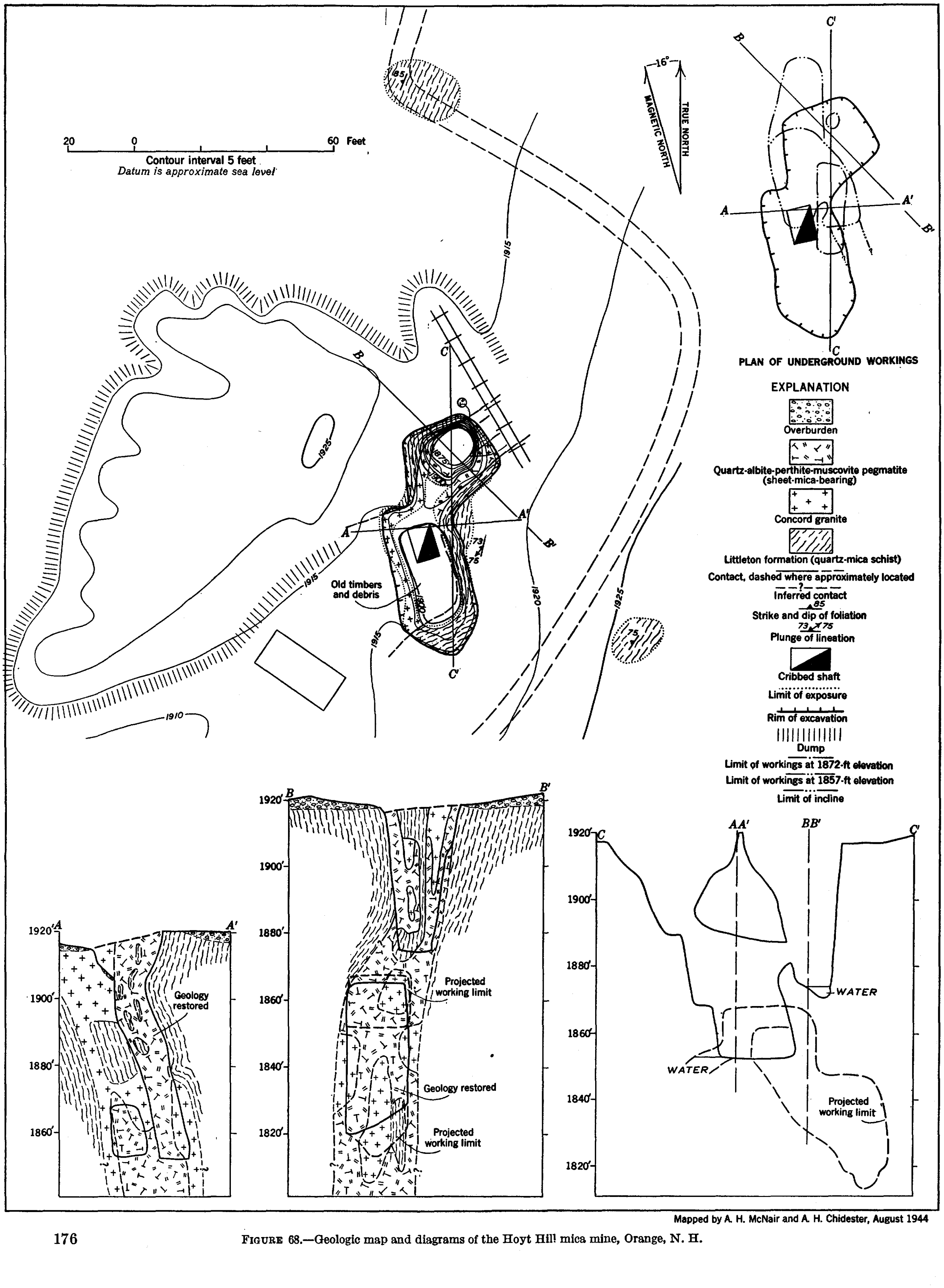


FIGURE 68.—Geologic map and diagrams of the Hoyt Hill mica mine, Orange, N. H.

of the opencut. It strikes N. 50° E. and dips approximately 75° NW. A small exposure, to the south end of the cut shows that the shear zone is earlier than the pegmatite, which cuts it.

Narrow, irregular apophyses of pegmatite cut both types of wall rock. The pegmatite contains many large and small inclusions of schist and granite and a few rounded inclusions of sugary aplite. The apophyses and large inclusions of schist and granite given the pegmatite body a highly irregular internal and external form, and made it difficult to follow during mining.

The pegmatite is composed of albite, quartz, muscovite, perthite, green apatite, and black tourmaline. A distinct border zone is commonly present at the walls and around the larger inclusions of schist and granite. The zone is 2 to 4 inches thick and consists of fine-grained quartz and albite or quartz and muscovite. The center of the pegmatite consists of coarse-grained albite (An_6), quartz, perthite, and muscovite. In the narrower parts of the body, muscovite, albite, and perthite anhedra extend almost completely across the width of the pegmatite. Outside the border zone the minerals of the pegmatite do not have a peristent zonal arrangement, but the larger muscovite crystals are more abundant along the bottoms and sides of schist and granite inclusions and along the hanging wall than in other parts of the body.

Muscovite obtained from the mine in 1943–44 was rum to ruby, extremely hard, flat, and exceptionally free from structural defects. It yielded an exceptionally high percentage of sheet. The books averaged about 5 by 6 by 2 inches, and some books were 18 by 24 by 6 inches. About 10 percent mine-run mica was recovered from the rock mined in 1944.

The mine produced much muscovite of good quality prior to 1942. In 1943–44 the mine proved difficult to pump, especially during winter months, and the floor of the inclined stope, from which the best mica was obtained, contained large irregular blocks of granite and schist. If the pegmatite extends southward or southwestward, some distance from the present cut, and if it maintains its relatively high content of mica, it may yield a considerable quantity of sheet mica of high quality.

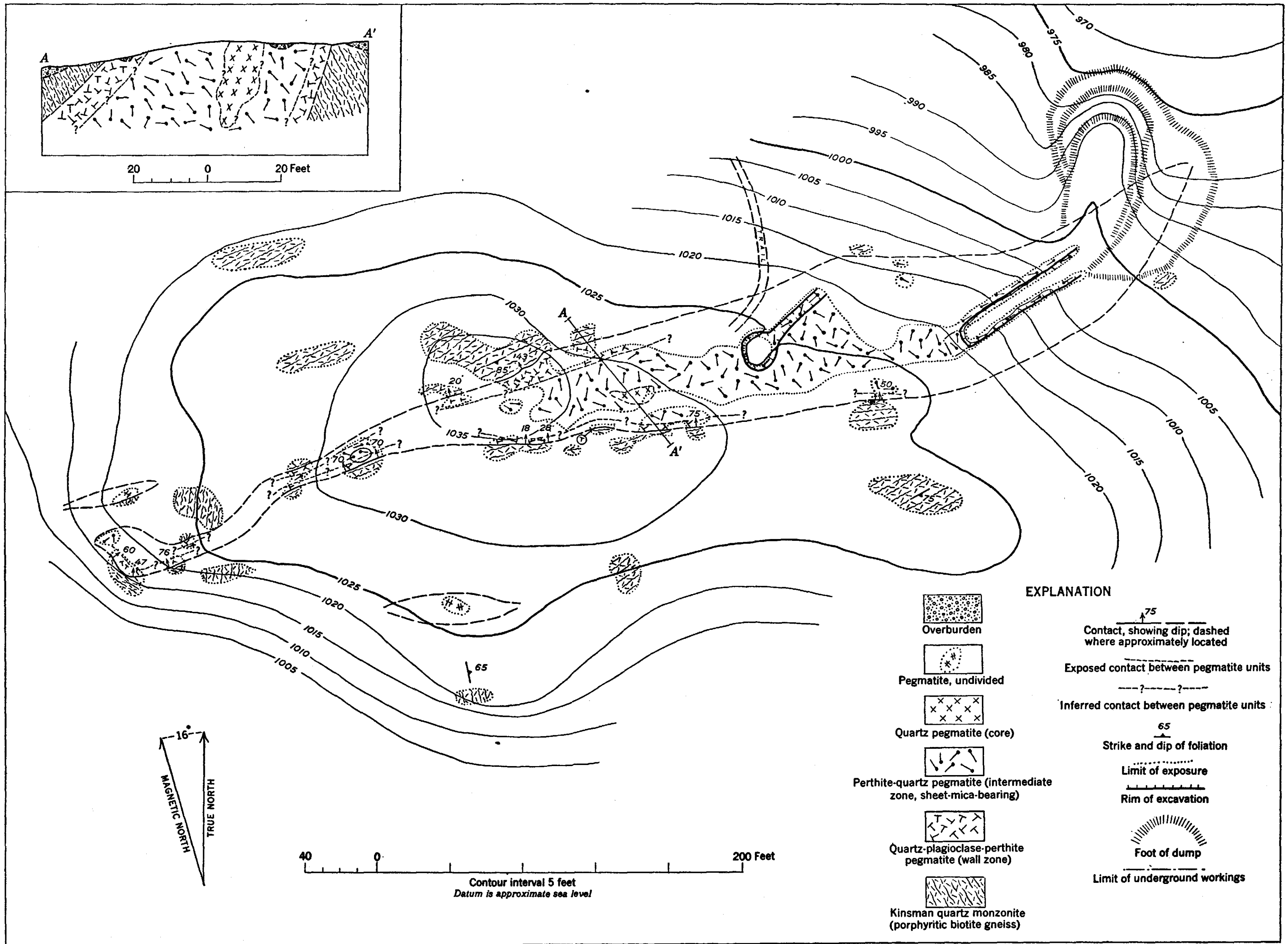
HUTCHINS HILL MICA MINE

The Hutchins Hill mine (pl. 1, no. 52), formerly known as the New Haven Mica Co.'s mine, is in the town of Alexandria, 2.9 miles N. 77° W. of Alexandria village. To reach it from Alexandria follow a hard surfaced road northwest for 0.2 mile to a fork; turn right on a graded gravel road and proceed for about 3.0 miles to a sharp right turn with a farm house on the left; and follow a farm lane about 1.5 miles southwest and south up the northern slope of Hutchins Hill to the mine. The property and mineral rights are owned by the New England Mineral Co., Newport, N. H.

Prior to 1914, an opencut, 75 feet long, 12 to 18 feet wide, and 5 to 20 feet deep, was dug southwest into the hillside at the northeastern end of the pegmatite. An adit, 10 feet long, 10 feet wide, and 7 feet high, was run from the floor of the cut into the southwest face. A small open pit, 20 feet long, 20 feet wide, and 4 to 8 feet deep, was made near the center of the pegmatite, approximately 100 feet west of the opencut. During August and September 1944, a trench, 35 feet long, 6 to 7 feet wide, and 1 to 5 feet deep, was dug northeastward from the small open pit. Several small test pits were also made in the pegmatite west of the cut. The mine was mapped by Glenn W. Stewart, Norman K. Flint, and Dabney W. Caldwell in August 1944 (fig. 69).

The pegmatite is well exposed for 560 feet along strike and is 10 to 80 feet wide. It strikes N. 60°–70° E. and dips irregularly northwest; the hanging wall dips 20°–43° and the footwall dips 17°–75°. At the southwest end the contact strikes N. 30°–40° W. and dips 47°–60° NE. In many places the contact and foliation of the wall rock are essentially parallel along strike, but in places near the southwest end the two diverge. The pegmatite cuts the dip of the foliation throughout its exposed length. The wall rock is Kinsman quartz monzonite with foliation that in general strikes N. 65°–80° E., and dips 65°–85° SE. At the southwest end of the pegmatite, however, the foliation of the gneiss strikes N. 20°–30° W., and dips 50°–65° NE.

The pegmatite is zoned, consisting of a quartz-muscovite-plagioclase border zone, a quartz-plagioclase-perthite wall zone, a perthite-quartz zone, and scattered quartz pods that may represent a core. The border zone, 2 to 6 inches thick, is composed of fine-grained quartz, muscovite, plagioclase, and accessory garnet. The wall zone, 1 to 10 feet thick, is a coarse-grained, uniform mixture of quartz, plagioclase, small quantities of perthite, and accessory muscovite and garnet. The perthite-quartz zone, 4 to 60 feet thick and at least 560 feet long, is composed of perthite, quartz, graphic granite, muscovite, biotite, secondary chlorite, small quantities of plagioclase, and accessory beryl. There are several scattered quartz-rich pods in the central part of the pegmatite. Most are 3 by 6 feet or less in surface area, but one is 3 to 10 feet wide and 25 feet long. Anhedral and subhedral cyrstals of perthite, commonly averaging 2 by 4 feet, are most abundant in the perthite-quartz zone, but some are embedded in the quartz pods. One subhedral crystal in the small pit measured 8 by 9 by 6 feet. Most of the larger muscovite books are near or along the hanging wall sides of the quartz pods, but some smaller books occur on the footwall sides and



Mapped by G. W. Stewart, N. K. Flint, and D. Caldwell, August 22-23, 1944

FIGURE 69.—Geologic map and section of the Hutchins Hill mica mine (New Haven Mica Co. mine), Alexandria, N. H.

others are sparsely disseminated through the quartz-perthite zone.

Most of the muscovite is green, hard, and flat, but is badly ruled, cracked, and has a "fishtail" structure. Many books are wedge-shaped and nearly all contain mineral inclusions, probably of magnetite. The books average 3 by 5 inches, but several measured 4 by 10 or 3 by 12 inches. Some are intergrown with partly chloritized biotite. The disseminated muscovite books are usually lath-shaped, 3 to 4 feet long, 4 to 8 inches wide, and ¼ inch in average thickness.

The results of prospecting in 1944 indicate that although muscovite is relatively abundant in the pegmatite it is of very poor quality, and that the deposit could not be operated profitably under 1944 conditions. There is no evidence that mica of higher quality could be recovered from parts of the body that have not been prospected.

ITASKA MICA MINE

The Itaska mine (pl. 1, no. 50) is in the town of Alexandria, 2.9 miles N. 40° W. of Alexandria village. To reach it from Alexandria village, follow a hard surfaced road northeast 1.0 mile to an intersection; turn left and follow a hard surfaced road 0.9 mile; continue on a gravel road 2.1 miles to a bridge across the Fowler River; follow a wood road south across Brock Brook and proceed southeast on the same road along Fowler River 0.2 mile to the mine. The property is owned by Charles J. Cowan of Alexandria (R. F. D. 1, Bristol), N. H. The mineral rights are held by Russell T. Bates, 57 Granite Street, Quincy, Mass.

A pit, 45 by 45 feet and about 20 feet deep, was excavated before 1920. At present it is filled with water and debris. Subsequent to mapping by G. W. Stewart and Harry Kamensky in August 1943, the pit was pumped and prospected intermittently during October and November 1943 by the Hill Mining Co. of Bristol, N. H.

The pegmatite is poorly exposed and can be traced along strike for only 50 feet. It strikes N. 35° W. and dips 45° NE. It cuts across the foliation of the enclosing Kinsman quartz monzonite gneiss, which strikes N. 20° E. and dips 35°-40° SE.

Visits were not made when the cut was being tested, so that only the outcrops of the pegmatite around the pit could be studied. The pegmatite consists of albite (An_{4-6}), quartz, perthite, muscovite, and accessory garnet. The muscovite recovered from the dump is light rum to light green and has conspicuous ruling and "A" structure. This mica is rejected material and is probably not representative of the product of the mine. The prospect work in 1943 did not repay operations, for only sparsely disseminated books of poor quality were recovered.

KENISTON MICA PROSPECT

The Keniston mica prospect (pl. 1, no. 12) is in the town of Rumney, 1.8 miles due west of the village of Rumney. From Rumney follow a gravel road west-northwest along the north side of the Baker River for 2.4 miles. From this point travel northeast 0.1 mile to the top of a small "knob" on the west slope of Rattlesnake Mountain.

The property and mineral rights are owned by Charles E. Keniston, 23 Fulton Street, Woburn, Mass. Several small exploratory pits were excavated in 1943 by Colonial Mica Corp., Newport, N. H. In July 1943 the prospect was mapped by G. W. Stewart and Harry Kamensky (fig. 70).

Three of the 4 small pegmatites exposed strike approximately north and dip steeply eastward. Their exposed lengths range from 20 to 55 feet and they are from 3 to 12 feet wide. The other pegmatite has a gentle dip and a very irregular strike and ranges from 5 to 100 feet in width. It extends northward 50 feet beyond a nearly vertical southward-facing cliff. The wall rock is quartz-mica schist and interbedded quartzite of the Littleton formation, the bedding of which strikes N. 40° E., and dips 80° to the northwest. All the pegmatites cut across the foliation of the wall rock. The contacts are sharp, at most places, but at others the schist is impregnated with pegmatite. Several small xenoliths of schist, 1 by 4 feet or smaller, occur in the pegmatites.

The pegmatites are similar in texture and composition. The essential minerals are perthite and quartz—in part in graphic intergrowth, plagioclase, muscovite, and biotite. The accessory minerals are black tourmaline, red garnets, and blue-green beryl. There is a narrow border zone, 2 to 3 inches thick, of fine-grained quartz and muscovite. The material inside the border zone is largely perthite, quartz, and graphic granite, with accessory minerals. Hard, clear ruby muscovite occurs in small sparsely disseminated books and locally in small clusters in coarse-grained, quartz-rich parts of the pegmatite. The average size of the books is about 2 by 2 inches. Many are intergrown with lath-shaped crystals of biotite.

Prospecting in 1943 did not yield enough good quality muscovite to encourage operations. The low content of muscovite in the prospect and the small size of the books indicate that the yield of sheet mica per ton of rock moved would be very small.

KEYES MICA MINES

The Keyes mica mines are in the northwest corner of Orange township, 1 mile N. 31° E. of the summit of Mount Tug. To reach the mine follow State Highway 118 northeast from Canaan village for 0.5 mile; turn

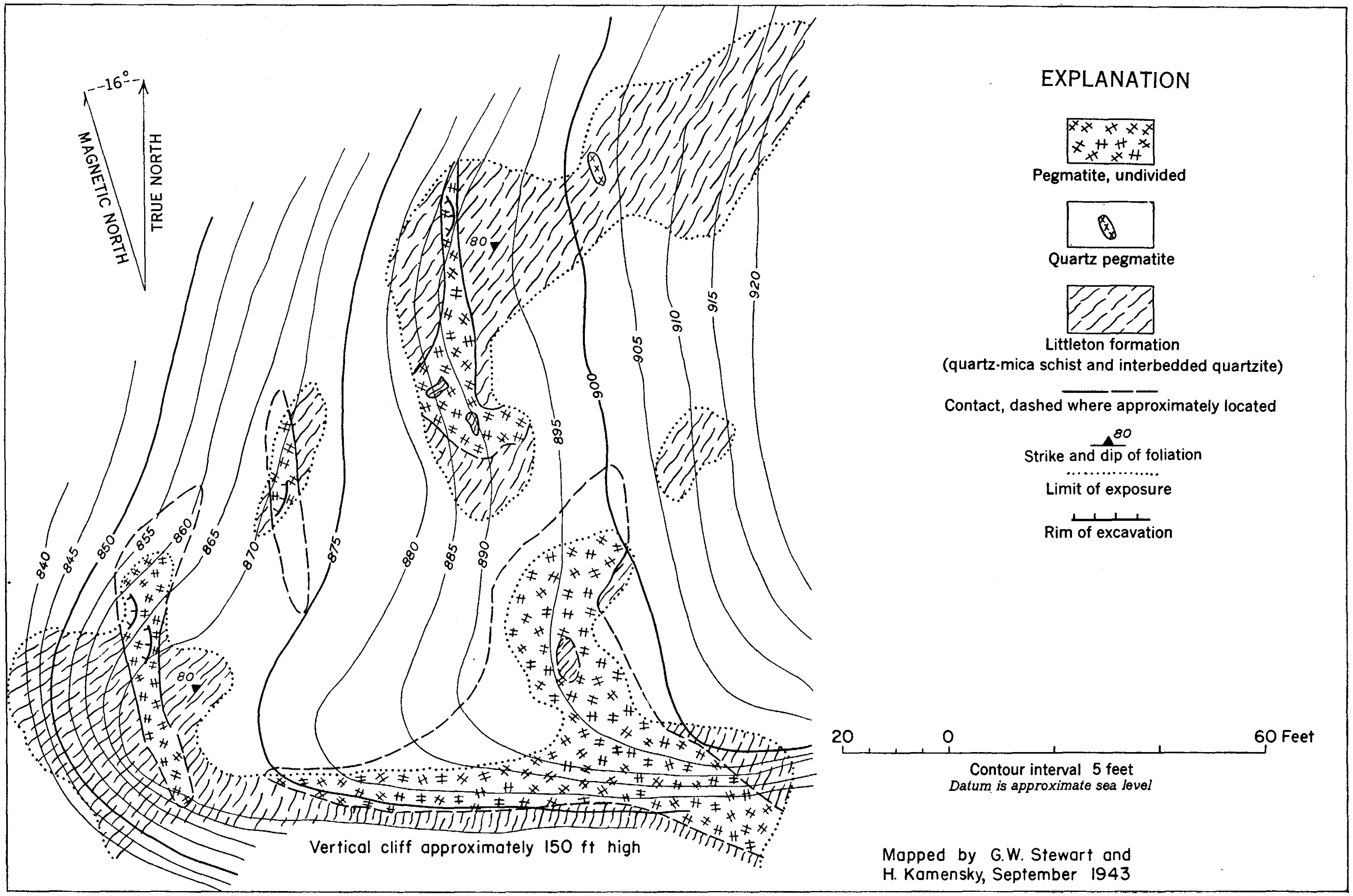


FIGURE 70.—Geologic sketch map of the Keniston mica prospect, Rumney, N. H.

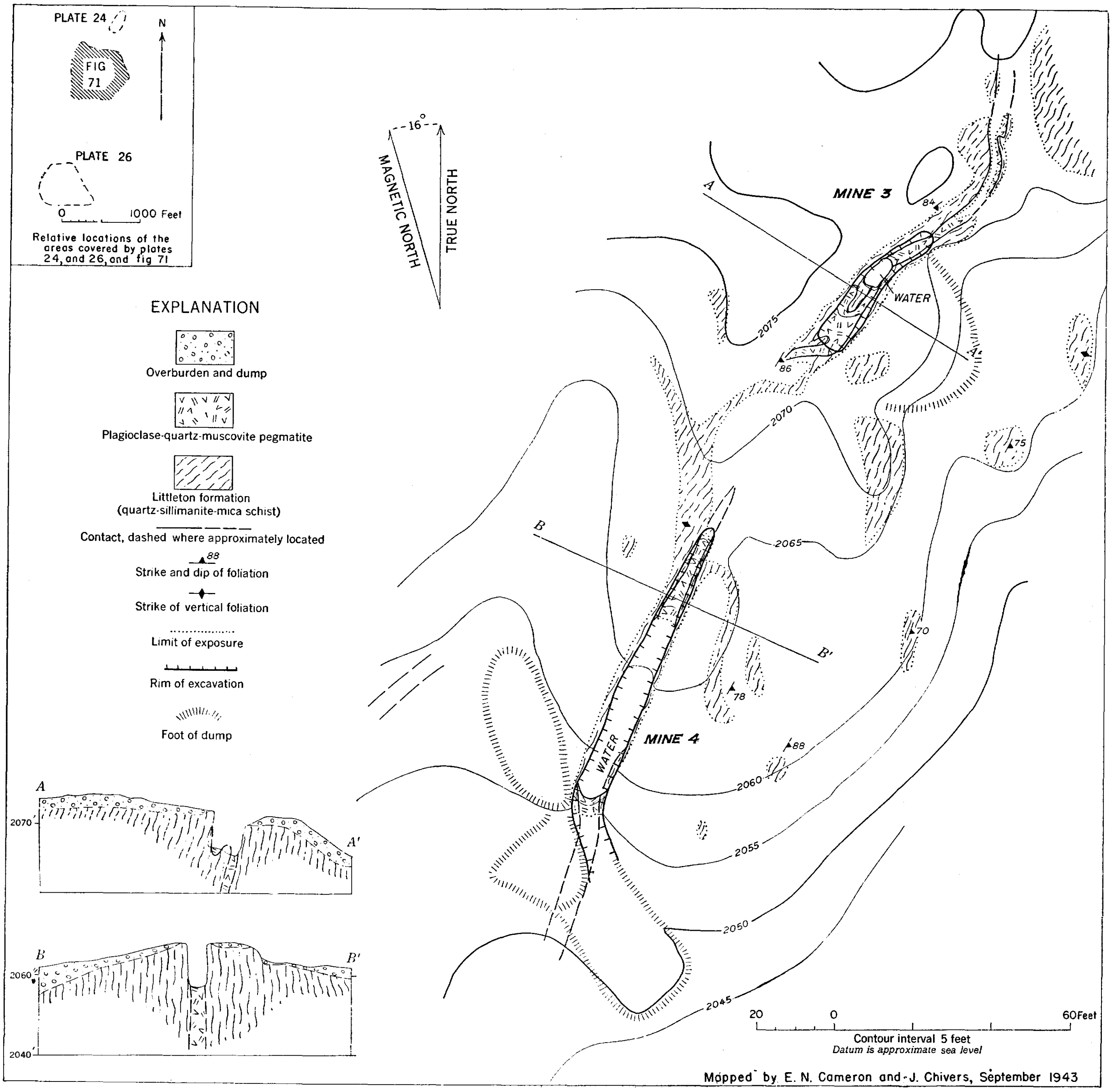


FIGURE 71.—Geologic map and sections of the Keyes No. 3 and No. 4 mica mines, Orange, N. H.

right and follow the Cardigan State Forest road (graded gravel and asphalt) for 2.85 miles to the fork just east of Orange Brook; follow the left fork, a graded gravel road, for 1.15 miles to a sharp right turn from which a poor dirt road leads north; follow the dirt road for 1.5 miles to a fork just beyond a ruined farmstead; and take the left fork for 1.0 mile to the buildings at the mines. The last 2.5 miles of the route was impassable to cars in April 1945.

The property is owned by Mrs. Serge Cheremeteff, Lebanon, N. H. According to local report the mines have been worked intermittently for more than 60 years. Mr. E. E. Smith purchased the property from Mr. W. Shepard, Canaan, N. H., in December 1940, and began operations early in 1941. In February 1943 Smith sold the mine to Cheremeteff, but continued operations under lease until October 1943. In 1944 the mineral rights were leased by Mrs. Cheremeteff to K. E. Curran of Berlin, N. H., who carried on intermittent mining from June until October.

The property includes 6 mines (pls. 24–26, figs. 71, 72,), scattered over an area approximately 2,500 feet long and 800 feet wide. The workings are opencuts, open stopes, pits, trenches, and short inclines. Operations were confined largely to the Nos. 1 and 2 mines before Smith acquired the property, but some work is said to have been done at each of the other four mines. Production during the period 1941–44 came mainly from the Nos. 1, 5, and 6 mines, although the other mines were also worked intermittently. Sterrett (1923, p. 134–135) visited and described the No. 2 mine, and descriptions of the Nos. 1 and 2 mines were prepared by H. M. Bannerman (1943, p. 19–21). The mines were mapped and studied by E. N. Cameron, J. Chivers, and V. E. Shainin in September and October 1943, and examined periodically by Cameron and J. J. Page during the summer of 1944. The No. 1 mine was mapped in greater detail by F. H. Main, K. S. Adams, and Cameron in April 1945.

Most of the pegmatite bodies are lenses with steep eastward dips and trends that range from N. 60° E. to N. 35° W. The No. 2 pegmatite is a series of steeply dipping, interconnected lenses that trend roughly north. The complex form of this body is in sharp contrast to the simple forms of other pegmatites exposed on the property and suggests that the visible parts of the No. 2 pegmatite are upward projections from, or the roots of, a large lens. The pegmatites generally conform to the foliation of the wall rock, but locally are sharply discordant, especially near sharp bends or bulges of the contacts. Near some of these bends the foliation is sharply contorted. The foliation of the schist immediately adjacent to the pegmatites in the vicinity of the No. 5 mine at most places is parallel to the pegmatite walls, but the trend of the pegmatites is more westerly than the general trend of the foliation.

The wall rocks are quartz-sillimanite-mica schists of the Littleton formation, the foliation of which strikes N. 7° E. to N. 58° E., and commonly dips steeply eastward to southeastward. Sillimanite has been changed partly or entirely to muscovite adjacent to the pegmatites, and numerous tourmaline prisms have developed. The schists in places along the contacts of the No. 2 pegmatite have been changed to rocks resembling gneissic granite and alaskite.

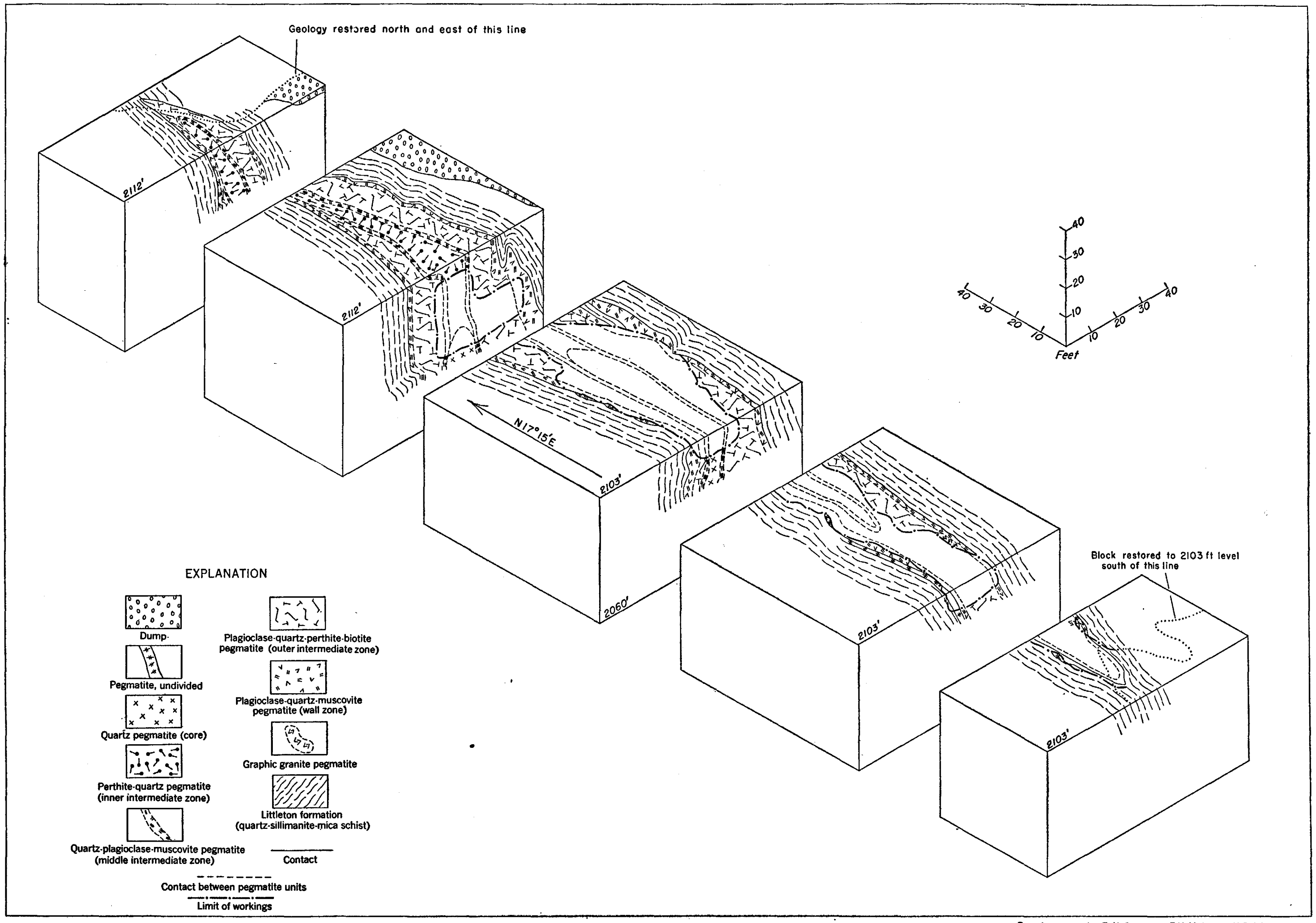
NO. 1 MINE

The main working at the No. 1 mine (pl. 1, no. 35, pls. 24, 25; fig. 72) is an opencut 170 feet long, 12 to 40 feet wide, and 12 to 60 feet deep. It is reported that during early operations the cut was opened to its present width from the south and nearly to the line of section BB′ (pl. 25). Mining was carried downward to an estimated altitude of 2,090–2,094 feet. A narrow cut was then made along the west wall to the head of the present cut and a similar cut was carried a short distance along the footwall. An incline down the east wall is said to extend 25 feet below the present floor. In 1941 Smith discovered sheet mica in the central part of the pegmatite. The cut was later enlarged to its present length and width and deepened to about 2,070 feet altitude at its north end. A pit was sunk at the south end of the cut to a depth reported as 16 feet below floor level. Finally, open stopes were carried eastward and northward from the north end of the cut, and the small cut north of the main working was made. The mine was closed down in August 1943. Curran partly unwatered the cut and tested the south end of the deep pit in 1944.

The pegmatite worked in the No. 1 mine is an elongate lens that strikes N. 17° E. and dips from 70° E. to vertical. It is exposed for about 240 feet along strike. It has a maximum thickness of about 50 feet in the northern part of the main cut but is progressively narrower northward and southward. One end of the pegmatite is exposed at the south end of the main cut, and the other end probably lies a short distance beyond the north cut.

The pegmatite shows six zones, in the following sequence inward from the walls:

1. Quartz-muscovite-plagioclase border zone—1 to 12 inches thick, composed of fine-grained quartz and scrap muscovite, with subordinate plagioclase and accessory garnet and tourmaline.
2. Plagioclase-quartz-muscovite wall zone—1 to 8 feet thick, composed of coarse plagioclase and quartz with subordinate muscovite, accessory black tourmaline, apatite, and garnet. Beryl, in small crystals, is rare. Muscovite is present as sparsely scattered books, 2 to 10 inches broad and 1 to 4 inches thick.
3. Plagioclase-quartz-perthite-biotite outer intermediate zone—1 to 17 feet thick, consisting of the minerals named with subordinate muscovite and accessory tourmaline and apatite. Biotite, much of it intergrown with flattened tourmaline crystals, forms diversely oriented strips 1 to 20 inches long and ¼ inch to 4 inches broad. Some of the biotite has been altered to chlorite. Muscovite is partly intergrown with biotite, but also forms numerous books as much as 2 inches in diameter.
4. Quartz-plagioclase-muscovite middle intermediate zone—6 inches to 2 feet thick, composed of quartz and plagioclase with subordinate muscovite, and accessory tourmaline, graftonite, triphylite(?), pyrrhotite, pyrite, and secondary vivianite(?). Crystals of beryl 1 to 12 inches long and ½ to 5 inches in diameter appear to be scattered sparsely through this zone. Sheet muscovite is present in books 2 to 10 inches broad and ½ to 1½ inches thick. Larger books are reported to have been found.
5. Perthite-quartz inner intermediate zone—3 to 15 feet thick, composed of stout perthite crystals 6 inches to 4 feet long with subordinate interstitial quartz. In this zone and also in the biotite-bearing zone, many of the perthite crystals have been partly or entirely converted to porous pseudomorphs composed of albite and greenish muscovite. Minute apatite crystals stud the walls of some of the pores. Some pseudomorphs are veined and partly replaced by quartz. Unaltered perthite is abundant.



Based on map by E. N. Cameron, F. H. Main, and K. S. Adams

FIGURE 72.—Isometric projection showing interpretation of Keyes No. 1 pegmatite, Orange, N. H.

only in the north cut, where graphic granite is also present in the quartz-perthite zone.

6. Quartz-pegmatite core—5 feet thick where observed, composed of massive quartz. The core is reported to have been 10 feet thick in places between the lines of sections BB′ and CC′ of plate 25.

Remnants of a small body of graphic granite and perthite are exposed along the east wall of the main cut between the biotite-bearing zone and the wall mica zone. This is probably a phase of the biotite-bearing zone, which varies in biotite content, but may be a distinct unit.

The relationships of the zones, so far as observed, are indicated on the map and sections of plates 24 and 25. Figure 72 is an interpretation of the structure based on observations, on information given by the operator and mine foreman, and on analogy to other deposits of similar structural type. The border zone (omitted from maps and diagrams) is a thin continuous envelope. The wall zone is absent only around the north end of the pegmatite and along the east wall near the north end. The biotite-bearing zone and intermediate sheet-mica bearing zone are absent only at the north end along the west side of the pegmatite. The sheet-mica-bearing intermediate zone is generally adjacent to the biotite-bearing zone. It adjoins the quartz core in the southern part of the pegmatites and the perthite-quartz intermediate zone in the northern part. The relationship of the quartz core to the quartz-perthite zone is suggested by the foreman's report that the quartz core extended, in the bottom of the deep pit, beneath the headwall of the main cut, and by a small body of quartz enclosed in the quartz-perthite zone (sec. CC′, pl. 25) in the headwall. The inner ends of the perthite crystals are euhedral against the quartz. This body and the main quartz body appear to be unequal segments of a discontinuous core. The perthite-quartz unit is interpreted as an asymmetrically developed intermediate zone, beneath which the upper edge of the main core segment plunges northward. The relative positions of the core and quartz-perthite zone suggest that the plunge of the pegmatite body as a whole is northward, despite the fact that the south end of the pegmatite, where exposed for a few feet at the south end of the main cut, plunges southward at an angle of about 80°.

Book mica from the deposit is hard, clear, free-splitting, ruby muscovite. Limonite stain is present in some books taken from points near the original ground surface. Most books seen are marred by ruling, cross-fractures, and reeving, but parts of books free of these defects yielded sheet of unusually high quality. The sheet recovery from crude mica was well above the average for New England.

Sheet mica was obtained both from the wall zone and the intermediate quartz-plagioclase-muscovite zone. The wall zone was most productive along the west wall and has been almost entirely removed above floor level in the main cut. The part along the east wall was less productive and was only partly removed, but probably it was richer in the vicinity of the incline. The mine foreman states that during Smith's operations, the intermediate zone was most productive in the northern half of the main cut. The part along the west side of the quartz core was especially rich in places. In both zones, however, lean parts were found. The part of the intermediate zone adjacent to the quartz-perthite zone was lean and little mica was obtained from the open stope beneath the headwall. The content of the zone is said to have decreased downward also, though both quartz core and sheet-mica-bearing intermediate zone are reported present at the bottom of the deep pit.

The No. 1 mine has produced a considerable quantity of sheet mica of unusually high quality. The average content of crude mica in the rock mined was probably not more than 2 or 3 percent, but the yield of sheet from crude was above average. The two productive zones apparently were lean at the limits of the workings, but the limits of the zones were not reached, and it is far from certain that the zones have been exhausted of ore minable under conditions comparable to those of the period 1942–44.

Certain features of the history of past operations suggest that the mica occurred in shoots. If so, it is likely that such shoots would be related to the plunge of the core and the plunge of the pegmatite body as a whole. If the core and pegmatite body plunge to northward, the extensions of shoots mined in the past in the northern half of the main working may lie down plunge from the working.

According to the operator, no work between 1941 and 1944 was done between the deepened northern part of working and the line of section AA′ (pl. 25), nor was the incline sampled.

North of the main working, the sheet-mica-bearing zones are ill-defined, lean, and not promising. The beryl content of the pegmatite is extremely low.

NO. 2 MINE

The main working at the No. 2 mine (pl. 1, no. 35; pl. 24) is an irregular opencut 120 feet long, 12 to 40 feet wide, and 10 to 35 feet deep. Prior to 1941 three steep inclines were sunk from the north wall of this cut. The inclines are reported to lead to a large chamber (not shown on pl. 24), 30 feet below the floor. Sterrett visited the mine about 1914 and found a cut about 100 feet long and 5 to 18 feet deep, with three small "rooms" (the inclines) on the north side. Smith unwatered the inclines in early 1941 and mined downward for a short distance. A fourth incline (the second from the west end) apparently was sunk at this time, but with scant results. Shallow pits were excavated in the floor of the cut, the cut was enlarged to its present dimensions, and two other shallow pits outside the main working were made. The yield of mica was everywhere disappointing, and operations ceased in the fall of 1941.

The pegmatite seems to be a series of connected lenses that trend north to N. 25° E. Partly separating the components of the complex are wedge-shaped or irregular projections of schist. Contacts are concordant to the foliation of the schist in places, discordant at others. The chief constituents of the pegmatite are quartz, plagioclase, and muscovite. Subordinate minerals are perthite (partly replaced by albite and greenish muscovite) and graphic granite. Garnet, apatite, and beryl are minor constituents.

The pegmatite is poorly zoned. A thin border zone of quartz, muscovite, and plagioclase is present along the walls. Inside this, on the under side of a large schist pendant (sec. AA′, pl. 24) is, a discontinuous, poorly defined wall zone composed of quartz, plagioclase, and muscovite. In places this zone contains clusters of sheet-bearing muscovite books. The two eastern inclines appear to extend directly down along this zone beneath the schist roof. The rest of the pegmatite exposed should probably be regarded as an intermediate zone. It consists largely of quartz, plagioclase, and scrap mica with scattered crystals of altered perthite and accessory tourmaline, apatite, garnet, and beryl. Small quantities of graphic granite are present. Scattered through this material are streaks of coarse plagioclase, and pods composed of quartz, quartz and perthite, quartz and coarse plagioclase, or coarse plagioclase, in various proportions. Marginal to or intergrown with some streaks and pods are books of mica and beryl crystals.

Mica from the wall zones resembles that from the No. 1 mine. It forms books 2 to 8 inches broad and ½ to 2 inches thick. Some of the mica from the margins of the pods, however, is green wedge, and shows herringbone structure.

Mica of high quality is present in the pegmatite, but available exposures and the experience of the most recent operators are discouraging. According to Smith, the wall zone yielded little mica in the underground workings, and the zone where exposed is lean. The pods are sparsely distributed, and many are barren or show only scrap mica. The beryl content of the pegmatite is extremely low. Crystals are rare in the quartz-plagioclase-muscovite pegmatite that constitutes the bulk of the body. In the pillar separating the two middle inclines 7 beryl crystals ranging from 12 by 4.5 by 4.5 inches to 2 by 1 by 1 inch were found at the margins of quartz pods, but most of the pods carry no beryl. The content of perthite is low and part of it is altered beyond use to albite and muscovite.

NO. 3 AND NO. 4 MINES

The history of these mines is not fully known, but the larger part of the mining was done by Smith in 1941 and 1943. The workings (pl. 1, no. 34; fig. 71) are two opencuts; the No. 3 cut is 40 feet long, 3 to 8 feet wide and 1 to 11 feet deep and the No. 4 cut is 100 feet long (1945), 4 to 8 feet wide and 1 to 24 feet deep. The pegmatites are steeply-dipping lenses. The No. 3 pegmatite is concordant with the foliation of the enclosing schists, but the No. 4 pegmatite is sharply discordant in places. The No. 3 pegmatite, which is 1 to 8 feet thick, has been traced for 95 feet. Its strike ranges from N. 6° E. to N. 60° E. and its dip from 77° W. to vertical. Parallel tourmaline crystals in the schist wall plunge 55° N. and suggest that the pegmatite may plunge northward. The No. 4 pegmatite is 1.5 to 7 feet thick. It is exposed for only 100 feet in the opencut, but may be represented by a pegmatite of similar trend and composition exposed sporadically for 235 feet south of the cut. The pegmatite strikes N. 24° E. and is vertical. The two bodies mined are similar in composition and structure and may be connected underground. The walls of both are distinctly fluted roughly parallel to the dip. Striae on the walls of the No. 4 pegmatite plunge 28° northward and suggest slippage along the contacts.

The lenses consist chiefly of quartz and plagioclase, with scrap and sheet-bearing muscovite. Tourmaline and apatite are abundant accessories. Much of the feldspar is porous, and has small cavities lined with apatite, albite, and (less commonly) tourmaline. Comparison with the No. 1 mines suggests that these porous feldspar crystals are pseudomorphs after perthite.

A border zone, 1 to 3 inches thick, is present along the wall of each pegmatite and is distinguished from the rest of the pegmatite by a slightly greater abundance of small muscovite books. In the No. 3 pegmatite there is no further indication of zoning. Commercial muscovite is found in irregularly distributed books, 2 to 6 inches broad and ½ to 3 inches thick. In places the schist is heavy tourmalinized and has been impregnated with feldspar; these effects are especially conspicuous in the wedge of schist between the forks of the pegmatite at the south end of the cut, where the schist contains books as much as 6 inches broad and 1 inch thick. In the No. 4 pegmatite book mica was observed during one visit chiefly in a layer 1 to 2 feet thick in the middle of the pegmatite. At the time of mapping, however, pegmatite was exposed only in the north end of the cut. Here books 2 inches to 12 inches broad and ½ to 4 inches thick were concentrated in a band ½ to 1 foot thick inside the border zone along the west wall. It is doubtful that any clearly defined persistent zones are present in the pegmatite apart from a border zone and sheet-mica-bearing core.

Muscovite books from the two mines are ruby except for greenish edges. The books are ruled, badly reeved, cross-fractured, and riddled with small tourmaline inclusions. Most books are tangle-sheet and some are stained with iron and manganese (?) oxides. The percentage of sheet mica recovered is said to have been very small.

The No. 3 pegmatite thins abruptly down dip at the south end of the cut but there is no indication that it pinches out. The floor of the No. 4 cut was not seen, but workmen report pegmatite present in the bottom. The tonnage of pegmatite remaining in the dikes may, therefore, be moderately large, and the average content of crude mica is probably high. The mica, however, was poor, and the closing of the mines is reported as due to insufficient yield of sheet.

NO. 5 MINE

This mine consists of a narrow trench leading to a roughly circular pit 54 feet long, 26 feet wide, and about 50 feet deep (pl. 1, no. 36; pl. 26). The trench was dug and the pit begun before 1941. Smith enlarged the pit during intermittent operations in 1941–43.

The pegmatite appears to be a thick sheet or lens that strikes approximately N. 22° W. The east contact, where exposed, has a dip ranging from vertical to 80° E., and the pegmatite as a whole probably has a steep easterly dip. Exposures east and northeast of the pegmatite suggest the presence of three other pegmatite bodies of roughly similar attitude.

The pegmatite mined is poorly zoned. Along contacts a thin border zone consisting of quartz, scrap muscovite, and plagioclase is present, and inside this is a wall zone consisting largely of medium-grained quartz, plagioclase, and muscovite, with accessory tourmaline, garnet, apatite, and secondary sericite. The wall zone shows very few muscovite books large enough to yield sheet. Enclosed in it is a core of quartz about 40 feet in diameter and roughly circular or elliptical in plan. Its long axis appears to be nearly vertical. The bottom of the body is a few feet above the bottom of the pit.

The northeast wall of the pit appears to have barely intersected the margin of the core, into which large perthite crystals project. Outside the perthite crystals, a discontinuous intermediate zone of coarse plagioclase, quartz, and book muscovite appears to have been present. (See sketch, pl. 26.) Opposite the crosscut trench, a small concentration of mica books, apparently associated with a small pod of coarse quartz and perthite, was found in the wall of the pit and mined out.

Mica from the pit is a hard ruby muscovite forming books 4 to 12 inches broad and ½ to 6 inches thick. Ruling, reeving, cross-fractures, and "A" structure mar most of the books seen, and ruling is especially conspicuous, but areas lacking these defects yield sheet of high quality. The mica adjacent to the sheer zone shown in the sketch (p. 26) is badly deformed, and part of the ruling may be due to the deformation that caused the shear zone. In part, however, the ruling may be related to an earlier deformation that produced three conspicuous sets of intersecting fractures in the quartz core.

According to Smith and the quarry foreman, sheet mica was found unevenly distributed along the margins of the core, as suggested by exposures, and was abundant in places. As the margin was followed northward from the crosscut the yield decreased. The condition of the mica adjacent to the shear zone discouraged mining along the southeast margin of the core, and the pit was then enlarged southwestward in the hope of finding another quartz body. This attempt was unsuccessful and operations ceased. Curran's later prospecting along the north rim of the pit revealed little mica.

Mica showing in the pit is poor but is probably not representative of the product of the mine, as Smith reports that good mica was obtained away from the shear zone. Possibilities for future production cannot be assessed accurately. The discontinuous quartz-plagioclase-muscovite zone is a deposit of the intermediate-zone type. The margin of the quartz body has not been fully explored, and mica-rich parts of the zone may be concealed. However the operators' experience indicates that, as is common in intermediate-zone deposits, the distribution of mica is spotty, and the average yield of the zone would probably be low.

NO. 6 MINE

The main working at this mine is an opencut 65 feet long, 15 to 30 feet wide, and 10 to 30 feet deep (pl. 1, no. 36; pl. 26). From the southwest end, a short drift with floor at an altitude of approximately 1922 feet has been run. The mine was worked prior to 1940, but most of the work was done by Smith in 1942-43. In the summer of 1944, Curran reopened the mine, enlarged the opencut, and ran the drift southwestward. In July, Colonial Mica Corp. trenched southwest of the quarry in order to define the limits of the pegmatite in this direction. The mine was shut down in September.

The pegmatite was exposed during operations for about 80 feet along the strike. It appears to be a lens, roughly 35 feet thick, that strikes approximately N. 34° E. Its dip is unknown. The northwest wall is steep but irregular. Available data suggest that the body plunges southwestward beneath schist, at an angle less than 35 degrees.

The internal structure of the pegmatite is obscure. A narrow border zone of quartz, plagioclase, and scrap muscovite is present where contacts are exposed. Along the northwest wall underground, a wall zone composed of medium- to coarse-grained quartz, plagioclase, and book mica was present in places inside the border zone. This zone carried accessory tourmaline and apatite, and was ½ to 2 feet thick. The remainder of the pegmatite consists largely of quartz, perthite, muscovite, and plagioclase. Muscovite occurs largely as strips of every size up to 5 feet long, 1 foot broad, and 1 inch thick. This part of the pegmatite is all coarse-grained, but is coarser in some places than in others. The coarser parts consist chiefly of quartz with stout perthite crystals, 6 inches to 2 feet long and appear to be ill-defined pods. Muscovite is associated with them, both as large strips and as scattered books 2 to 10 inches broad and ¼ to 2 inches thick.

Along the northwest side of the drift a pod consisting of quartz with subordinate coarse perthite was traced for 29 feet, appearing to plunge approximately S. 5° W. at an angle of 32°. In a narrow layer around the body (see pl. 26, plan of 1930-foot level) books of muscovite were abundant. A similar pod partly exposed in the floor of the shallow chamber on the southeast side of the cut appears to have yielded most of the sheet mica produced in 1943.

Muscovite occurs in the deposit both as strips and as books, mostly ruled and cross fractured. Many of the strips consist of overlapping scales and are riddled with flat tourmaline inclusions, and some contain intergrown biotite. Parts of the thicker and broader strips, however, yield free-splitting ruby sheet of high quality. The books are reeved, ruled, and cross fractured, but sheet recovery from them during Curran's operations was high. The percentage of large sheet, however, was low. Recovery of crude mica from rock mined in the drift was about 1.4 percent. In the southwest part of the mine the pegmatite is cut by several shear surfaces, and here the mica is broken and stained by limonite.

The structure of this deposit is only partly known, and its potentialities are difficult to assess. The chief sources of mica have been pods of quartz and of quartz and perthite, but some sheet mica has been recovered from strips and scattered books of muscovite elsewhere in the pegmatite. Owing to this, and because the pods seem to be unusually numerous, this pegmatite is more promising than most pod-bearing pegmatites. The content of muscovite in the pegmatite as a whole may be less, however, than the yield of 1.4 percent would indicate, for the ratio applies to a part of the pegmatite that seems richer in book mica than the pegmatite as a whole. The yield of sheet per ton of crude mica would likewise probably be less, owing to the preponderance of strip mica.

Between the No. 5 and No. 6 mines, a shallow cut has been excavated along the contact of one of the other pegmatites. Very little sheet mica was obtained from it.

KILTON MICA MINE

The Kilton mica mine (pl. 1, no. 66) in the town of Grafton, is 1.2 miles N. 51° W. of Grafton Center. To reach it from Grafton Center take the gravel road that leads from U. S. Highway 4 west-northwest up the valley of Manfeltree Brook. Follow this for 1.3 miles, then take an indistinct wood road that turns right just beyond the brook crossing; follow the winding, uphill course of the road for about 2,200 feet to the mine.

Sterrett (1923, p. 143–144) reports that the mine was operated intermittently prior to 1923. The mine has been leased for some years by the Whitehall Co., of New York. In the late 1930's, and again in August-September 1943 and June-August 1944, the mine was subleased and operated by Mr. E. E. Smith, of Canaan. Production was small. The main working prior to 1943 was a crosscut trench leading to a short opencut, from which a small room extended east and an adit about 50 feet long extended N. 20° E. Smith prospected the adit in 1943 and made a series of pits on the hillside about it. In 1944 he sank a shaft on the site of an old pit to connect with the head of the adit, then stoped downward from the adit to the east.

A map and brief description of the mine were prepared by Bannerman in 1943 (p. 16–17). In September 1943, the deposit was mapped and studied by E. N. Cameron, J. Chivers, and V. E. Shainin. The map was revised on July 27, 1944 by Cameron and N. K. Flint (fig. 73).

The mine explores a discordant, elongate body of aplite and alaskite that is cut by irregular stringers and lenses of pegmatite of various sizes, and by quartz veins. The pegmatites are mostly near the contact of aplite with schist. The pits above the working tested the stringers and several of the small bodies. All consisted of coarse quartz, plagioclase, perthite, book and scrap muscovite, and accessory garnet, apatite, and tourmaline. The larger bodies are zoned with quartz or quartz-rich cores flanked by feldspathic zones.

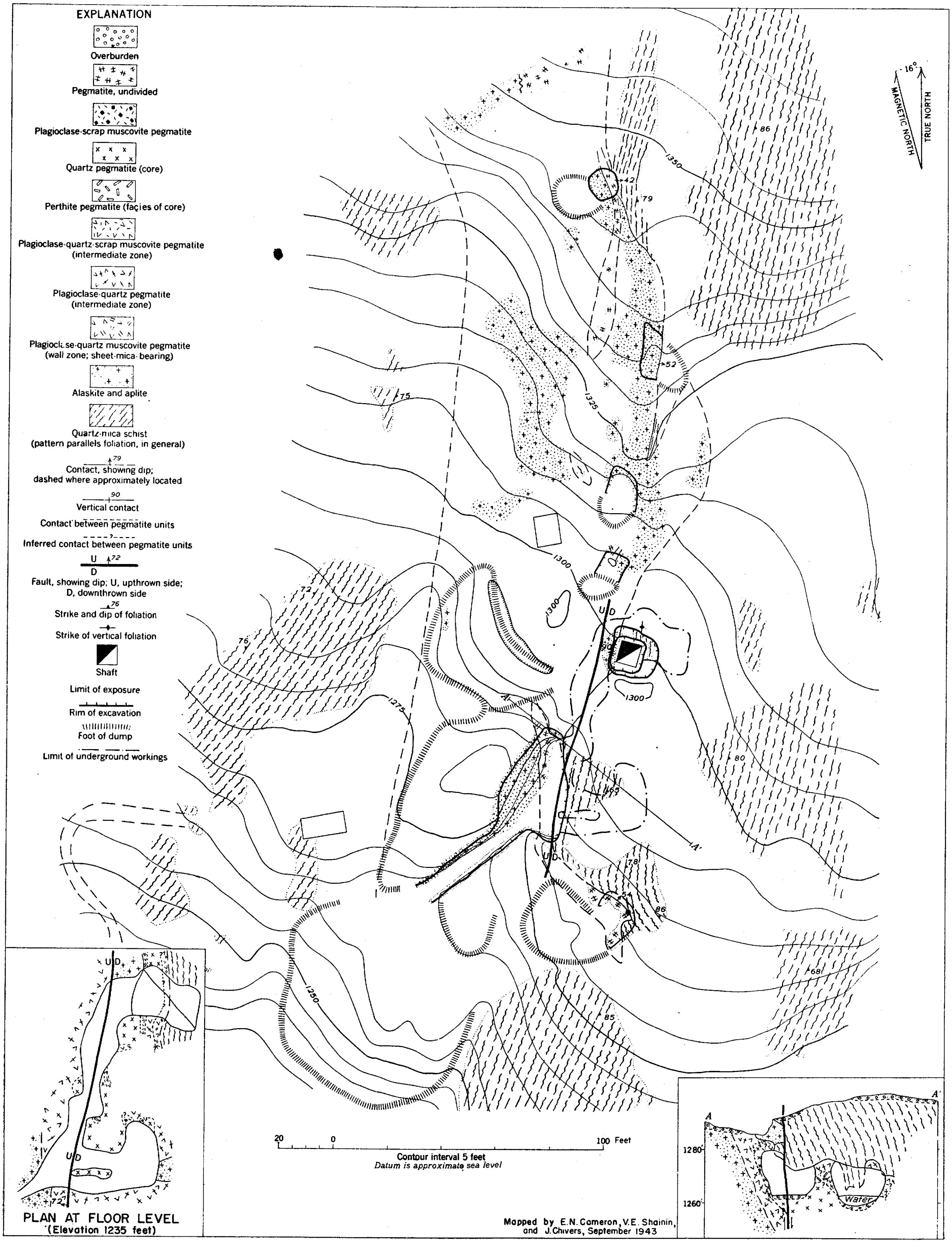


FIGURE 73.—Geologic map, plan, and section of the Kilton mica mine, Grafton, N. H.

The largest pegmatite, exposed in the mine workings, is an irregular body that strikes roughly N. 15° E. The walls in general dip east at moderate to steep angles. The pegmatite expands irregularly downward in the workings. Its upper edge is not exposed but probably plunges gently northward from the opencut. The pegmatite is intruded along the east contact of the aplite with schist, apparently a zone of fracture. Aplite forms the footwall of the body, but the hanging wall is schist in some places, aplite in others. Contacts with both rocks are uneven, and numerous angular xenoliths of aplite are present in the pegmatite. A hinge fault striking N. 12° E. and dipping 72° W. to 85° E. cuts the pegmatite and wall rocks along the line of the adit and opencut. The maximum displacement is about 3 feet.

The body of aplite-alaskite consists of fine- to coarse-granitoid rock composed of quartz, feldspar, and tourmaline with accessory biotite, apatite, and garnet. The schist is quartz-mica schist containing sililmanite in places. The contacts between aplite-alaskite and pegmatite range from sharp to gradational. Partial replacement of aplite by pegmatite is indicated in places in the pits above the main working. In the main working contacts of the two rocks in general are sharp. The schist is markedly tourmalinized adjacent to the pegmatite and in places is enriched in muscovite. Contacts between aplite and schist are sharp and in general discordant.

The main pegmatite is zoned. Adjacent to the walls is a thin, fine-grained, border zone composed of quartz, scrap muscovite, and varying amounts of plagioclase. Inside this, along the hanging wall, is a wall zone 2 inches to 2 feet thick that is made up of medium- to coarse-grained plagioclase, quartz, and muscovite. The zone is thickest and richest in mica along the west side and head of the adit, and in the inclined stope below the shaft. Elsewhere it is commonly lean and thin. Inside the wall zone is an intermediate zone composed essentially of medium- to coarse-grained quartz and plagioclase (cleavelandite in part) in various proportions, with subordinate scrap muscovite, accessory tourmaline, and sparsely scattered beryl crystals. This zone encloses an irregular discontinuous core composed of quartz and stout perthite crystals as much as 5 feet in length. Along parts of the margin of the core in the north end of the drift, a narrow intermediate zone composed of plagioclase, quartz, and scrap muscovite is present.

In the room east of the opencut the pegmatite contains numerous xenoliths of aplite, and some of these are bordered by layers similar to the border zone and wall zone but contain coarse tourmaline, garnet, and scattered golden beryl crystals. The outer margins of the core are concavely scalloped. The material bordering the core is fine-grained cleavelandite in coalesced radial growths. The relation of this material to the core is uncertain. Both perthite and quartz are in sharp contact with the outer surfaces of the cleavelandite scale lops and appear molded around them. Apophyses of the quartz fill fractures cutting the cleavelandite, and the quartz therefore appears to be younger than cleavelandite. The perthite crystals are euhedral against quartz. Some crystals have been converted to pseudomorphs of albite and muscovite, then veined by quartz and partly silicified. These features suggest that the quartz of the core, and possibly the perthite, was formed after cleavelandite, but the evidence is inconclusive. In places along the margins of the core patches of intergrown medium-grained plagioclase and scrap muscovite are exposed.

Mica from the small pegmatites is hard, flat, free-splitting ruby muscovite in books, 1 to 5 inches in diameter and ¼ to 1 inch thick. Cross cracking, reeving, and ruling mar most books, and only a small amount of sheet, all of small sizes, was obtained in 1943. Operations in two of the pits yielded about 0.2 percent and 0.1 percent crude mica, respectively, from rock moved. The yields of the other pits were similar.

Mica from the main workings is pale ruby to greenish muscovite, clear to moderately stained. Ruling, reeving, "A" and herringbone structures, wedging, and films of quartz and plagioclase so mar the books that very little sheet has been obtained. Rock mined from the incline beneath the shaft in 1944 yielded about 2 percent of crude mica.

The wall mica zone, the principal source of book mica in the deposit, is patchy, and the mica is low in sheet content. In addition, exposures indicate that the mica zone is probably not consistent in mica content or thickness over any large area. Some of the crumpling shown by the mica in the north heading is due to slippage along the fault, but the principal defects of the mica appear to have been developed prior to faulting.

Green to golden beryl crystals as much as 2 by 8 inches are scattered through the central parts of the pegmatite and along the margins of some of the aplite xenoliths, but the average beryl content of the pegmatite is very low.

The irregularity of the main pegmatite, the poor quality of the mica, and the patchy distribution of book-mica-bearing parts of the wall zone have been serious drawbacks to mining, and would explain why the mine was worked only briefly during the war period. None of the smaller pegmatites seems promising.

MICA PROSPECT NEAR KILTON MINE

An old mica prospect (pl. 1, no. 67), 365 feet S. 64° W. of the Kilton mine, was unwatered in July 1944 by Colonial Mica Corp. and was examined by E. N. Cameron with N. K. Flint and D. W. Caldwell. The prospect is presumably on land leased by the Whitehall Co., of New York.

The working consists of a crosscut trench leading to a curving adit 40 feet long. The trench and adit reveal a small pegmatite body with uneven walls that trends in general N. 30° E., roughly parallel to sharp rolls of the contact. The bottom of the pegmatite is not exposed. The pegmatite pinches out about 20 feet south-southwest of the entrance to the adit. Outcrops south and southwest of this point show quartz, mica schist, and granitized schist injected by aplite and pegmatite. The schist, where not granitized and injected, is similar to that at the Kilton mine. The adit follows the strike of the pegmatite for about 15 feet, then cuts across it, ending in schist.

The pegmatite is zoned. Adjacent to the walls is a layer of aplite, 2 to 10 inches thick, banded parallel to the contact. Inside this is coarse quartz-plagioclase-muscovite pegmatite with scattered tourmaline crystals. This material veins the aplite along joints, and blocks of aplite are present in it. In the east wall of the adit entrance, a quartz body 2 by 4 feet in cross-section is enclosed in the quartz-plagioclase zone. This body appears to have been spindle-shaped, the long axis plunging about 15° in a N. 35° E. direction, roughly parallel to the rolls and apparent plunge of the pegmatite. Wedged, cracked, and reeved small muscovite books occur in places along the margins of the quartz body.

The deposit is of little economic interest but should yield, with more detailed study, information bearing on the problem of the widespread association of pegmatite and aplite in the Grafton district.

KIMBALL HILL MICA MINE

The Kimball Hill mine (pl. 1, no. 18), sometimes known as the India Mica Co. mine, lies in the town of Dorchester, 5.5 miles N. 40° E. of Canaan Village. From Canaan follow the Dorchester road 7.0 miles to an obscure side road leading eastward. Follow the side road, which is overgrown and poorly graded, 2.5 miles to the mine.

Mineral rights are owned by the Town of Dorchester. Two inclined cuts were opened prior to 1906 by the India Mica Co. of Canaan, N. H. (Sterrett, 1923, p. 135). Workmen at the mine said that the north cut was 100 to 150 feet deep and the south cut 25 to 50 feet deep, but the size of the dumps adjacent to the cuts indicates that they probably are not so deep. In 1943 Alton Stephens of Canaan leased the mining rights and carried out small-scale operations during June and July. The north cut was extended northward, and a small open pit was excavated a short distance south of the south cut. Waste rock from both places was dumped into adjacent flooded parts of the old workings. The property was mapped by G. W. Stewart and R. P. Brundage in June 1943 (fig. 74).

Three pegmatites crop out in the vicinity of the mine, but only the northwestern body has been mined. This pegmatite can be traced for a distance of 300 feet and ranges from 5 to 15 feet wide. It strikes N. 30° E. and dips 60°–75° E. Its north end terminates in a keel that plunges south approximately 40°.

A second pegmatite is partly exposed in a small cut 180 feet southeast of the south cut. Only the footwall contact is visible. It appears to strike N. 20° E. and dip steeply eastward. It is separated from the third pegmatite by 3 to 5 feet of schist. The third pegmatite, roughly parallel to the others, seems to terminate a short distance north of the cut but extends south from the cut for more than 100 feet.

All the pegmatites contain white and gray plagioclase, perthite, quartz, muscovite, garnet, and tourmaline. The pegmatite exposures do not show a sharply defined zonal arrangement. Muscovite appears to be most abundant in the northern pegmatite. A pillar in the upper part of the south cut revealed that the central part of this pegmatite had a wall-zone mica concentration along the hanging wall. Operations in 1943 at the north part of the north cut, in the vicinity of the keel, exposed what appears to be an extension of the same zone. Some of the muscovite at the north and south ends however, occurs as crystals disseminated through the central part of the body. Sterrett (p. 133) reports that the entire thickness of the pegmatite was removed in the underground workings, and this suggests that some commercial mica was obtained from parts of the body other than the hanging wall. The central part appears to be somewhat richer in quartz than the outer parts and a few mica books are associated with the quartz-rich areas. Definite core and core-margin zones, however, cannot be traced.

Muscovite obtained from the deposit was light rum, of good quality, and relatively free from staining or structural defects. Most of the books, however, were small.

The tops of the cuts are 22 feet above Bryant Pond, which lies a short distance east of the mine. Underground drainage from the pond, together with an intermittent stream draining the area northwest of the mine, maintains a relatively high water level in the cuts, but the stream could be diverted by a short aqueduct across the southern end of the opencut. It is reported

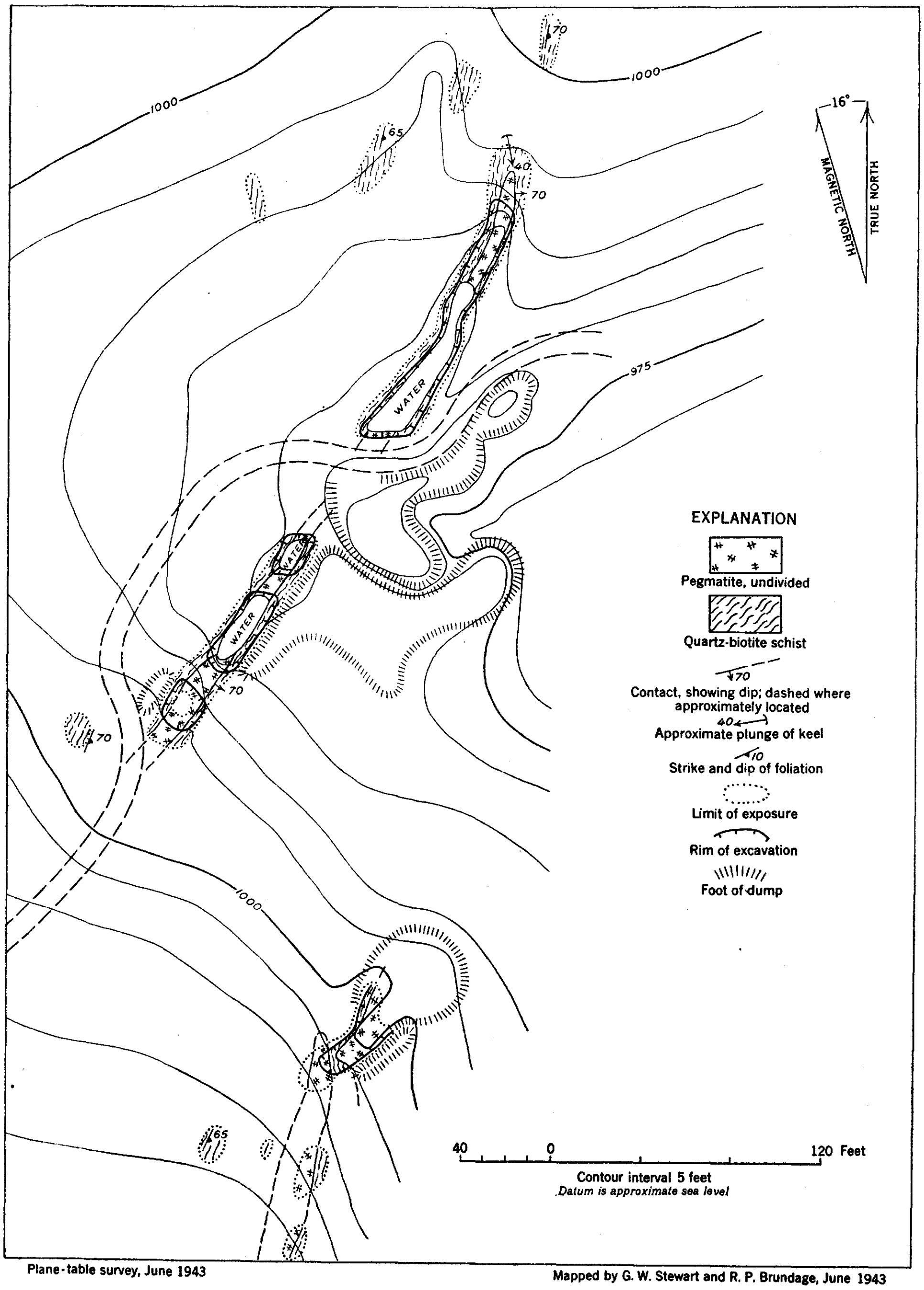


FIGURE 74.—Geologic map of the Kimball Hill mica mine, Dorchester, N. H.

that the early operations ceased when pumping became a serious problem.

The potential productivity of the mine cannot be determined because the richest parts of the pegmatite probably were removed by past mining operations, and the old workings contain considerable backfill and are flooded. The pegmatite south of the southern cut contains little book muscovite. Exposed parts of the other two pegmatites contain little muscovite.

LEGGETT MICA PROSPECT

The Leggett prospect (pl. 1, no. 9) is in the town of Rumney 0.9 mile N. 52° W. of the village of West Rumney. To reach it from West Rumney follow State Highway 25 northwest 0.8 mile to a gravel road on the right; follow the gravel road 0.1 mile to a lane on the left; proceed along the lane for 0.1 mile north to the prospect. Property and mineral rights are owned by Percy Leggett of Gorham, N. H. Two cuts

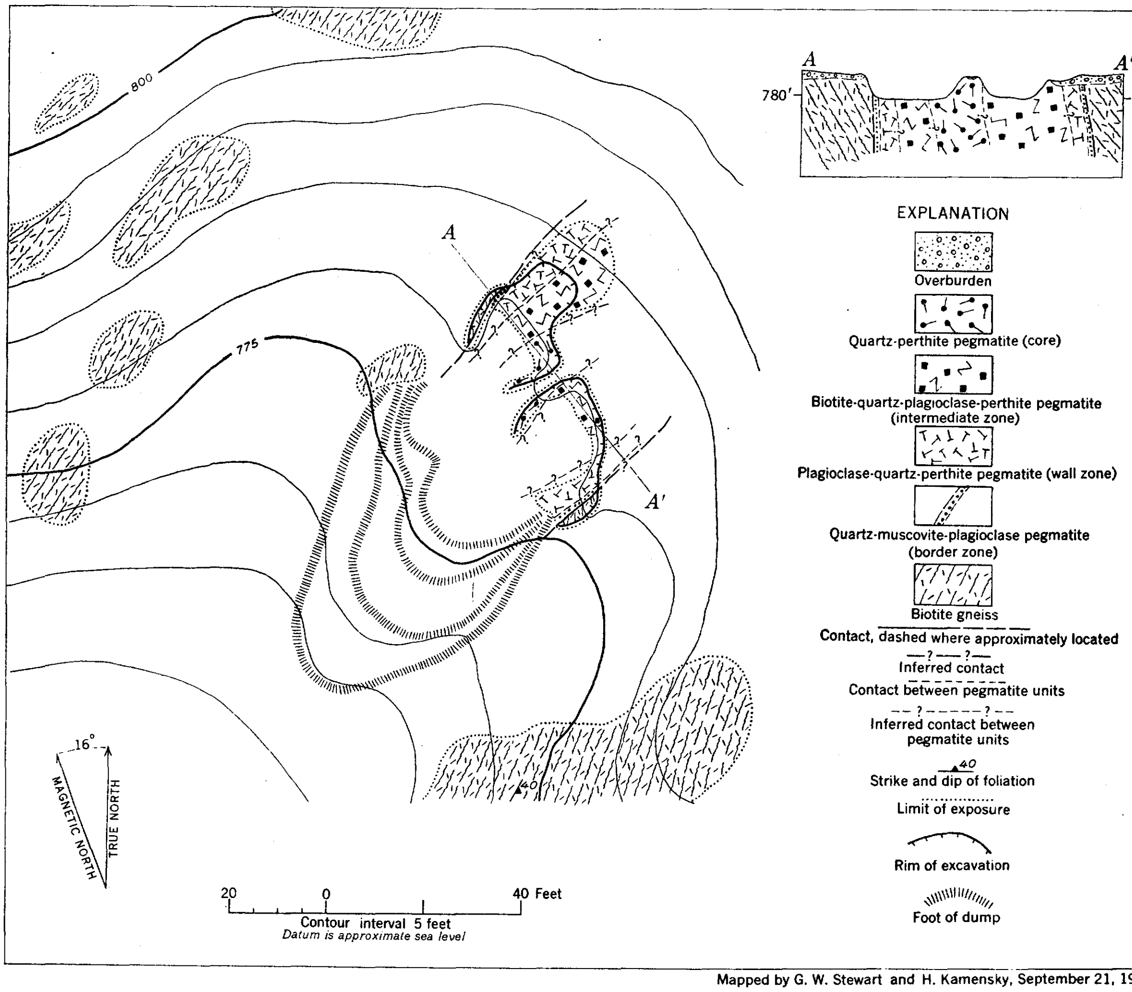


FIGURE 75.—Geologic map and section of the Leggett mica prospect, Rumney, N. H.

were excavated during August and September 1943. The northwest cut is 25 feet long, 12 to 20 feet wide, and 5 to 8 feet deep. The southeast cut is 15 feet long, 25 feet wide, and 5 to 12 feet deep. Both cuts are partly backfilled. About 500 tons of rock was moved and yielded 0.2 percent mine-run mica. The deposit was mapped by Glenn W. Stewart and Harry Kamensky in September 1943 (fig. 75) and further studied by E. N. Cameron in October 1943.

The pegmatite is exposed for 50 feet along strike and has a maximum width of 45 feet. It strikes about N. 50° E. and cuts across the strike and dip of the wallrock foliation. Slickensides and thin gouge along both contacts suggest that slight movement occurred after solidification of the pegmatite. The wallrock, Bethlehem gneiss, strikes N. 20°–40° E. and dips 40° SE.

The essential minerals in the pegmatite are albite-oligoclase (An_{10-12}), quartz, perthite, biotite, and muscovite. Accessory minerals are black tourmaline and small, scattered beryl crystals. The pegmatite has four zones. The border zone, 3 to 4 inches thick, is fine grained and is composed of quartz, muscovite, and subordinate plagioclase. The plagioclase-quartz-perthite wall zone, 4 to 5 feet thick, is medium-grained and is composed of albite-oligoclase (An_{10-12}), quartz, and perthite. Small, sparsely scattered muscovite books are present. The biotite-quartz-plagioclase-perthite intermediate zone has a medium- to coarse-texture, is 7 to 8 feet thick on the north-west side of the core, and is 15 to 16 feet thick on the southeast side. It is composed of plagioclase, quartz, and perthite with conspicuous lath-shaped books of biotite, some of which are 12 to 20 inches long and 1 to 2 inches wide. The quartz-perthite core, 10 to 12 feet thick, which lies between the two cuts, is composed of coarse quartz and perthite with subordinate plagioclase. Many subhedral crystals of perthite, 1 by 3 feet to 2 by 5 feet occur in this zone.

Very small quantities of sheet muscovite occur in the plagioclase-quartz-perthite wall zone. The mica is ruby, hard, flat, and free from mineral or organic stains. The muscovite books average about 2 by 2 inches. The extremely low muscovite content and small size of the books prevented profitable operation in 1943.

MARSTON MICA MINE

The Marston mine (pl. 1, no. 47) is in the town of Alexandria 3.9 miles N. 35° W. of Alexandria village. To reach it from Alexandria follow a hard-surfaced road 1.0 mile to an intersection; turn left and follow a hard-surfaced road 0.9 mile; continue on a graded gravel road for 2.3 miles to a fork; turn right and follow the road 0.1 mile to a farm lane on the right; follow the farm lane 0.2 mile to Welton Falls Trail; proceed about 0.5 mile northward along trail; turn southeast and follow a mine road for 0.1 mile to the mine.

The property is owned by A. Marston, Bristol, N. H. The mine was first operated by Frank Tucker of the Bristol Construction Company, probably during the summer of 1940, when several cuts were made in three pegmatites. Cut A in pegmatite no. 1 (fig. 76) is about 90 feet long, 12 to 22 feet wide, and 5 to 15 feet deep. The deepest part is a small inclined stope down the dip of the pegmatite. Cut C in pegmatite no. 2 is 15 feet long, 10 feet wide, and 5 feet deep. Cut D is 10 to 15 feet long, 10 feet wide, and 5 feet deep. Cut E in pegmatite no. 3 is 11 feet long, 7 feet wide, and 2 to 3 feet deep. Cut F is 28 feet long, 16 feet wide, and 5 to 10 feet deep. In July 1943 the mineral rights were leased by William Lislie of Melrose Highlands, Mass. Cut B, 15 feet long, 10 to 17 feet wide, and 5 to 10 feet deep was excavated southeastward into the hillside along the strike of pegmatite no. 1. From September to December 1943 the mineral rights were leased by the Hill Mining Co. of Bristol. The inclined stope in cut A was drained, partly cleaned, and then deepened by underhand stoping to about 40 feet (measured along the dip). Cut B was extended southward approximately 15 feet. The pegmatite seemed to be lensing out at the southeast end of the cut. The mine was mapped by Glenn W. Stewart and Harry Kamensky in August 1943. Subsequent visits were made in 1943 by E. N. Cameron.

Pegmatite no. 1 is exposed for 135 feet along strike. It is 5 to 10 feet thick near its southern end in cut A and is 3 to 5 feet thick in cut B. It strikes approximately N. 40° W. and dips 40°–50° NE. Pegmatite no. 2 has a strike-length of 35 feet, is 8 to 10 feet thick, strikes approximately N. 65° W. and dips 35°–45° NE. Near its western end it is nearly vertical. Pegmatite no. 3 is exposed for 168 feet along strike and is 9 to 22 feet thick. It strikes about N. 40° W. and dips 40°–50° NE. The three pegmatites are in echelon, cut across the foliation of the wallrock, and apparently were injected along shear planes. In places along the contacts there is a conspicuous drag in the foliation of the gneiss. In cut B, a small aplite dike, 3 inches thick, striking N. 65° E. and dipping 45° southeast, is cut by the pegmatite. The two segments of the dike seem to be offset 5 to 7 feet parallel to the strike of the pegmatite.

The wallrock, Kinsman quartz monzonite, has a well-developed foliation which strikes in general N. 25° E. and dips 40°–65° SE. The strike ranges, however, from north to N. 35° E. Several small xenoliths of highly feldspathized schist occur several feet south of pegmatite no. 3.

The essential minerals of pegmatites no. 2 and no. 3 are perthite, quartz, plagioclase, muscovite, and biotite. Accessory minerals are tourmaline and garnet. Each of these pegmatites shows a narrow chilled border zone and a core, but is otherwise unzoned.

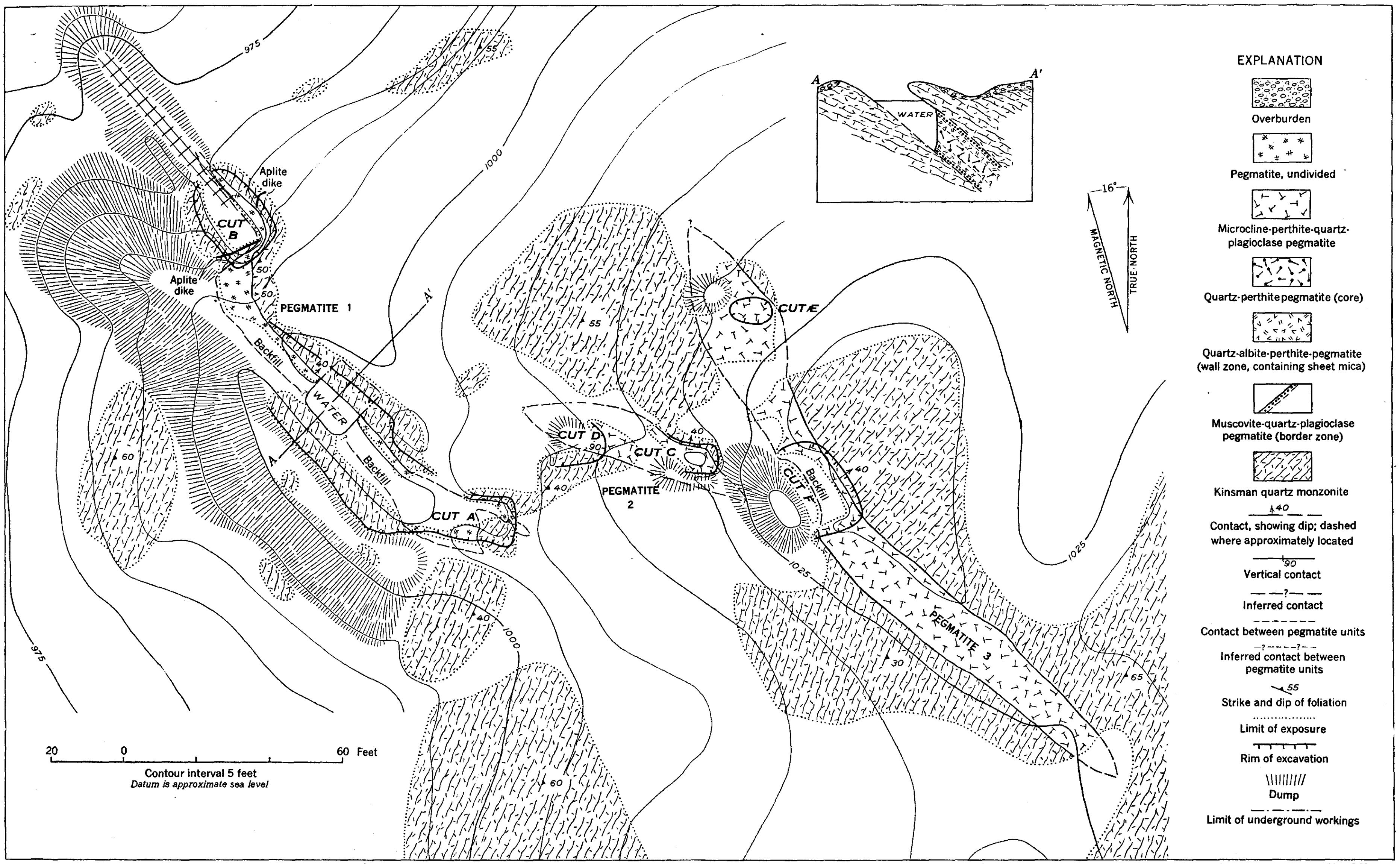
Pegmatite no. 1 is composed of perthite, quartz, albite (An_6), and muscovite. Accessory minerals are tourmaline, garnet, and beryl. The pegmatite shows the following zones: border zone of muscovite-quartz-plagioclase pegmatite, quartz-albite-perthite wall zone, and a quartz-perthite core. The border zone, 4 to 6 inches thick, consists of fine-grained quartz, muscovite, and subordinate plagioclase. The medium-grained quartz-albite-perthite wall zone is 2 to 3 feet thick. The footwall part of the zone pinches and swells and is discontinuous. The core, 3 to 4 feet thick, is composed largely of medium to coarse-grained quartz and perthite with small quantities of albite. The zonal boundaries of the core are obscure at the northwestern and southeastern ends where the pegmatite lenses out.

Most of the muscovite is in the hanging-wall part of the wall zone, which was richest in a broad roll near the southeastern end of cut A. The roll plunges approximately parallel to the dip of the pegmatite. Book muscovite is disseminated sparsely in the core and scattered small books occur in the footwall part of the wall zone. The muscovite books average 3 by 3 inches and are hard, flat, and slightly ruled. Most of the muscovite in pegmatites no. 2 and no. 3 is intergrown with biotite, and occurs as lath-shaped books in cleavage planes of perthite and between perthite crystals.

Pegmatite no. 1, by far the most promising of the three, was mined both along strike and down dip to points where the muscovite content so decreased that operations reportedly became unprofitable.

McGINNIS MICA MINE

The McGinnis, also known as the Wicher and Pilsbury mine (pl. 1, no. 6), is in the town of Wentworth, 3.0 miles N. 72° W. of West Rumney. To reach it from West Rumney follow State Highway 25 northwestward 1.25 miles to an intersection; take the left fork 1.4 miles to the second right fork; proceed on the



Mapped by G. W. Stewart and H. Kamensky, August 14-15, 1943

FIGURE 76.—Geologic map and section of the Marston mica mine, Alexandria, N. H.

right fork, crossing the South Branch of Baker River, 0.65 mile to a woods road on the right. Follow the woods road 0.25 mile to the mine.

The mine is on land owned by Mrs. Verna McGinnis and land owned by Mrs. Grace Rodiman, both of West Rumney. It is leased and operated by H. A. Ashley of Dorchester, N. H. Two small prospect pits were made by the Colonial Mica Corp. and the White Mountain Mica Mining Co. of Campton, N. H., in 1943. Ashley began operations in May 1944 and continued work through March 1945, when the 2 prospects were incorporated into an opencut 100 feet long, 8 to 25 feet wide, and 40 to 50 feet deep. A rock partition 20 feet high was left in the cut 30 feet from the northeast rim. A short drift 10 feet long was started along the footwall in March 1945 from floor level at the northeast end of the cut. The mine was studied in 1943 by D. M. Larrabee, by A. H. McNair and A. H. Chidester in July 1944, and by McNair and G. W. Stewart in March 1945 (fig. 77).

The McGinnis pegmatite is exposed for 100 feet along strike. It is 4 feet thick at the southwest end of the cut. It widens gradually to 18 feet toward the northeast and extends beneath overburden northeast of the cut. The foliation of the wall rock, the Bethlehem gneiss, strikes N. 50° E. and dips 42° to 50° SE. The gneiss is covered in most places by glacial till. The pegmatite contains quartz, oligoclase, perthite, muscovite, accessory beryl, black tourmaline, and red garnet. A well-developed zonal structure can be recognized.

The border zone, generally less than 1 inch thick, contains fine-grained (0.08 to 0.2 inch) quartz, oligoclase (An_{20}), muscovite, and black tourmaline. It is in sharp contact with the wall rock. A quartz-muscovite wall zone, 2 to 8 inches thick, lies inside the border zone. It consists of numerous 1½ by 2 by ½ inch muscovite crystals arranged normal to the contact and surrounded by gray quartz. The edges of the muscovite books are irregular. Many are fluted and have quartz extending into them. The quartz-muscovite zone is best developed along the hanging wall. It is less conspicuous along the footwall where it grades into the sheet-bearing mica zone and is not shown separately on the map. On figure 77 it is shown only where the sheet-mica zone is absent, and its thickness is exaggerated.

The outer intermediate zone, 4 inches to 3 feet thick, contains quartz, oligoclase (An_{14}), and sheet-bearing muscovite. It is thickest and richest along the footwall, and is present locally along the hanging wall. The mica content of the zone is varied, and in some places, even in the footwall part of the zone, is almost nil.

The quartz-oligoclase-perthite middle intermediate zone is 2 to 8 feet thick and contains small amounts of pink garnet, and both scrap and sheet muscovite.

The core consists of discontinuous quartz segments enclosed by the quartz-oligoclase-perthite zone. The largest segment is at least 65 feet long, 1.5 to 6 feet thick, and plunges northeastward 35°–50°. A core-margin zone 6 to 12 inches thick along the top and outer margins of the core contains numerous straw-yellow to aquamarine beryl crystals. The crystals are completely enclosed by quartz and are arranged, in general, with their long axes normal to the outer contact of the core. They range from ¼ by 1 to 3 by 12 inches. Most have 18 prism faces and apparently shown combinations of prisms and dihexagonal prisms. Many crystals have basal pinacoids and most have color-banding roughly parallel to the pinacoids. Most are fractured.

The muscovite is rum to ruby, and hard; most books are small and marred by rules and reeves. The books are free-splitting and a satisfactory percentage of sheet was obtained from them in 1944. At least 2.3 percent mine-run mica was recovered from the rock moved in 1944–45.

Possible future sheet-mica production depends on the extent of the intermediate mica-bearing zones and on the extent of the pegmatite down dip and northeastward. The eastern end of the McGinnis pegmatite is not exposed, but the pegmatite appears to increase in thickness northeastward and presumably extends some distance in that direction. The sheet muscovite-bearing zone parallel to the footwall was lean and varied in muscovite content throughout the opencut. The mica content is lowest in the floor of the northeast part of the opencut. The hanging-wall part of the zone is indistinct. Mica is not concentrated near the margins of the segments of the quartz core although a few scattered books of muscovite occur in the quartz-plagioclase-perthite zone.

The core-margin zone contains numerous beryl crystals. Because the crystals are well developed and have an unusual combination of prism faces they probably are of more value as laboratory and museum specimens than as a source of beryllium. The average content of beryl and the total tonnage present in the pegmatite are small.

MONARCH MICA MINE

The Monarch mica mine (pl. 1, no. 49) is in the town of Alexandria, 3.1 miles N. 40° W. of Alexandria village. From Alexandria follow a hard-surfaced road for 1.0 mile to an intersection; turn left and continue on a hard-surfaced road for 0.9 mile; continue on gravel

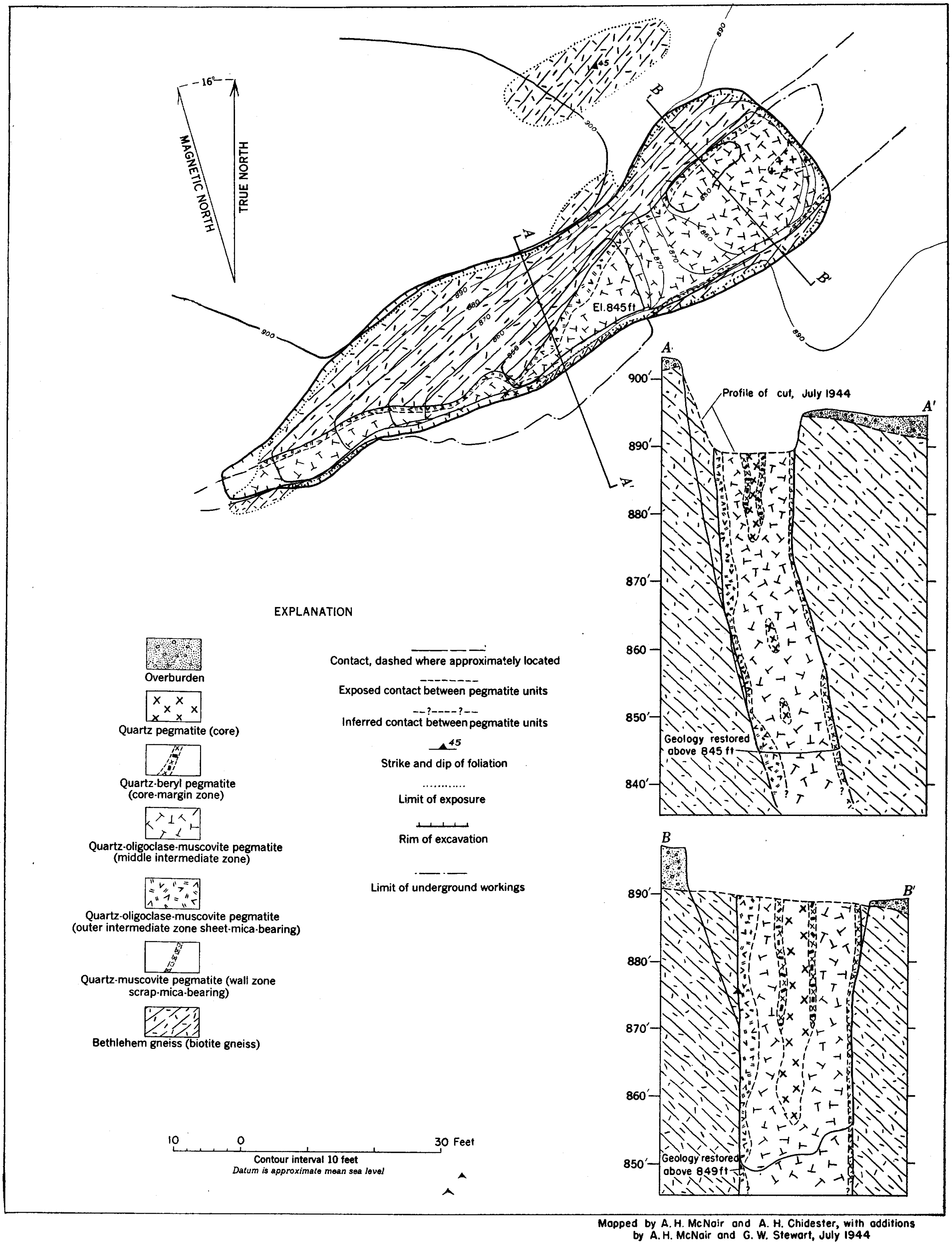


FIGURE 77.—Geologic map and sections of the McGinnis mica mine, Wentworth, N. H.

road for 2.1 miles to the mine, 80 feet east of the bridge across the Fowler River. Mr. Perley Healey of Alexandria (R. F. D. 1, Bristol) is owner of the property and Russell T. Bates, 57 Granite Street, Quincy, Mass., is the owner of the mining rights.

The mine has not been operated since 1920. The workings are all underground. Sterrett's (1923, p. 150) description of them differs only slightly from that given by the one-time foreman, Peter Bliss of Bristol, N. H. According to Mr. Bliss the shaft slopes 43° eastward and follows the pegmatite 150 feet down dip. The dike strikes about north and is estimated to have an average thickness of 12 feet. Drifts at 2 levels extend northward along the strike of the pegmatite; 1 is about 50 feet long, the other 100 feet. The workings are flooded and the shaft is partly filled with debris. The surface geology was mapped by Glenn W. Stewart and Harry Kamensky in August 1943.

The pegmatite is not exposed but material in the dump suggests that it is rich in quartz and albite (An_4) and contains small amounts of perthite. The Kinsman quartz monzonite, which forms the wall rock, is exposed on the east face of the shaft, to the northeast, and in the Fowler River to the west and south. Its foliation has an average strike of N. 25° E. and an average dip of 35° SE.

Several small muscovite books, 2 by 2 inches, found in the dump were fresh, hard, and nearly free from mineral stains, inclusions or structural defects, but otherwise the quality, quantity, and occurrence of the muscovite are unknown.

MORGAN MICA PROSPECT

The Morgan prospect (pl. 1, no. 46) lies in the town of Alexandria, 4.4 miles N. 31° W. of Alexandria village. To reach it from Alexandria follow a hard-surfaced road 1.0 mile to an intersection; turn left and follow a hard-surfaced road 0.9 mile; continue on a gravel road 2.3 miles to a fork; follow the right fork 0.1 mile to a farm lane on the right; follow the farm lane 0.2 mile to Welton Falls Trail; proceed northward along the trail about 1.2 miles, turn right a short distance beyond an old shack on the left and walk 100 feet to the prospect. The property is owned by W. W. Morgan of Alexandria, N. H. The mineral rights are leased by William Lislie, Melrose Highlands, Mass.

A cut 20 feet long, 5 feet wide, and 3 to 4 feet deep was excavated along the strike of the pegmatite in August 1943. The prospect was mapped by chain and compass in August 1943 by Glenn W. Stewart and Harry Kamensky (fig. 78).

The pegmatite, a tabular body exposed along strike for 80 feet, is 2 to 4 feet wide, strikes about N. 10° W., and dips 65°–70° NE. The contacts are sharp and the pegmatite cuts across the foliation of the wall rock, the Kinsman quartz monzonite gneiss, which strikes N. 15°–20° E. and dips 70° southeast. A small aplitic dike lies about 15 feet south of the pegmatite. It is exposed for only 10 feet along strike. It has an average thickness of 1 foot, and strikes N. 50° E.

The pegmatite has a border zone 1 to 3 inches thick, which consists of fine-grained quartz and muscovite. The wall zone is medium- to coarse-grained perthite, quartz, plagioclase, muscovite, biotite, and secondary chlorite. A lenticular quartz pod, 1 foot wide and 6 feet long, exposed in the cut, may be the core of the pegmatite.

Large books of muscovite are found along the margin of the quartz pod, but small books are disseminated through the pegmatite. Several of the larger books are embedded in quartz. Most of the books are light to medium rum, average 3 inches in diameter and are heavily stained. Many books are intergrown with chloritized biotite, and most of them are cracked, ruled, and have herringbone structure.

The poor quality of the muscovite and the small size of the pegmatite discouraged operation in 1943.

MUD MICA MINE

The Mud (Alexandria) mine (pl. 1, no. 55) is in the town of Alexandria, 2.2 miles S. 81° W. of Alexandria village. To reach it from Alexandria, follow a hard-surfaced road 0.25 mile northwest to a fork; drive 0.9 mile along the left fork to Tenný School, and then westward on a graded gravel road 1.5 miles to a left fork. Follow the left fork, passable by truck in the summer, 0.3 mile southeast to the mine. The property is owned by the General Electric Co., Schenectady, N. Y. The mine was visited in 1913 by Sterrett (1914, p. 85–86) and in 1940 by Olson (1942, p. 384). The mine was mapped in December 1942 and June 1943 by D. M. Larrabee, J. B. Headley, Jr., and H. R. Morris (pl. 27).

The mine was opened for mica in 1883 by George D. Patten, Alexandria, but was purchased in the early 1900's by the General Electric Co., which continued the operation until 1910. It was idle until 1916, when the owners reopened and operated it continuously until 1931. During this time, it yielded 2,015 tons of mine-run mica (Olson, 1942, p. 384) and was one of the major mica-producing mines in New Hampshire. Mining was first done by open pit methods, and later by a system of shafts and drifts. Later, the pillars were removed, the underground workings caved, and operation ceased. The mine has been flooded since 1931. According to W. H. Patten and R. P. Sargent, Bristol, N. H., respectively mine superintendent and pit boss during the most recent operation, the mine was worked for a dis-

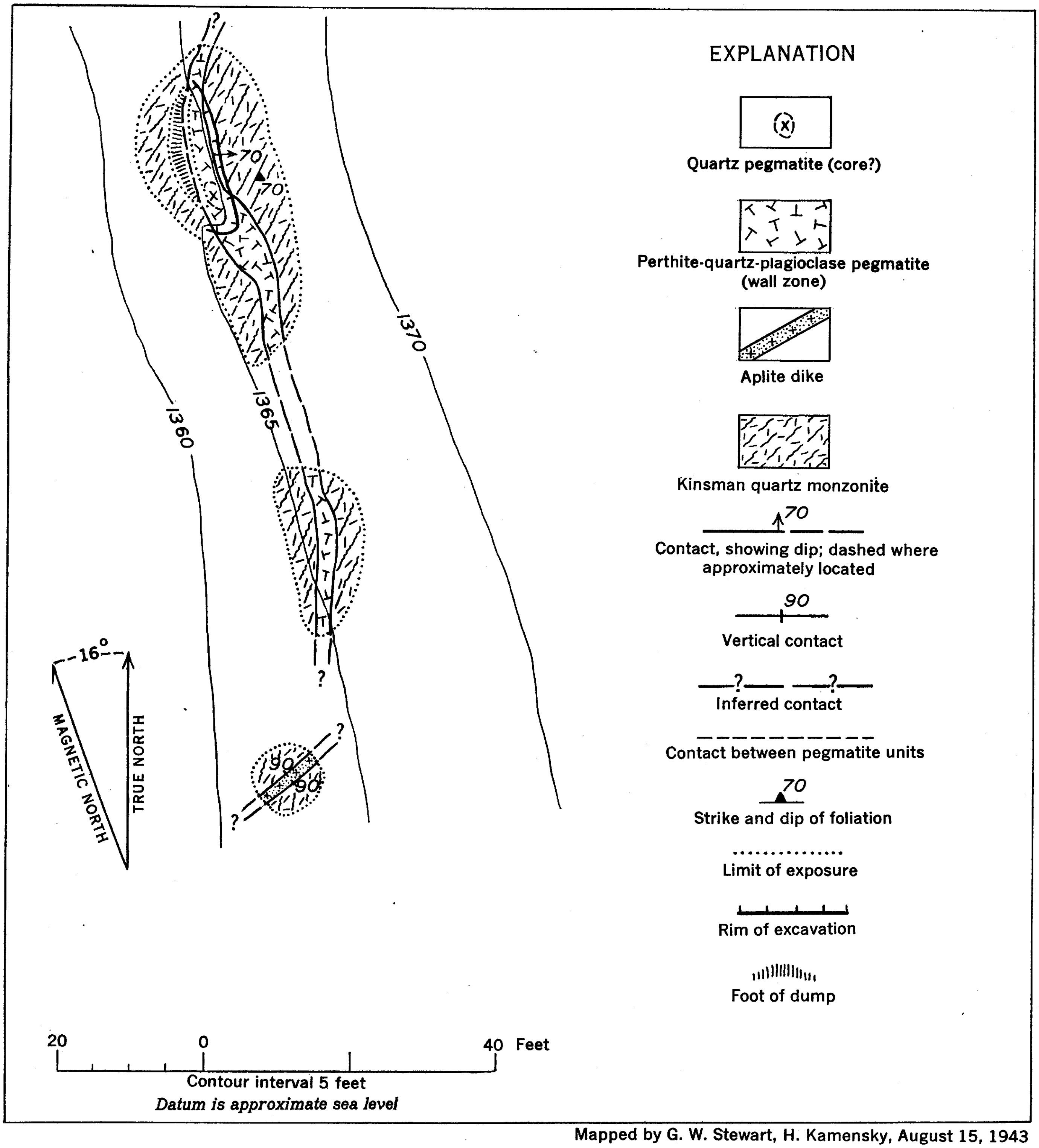


FIGURE 78.—Geologic map of the Morgan mica prospect, Alexandria, N. H.

tance of 760 feet along strike and to a depth of about 170 feet below the collar of the main shaft. Mica-bearing rock was stoped between levels and many of the pillars were removed before the mine was abandoned in 1931. A 50-foot crosscut is reported to have been driven from the hanging wall to the footwall sometime between 1917 and 1931, but no rich mica concentration was found near the footwall. The approximate location and extent of underground workings are indicated on the longitudinal section (pl. 27). A trench 50 feet long crosses the pegmatite 60 feet south of the opencut and corroborates reports of the width of the body.

The pegmatite was prospected during 1942–43 by E. E. Braley, Alexandria, who made a small opencut 200 feet southwest of the main shaft. This cut encountered pegmatite below 12 feet of overburden and appears to be near the hanging wall. Mica was recovered from the old dump and from pillars during small-scale operations in 1942–43.

The wall rock, Kinsman quartz monzonite, is a porphyritic biotite gneiss, the foliation of which strikes about N. 25° E. and dips 40°–50° SE. It has been heavily tourmalinized at the contacts. The pegmatite is exposed only in the prospect pit and along the margins of the opencut. The underground workings indicate that the pegmatite has a length of at least 750 feet and a width of 50 feet; it strikes N. 40° E. and dips 45° NW.

Present exposures indicate that the pegmatite contains a narrow aplitic border zone of plagioclase, quartz, and muscovite. Inside this is a wall zone 1 to 3 feet thick of quartz, plagioclase, perthite, muscovite, biotite, apatite, tourmaline, garnet, and small quantities of beryl. This zone is generally barren of sheet-bearing muscovite and is sheared, altered, and stained. An intermediate zone of quartz, plagioclase, and muscovite, 3–6 feet thick, lies adjacent to the wall zone, and below the hanging wall contains a mica shoot that seems to plunge southwest at about 30°. A block containing a small amount of mica between the north and south underground workings suggests that the mica shoot forks downward.

The innermost zone observed consists of quartz, plagioclase, perthite, and accessory apatite and beryl; its thickness is unknown. The footwall parts of the zones were not observed because the underground workings were inaccessible and outcrops are lacking.

The mica obtained in 1942–43 was from the pillars in the intermediate zone and the mica recovered was 12 percent of the rock mined. The mica is ruby, hard, somewhat ruled and reeved. "A" structure is common and some books have inclusions of tourmaline, garnet, and quartz. Inclusions of magnetite and secondary iron stains are most common along reeves. Most of the mica books are of good size and yielded a satisfactory percentage of sheet during 1942–43. The rich mica shoot below the hanging wall is probably mined out to a depth of 170 feet, and the only possible mica reserves above that level are in the unexplored footwall part of the intermediate zone. Braley recovered some high-quality mica from his prospect pit in the southwestern part of the pegmatite, before the pit caved, and further exploration might find another shoot roughly parallel to the one that has been mined in the underground workings.

NANCY MICA MINES

The Nancy mines are in the town of Groton, approximately 0.5 mile N. 20° W. of the village of North Groton. To reach them from North Groton, follow a graded gravel road northeast 0.2 mile, passing a church, to a mine-access road on the left; turn left and proceed northwest 0.5 mile to the mines.

The mines (figs. 79, 80) are owned by Kenneth L. Jones, Franklin, N. H., and were leased and operated by the Strafford Mining Co., Bristol, N. H. Two mines are located on the property. The Nancy No. 1 mine was operated between July 1943 and June 1944. The working is an irregular open pit about 70 feet long, 25 to 35 feet wide, and 3 to 4 feet deep. About 1,800 tons of rock were moved.

The Nancy No. 2 mine, about 300 feet northwest of the Nancy No. 1, was operated from September 1943 to May 1945. The mine consists of two workings. Pit A, 60 to 65 feet long, 10 to 20 feet wide, and 5 to 35 feet deep, was first worked as an open pit. In September 1944 a vertical shaft, 10 by 10 feet, and about 30 feet deep was sunk in the deepest part of the open pit. The upper half of the shaft was timbered and waste rock was used to fill the open pit around the upper 5 feet of timbers. From the bottom of the shaft a drift, 6 by 6 feet, was extended eastward for 25 to 30 feet along the strike of the pegmatite. This drift was enlarged and extended upward by overhand stoping. A second working level was opened about 12 feet above the bottom of the shaft and a raise was carried upward to the upper level. During March and April 1945 the stope was extended 10 to 15 feet eastward at both levels beyond the limit of underground working shown on figure 80. About 950 tons of rock were moved in 1943–44. It is estimated that the mine-run mica recovered was about 5 percent of the total rock mined. Pit B is an open pit 35 feet long, 10 to 15 feet wide, and 15 to 20 feet deep. It was worked between August and December 1944, when about 400 tons of rock were moved. Both workings are flooded and partly backfilled.

The Nancy No. 1 mine was mapped in August 1943 by Glenn W. Stewart and Harry Kamensky. In October 1943 and June 1944 it was remapped by Stewart

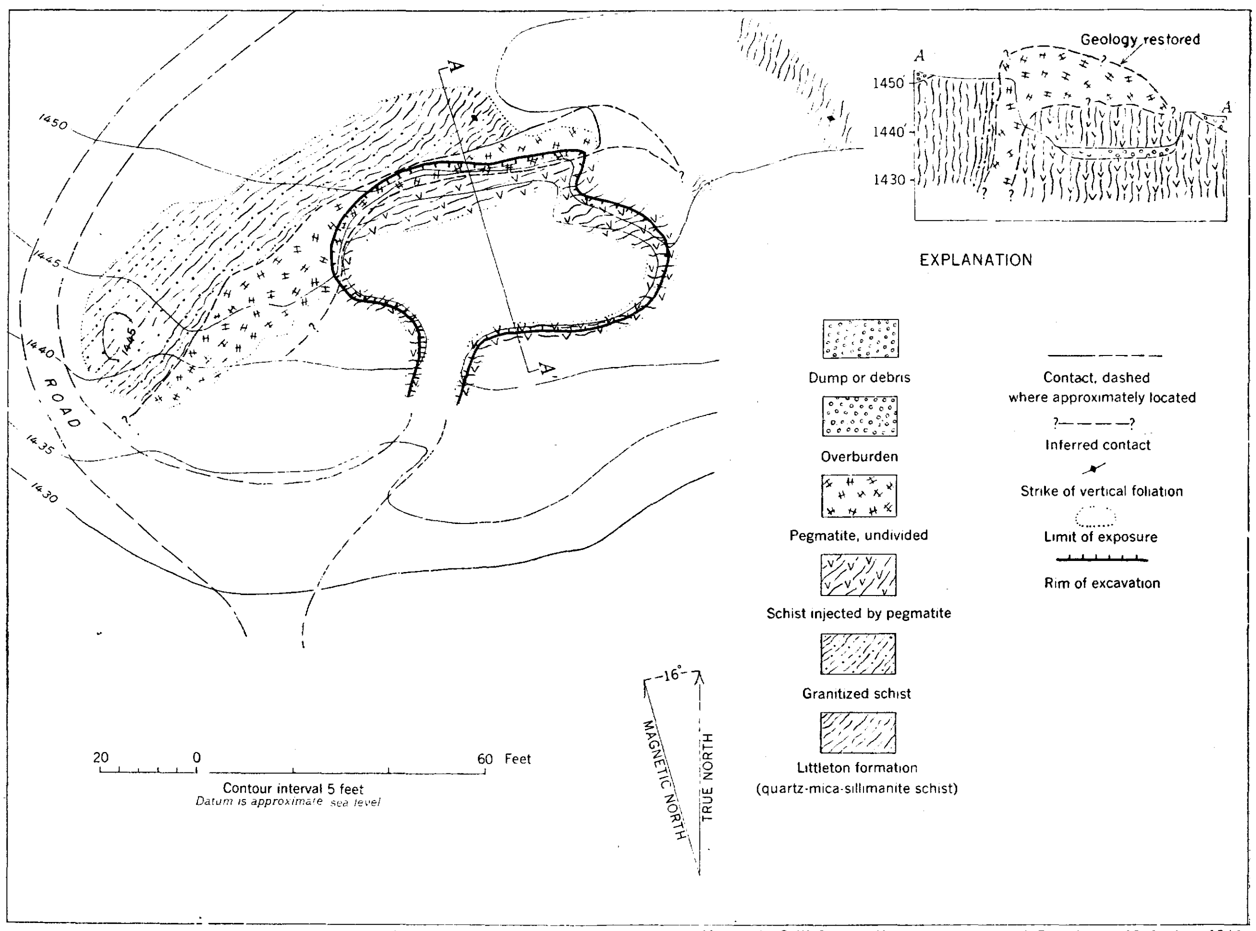


FIGURE 79.—Geologic map and section of the Nancy No. 1 mica mine, Groton, N. H.

and Norman K. Flint and maps were also made of the No. 2 mine. Progress maps of the Nancy No. 2 were made by Stewart from April 1944 to April 1945.

NANCY NO. 1 MINE

The pegmatites and the occurrence of sheet-bearing muscovite crystals at the Nancy No. 1 (pl. 1, no. 22) mine are very unusual. When the mine was opened, a pegmatite rich in biotite covered most of the present workings. It seemed to be dipping steeply northwest, but as the open pit was deepened and enlarged northward, the pegmatite was found to be a capping above wall rock, and it thickened northward until it was exposed as a tabular body, 5 to 10 feet thick, along the north face of the pit (see map and section on fig. 79). This part has been removed, and most of the part remaining strikes N. 75° E., dips steeply northwest and is discordant to the wall rock foliation. It has been exposed, however, by stripping to a point about 50 feet southwest of the working, where it is 5 to 15 feet wide and may cap the wall rock in places. The pegmatite is composed of fine- to medium-grained quartz, albite (An_{5-7}), abundant scrap muscovite, and biotite, and accessory tourmaline and garnet.

Pegmatite bodies of various shapes and sizes are exposed in the wall rock that lies beneath the pegmatite capping. Lenticular bodies as much as 5 feet long and 2 feet thick and tabular bodies as much as 6 feet long and 1 foot thick are most common, but there are a few spherical bodies. Some of the lenticular and tabular bodies are zoned. Some have a border zone, 1 to 2 inches thick, composed of fine-grained quartz and muscovite with small amounts of plagioclase, garnet and tourmaline. Inside the border zone the rock is composed of medium-grained albite (An_{5-7}), quartz, sheet-bearing muscovite crystals, and accessory tourmaline, garnet, and biotite. The muscovite crystals commonly are scattered through the pegmatite bodies, but in some the muscovite crystals are more abundant near the walls. The spherical pegmatites are as much as 1½ feet across. They resemble the tabular and lenticular pegmatites in texture and composition, but in one mass most of the muscovite crystals were along the margin. Most were in random orientation, but there were

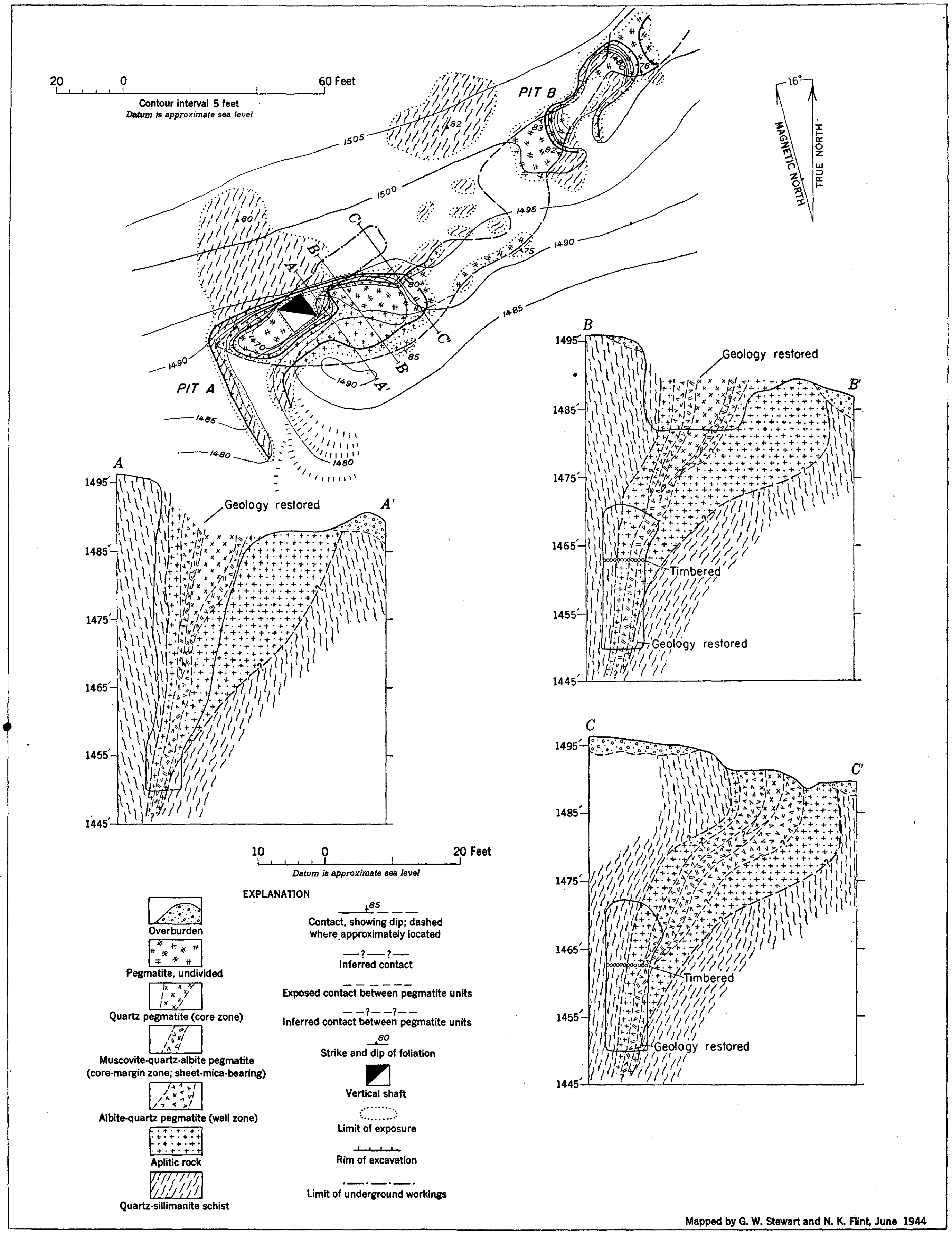


FIGURE 80.—Geologic map and sections of the Nancy No. 2 mica mine, Groton, N. H.

several with cleavage parallel to the contact. Several quartz lenses, 2 to 3 feet long and 6 to 8 inches thick, contain muscovite crystals as much as 1½ inches across.

The wall rock is quartz-mica-sillimanite schist of the Littleton formation in which most of the sillimanite has been altered to sericite. The schist is interbedded with layers of quartzite as much as 2 inches thick in places. The foliation strikes N. 20°–40° E. and has a vertical dip. All the schist exposed in the open pit, and some north and west of it, has been partly or wholly replaced by pegmatitic material in such a way that the contacts with unaltered schist are irregular and indistinct. However, in most places the texture of the altered and recrystallized schist is much coarser.

Present studies indicate that the large tabular pegmatite that originally capped the smaller pegmatites was formed, at least in part, by replacement of the wall rock. The small irregular pegmatites seem to have been formed by forceful injection and replacement of the wall rock. Scattered metacrysts of muscovite and plagioclase in the wall rock and the coarse texture of the wall rock indicate replacement and reorganization owing to introduction of pegmatitic material.

Most of the sheet-bearing muscovite occurs in subhedral crystals averaging 3 by 4 inches in width, but many are 4 by 6 inches, and one measured 6 by 9 inches. The maximum thickness is three-fourths of an inch. The muscovite is dark rum to ruby and exceptionally hard, flat, and compact. Some crystals are fractured and a few show ruling and herringbone structure. Many large and small subhedral crystals, isolated or in clusters, are found as metacrysts in the wall rock.

The depth to which the sheet-mica bearing pegmatites and the altered wall rock extend, as well as the percentage of mica that has been recovered from rock already mined are unknown. The possibility of future economic operations is doubtful, even though the quality of the sheet mica recovered and the yield of sheet mica from mine-run mica was satisfactory during the last operations.

NANCY NO. 2 MINE

The pegmatite at the Nancy No. 2 mine (pl. 1, no. 23) is exposed for 165 feet along strike and is 3 to 27 feet thick. It strikes N. 35°–75° E. and in most places dips steeply northwest, but there are local reversals of dip in the upper part in pit A and a short distance northeast of it (see sections B–B′ and C–C′ in fig. 80). The pegmatite narrows downward and may pinch out a short distance below the workings. Its contacts are discordant to the wall-rock foliation in some places. The several small pegmatite exposures, 25 and 60 feet southwest of pit A, are probably a separate body.

The Nancy No. 2 pegmatite at most places is generally separated from the unaltered wall rock by a layer of aplitic rock that ranges from 2 inches to 15 feet thick; at one place, in pit A, this is absent. It is composed of quartz, albite (An_{5-7}), fine-grained muscovite, and accessory tourmaline, garnet, biotite, and apatite. It has a strong foliation, made more conspicuous by weathering, that is due to the alinement of biotite, narrow bands of crystals of tourmaline and garnet, and fine-grained muscovite. The foliation is essentially parallel to the foliation of the wall rock. Locally, the tourmaline and garnet crystals are in lens-shaped segregations, as much as 5 inches long and 1 to 2 inches thick, containing small amounts of quartz and albite. Small lens-shaped xenoliths of partly unaltered wall rock that are present in the aplitic rock reach a maximum of 1 foot in length and 4 inches in thickness. The foliation of the aplitic rock and xenoliths is unbroken at the contacts. The contacts between the unaltered wall rock and the aplitic rock are sharp in places, gradational in others, and are commonly very irregular. In a few places concentric bulges of the aplitic rock, 1 to 2 inches in diameter, project into the wall rock. The re-entrants between these bulges are sharp and range from ½ to 1 inch in length. Medium-grained pegmatites as much as 6 feet long and 1 foot thick, whose long dimension is commonly parallel to the foliation of the unaltered wall rock, are present in this aplitic rock.

The main pegmatite has a well defined zonal structure. A fine-grained border zone, 1 to 2 inches thick, of albite (An_{5-7}), quartz, muscovite, and accessory tourmaline, garnet, and apatite, is present adjacent to the aplitic rock in a few places. The contact between the pegmatite and the aplitic rock is locally gradational. The wall zone, 1 to 4 feet thick, is discontinuous and was seen only in the upper and wider parts of the pegmatite. It is composed of albite (An_{5-7}), smoky quartz, scattered muscovite books, small amounts of biotite, and accessory tourmaline, garnet, apatite, and pyrite. This zone merges with the core-margin zone in the narrower parts of the pegmatite in both workings. Where the core and core-margin zones are absent it forms the center of the pegmatite.

The core-margin zone, 1 to 3 feet thick, is discontinuous, and in pit B is indistinct. It is composed of sheet-bearing muscovite, smoky quartz, albite (An_{5-7}), and accessory tourmaline, garnet, apatite, and pyrite. Most of the albite is dark green and specked with sericite. This zone forms the center of the pegmatite, in the narrow parts of the open stope.

The quartz pegmatite core has a maximum thickness of 5 feet, but is discontinuous along strike and dip. Most of the quartz is smoky, but milky quartz is present at the surface and in the upper parts of the pegmatite. Subhedral and anhedral perthite crystals, as much as 1 by 1 foot by 8 inches, occur in some of the quartz bodies in the upper 3 to 5 feet of the pegmatite. Aggregates of graftonite, triphylite, and vivianite as much as 4 inches in diameter are scattered in the core.

Most of the sheet-bearing muscovite is in the core-margin zone. The muscovite is light- to medium-rum in pit A, light-rum to light-green in pit B. The books are hard, flat, compact, and slightly ruled and stained, and they average 4 by 4 inches or larger. The outer parts of the larger books, and of some of the smaller ones, have a herringbone structure. Tourmaline and magnetite inclusions and quartz films along cleavages are not abundant.

Probably only small quantities of muscovite could be recovered from the mine by deepening the present workings because the pegmatite probably pinches out 5 to 10 feet below. The quantity of mica in the unmined parts of the pegmatite between the two workings is unknown, but assuming a mica content equal to the 1944–45 recovery, it would appear that 50 to 75 tons of mine-run mica might be recovered. It is doubtful that the core extends southwestward in pit A because the mica zone is discontinuous and the pegmatite probably terminates near the southwest edge of the pit.

NEW GOVE MICA PROSPECT

The New Gove prospect (pl. 1, no. 5) is in the town of Wentworth, 1.65 miles S. 7° W. of Wentworth village. To reach it from Wentworth, follow State Highway 25 south 1.7 miles a short distance beyond the Baker River bridge. Walk east 0.2 mile across a field to the prospect.

Mineral rights are owned by Mrs. Lewis Gove of Wentworth and were leased in 1944 by Mr. H. A. Ashley of Dorchester, N. H., who made a small cut in sandy overburden at the south end of the pegmatite outcrop. A sketch map was made by A. H. Chidester in June 1944 (fig. 81).

The New Gove pegmatite is exposed along the strike for 50 feet and is 3 to 22 feet wide. It strikes N. 15° E. in general and appears to dip 75° SE. It is very irregular in outline. The pegmatite contacts at the north end of the outcrop are parallel in general to the foliation of the wall rock but are sharply discordant in the south and southwest parts of the outcrop. The wall rock is quartz-mica schist of the Littleton formation; its foliation strikes N. 45° E. and dips 75° SE.

The border zone is 1 to 2 inches thick. The wall zone is coarse-grained and contains quartz, plagioclase, and scrap muscovite. Scattered, irregular pods of quartz ranging from 1 by 2 to 6 by 8 feet in plan lie inside the wall zone. Some of the pods are bordered by discontinuous zones containing small sheet-muscovite books. The largest pod contains a few beryl crystals measuring 0.5 by 2 to 1.5 by 3 inches.

Sheet-bearing muscovite occurs only in discontinuous marginal bands around quartz pods. The muscovite is amber to rum, hard, somewhat ruled, and reeved. Because the books are small and not abundant it is believed that little sheet mica could be obtained from the prospect.

NEW HILL MICA MINE

The New Hill mine (pl. 1, no. 64) lies 1.8 miles N. 24° W. of Grafton Center. To reach it from Grafton Center, follow U. S. Route 4 north for 1.7 miles to an obscure wood road leading southwestward; follow the wood road 0.3 mile to an abandoned cabin; walk south 0.3 mile along a trail, then west 0.6 mile to the mine.

Mineral rights are owned by the Whitehall Co., of New York. Four small opencuts were made prior to 1875 and sporadic work has been done since. The property was prospected for mica by the Hill Mining Co. of Bristol, N. H., in July 1943. The cuts were mapped by A. H. McNair and P. W. Gates in August 1944 (fig. 82).

The New Hill mine is located in a complex pegmatite-aplite body at least 300 feet long and 140 feet wide. Pegmatite occurs as numerous irregular bodies and stringers within the aplite. The thickest pegmatite appears to be one that is exposed at the northernmost cut.

The wall rocks are quartz-mica schist and hornblende schist of the Littleton formation. The foliation of these rocks strikes N. 15° E. and dips 55° to 85° E. The aplite-pegmatite body in general parallels the foliation of the country rock and encloses large lenticular inclusions of schist impregnated with quartz and feldspar. The foliation of the inclusions is parallel to the foliation of the wall rock, and this feature suggests that the aplite has formed by replacement of the schist.

The pegmatite exposed in the northernmost cut consists of perthite, quartz, cleavelandite, black tourmaline, and muscovite. No zonal arrangement of minerals is apparent. Narrow bands of black tourmaline around some of the aplite inclusions suggest that the pegmatite replaced the aplite or reacted with it.

Muscovite occurs as crystals that in general are widely scattered. It is most abundant in a tabular fracture-controlled deposit exposed on the face and west side of the largest cut. The deposit strikes about N. 20° E., dips 45° W. and extends along strike for about 25 feet. It contains mica books as much as 12 by 18 by 3 inches, associated with quartz and cleavelandite. The average content of book muscovite is low. The mica is hard, rum, and excessively ruled and reeved. The fracture-controlled deposit probably does not extend far either along its strike or dip because the pegmatite enclosing it appears to terminate against the aplite a short distance north and south of the deposit.

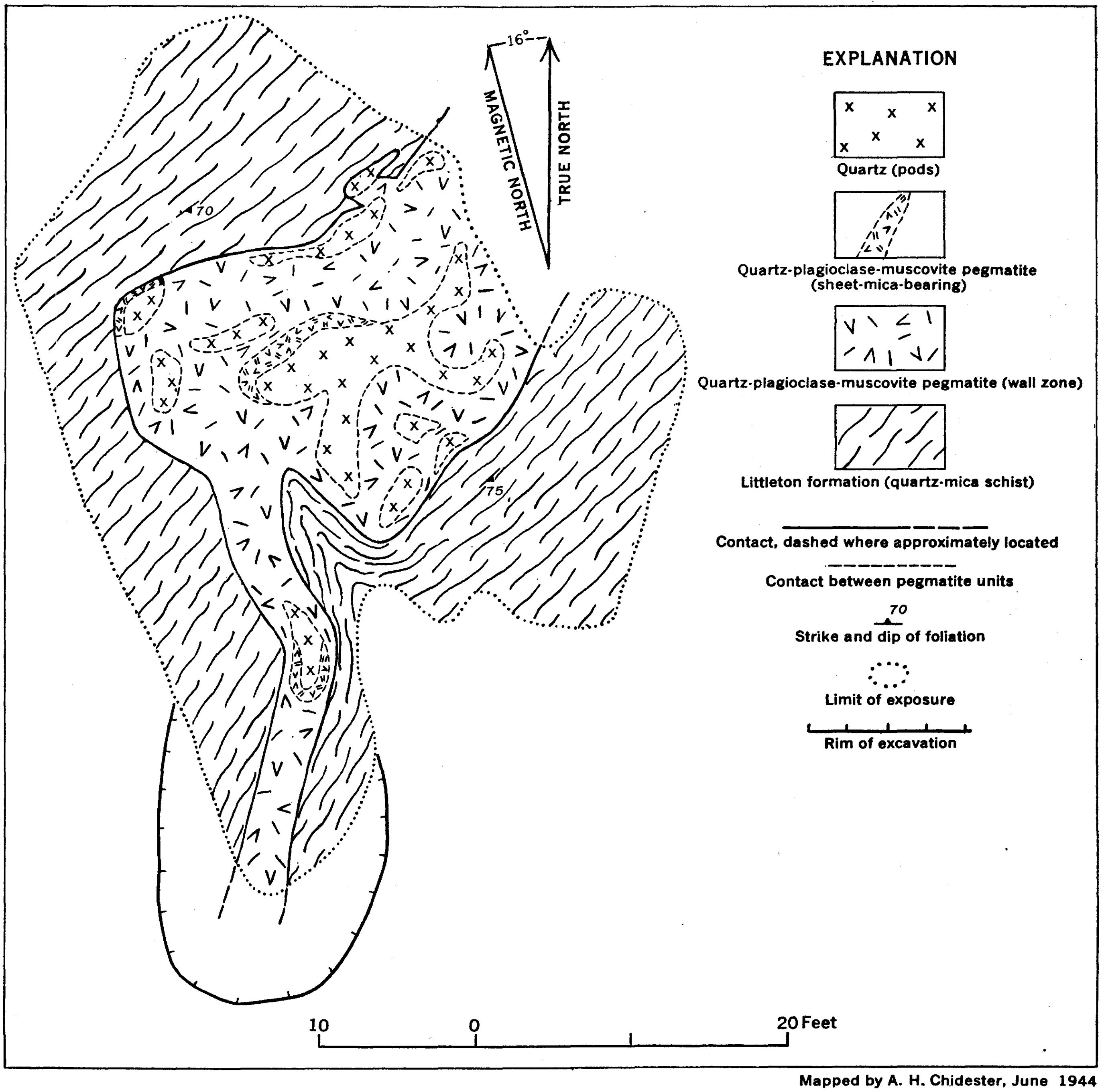


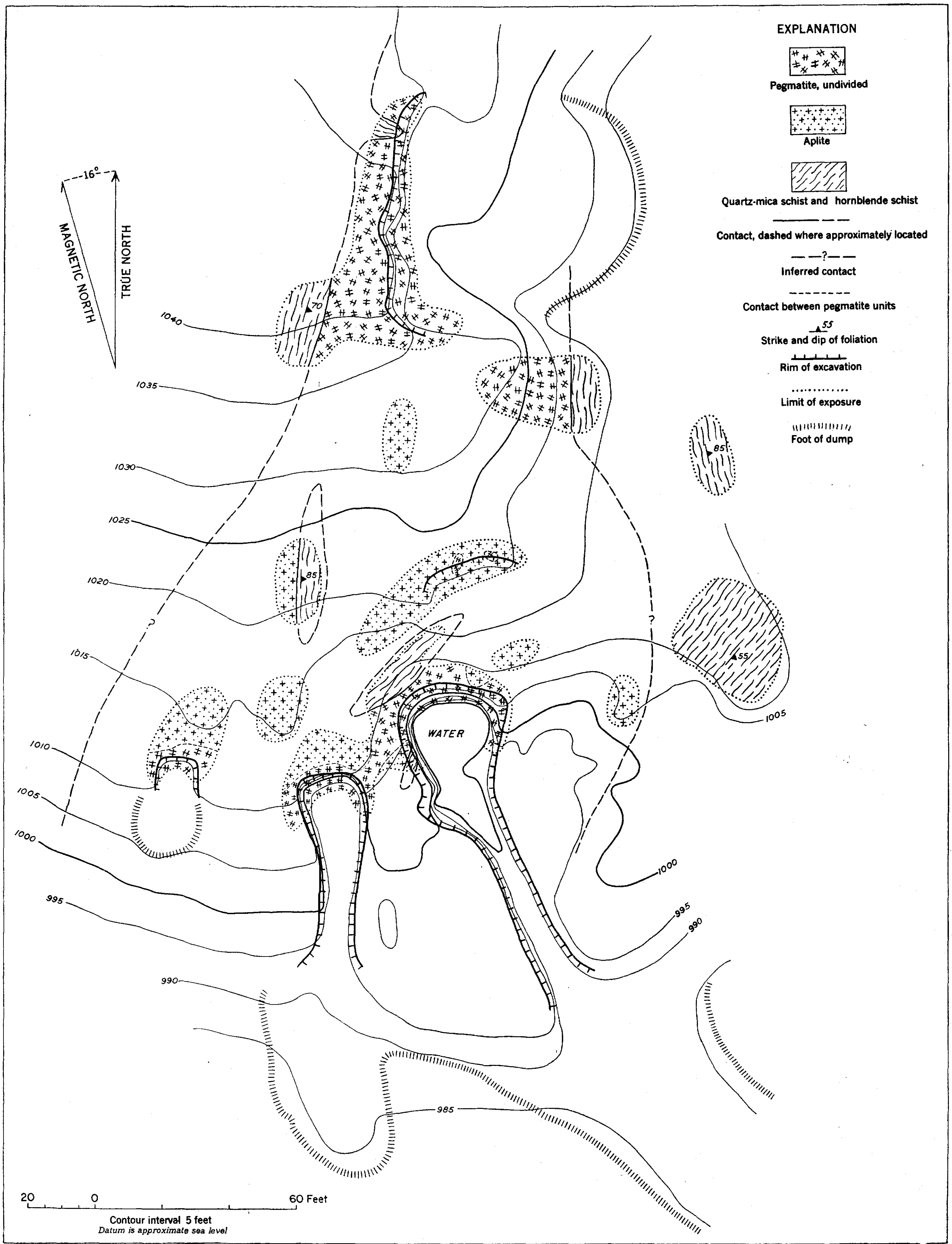
FIGURE 81.—Sketch map of the New Gove mica prospect, Wentworth, N. H.

The scarcity of disseminated mica books in the New Hill pegmatite and the limited size of the tabular fracture-controlled deposit, together with the poor quality of the mica, indicate that only small quantities of sheet mica could be obtained from the mine.

NICKERSON MINE

The Nickerson mine (pl. 1, no. 15) is in the town of Rumney, 2 miles west of Rumney Depot. To reach the mine, follow State Highway 25 for 2.1 miles west from Rumney Depot. Opposite the town tool yard at this point there is a group of farm buildings. The mine lies about 400 feet south of the buildings and can be reached by a wood road leading from the barn.

The mining rights to the property are owned by the town of Rumney. The visible workings are an open-cut leading to a shaft flooded at a depth of 40 feet below the collar. The shaft is 15 to 30 feet wide. Judging from size of the dumps, the shaft extends a considerable



Mapped by A. H. McNair and P. W. Gates, August 1944

FIGURE 82.—Geologic map of the New Hill mica mine, Grafton, N. H.

distance below water level, or connects with underground workings. The mine was examined briefly by E. N. Cameron and J. Chivers in July 1943.

The pegmatite mined is enclosed in interbedded mica-quartzites and quartz-mica schists of the Littleton formation that strike N. 20° E. to N. 30° E. and dip 65° to 83° NW. The bedding and foliation of the rocks are parallel. The hanging wall of the pegmatite is exposed in the northwest corner of the shaft, where it strikes N. 55° E. and dips 65° NW. The footwall is not exposed. The pegmatite can be traced about 100 feet southwest from the shaft. It is at least 40 feet thick in the shaft but seems to thin southwestward.

The pegmatite is exposed in the shaft walls, where it is a mixture of quartz, plagioclase, and perthite. Border, wall, and intermediate zones differ in proportions of quartz, muscovite, plagioclase, and perthite, and are vaguely distinguishable, and small, centrally located quartz bodies may represent segments of a quartz core. Much massive quartz is present on the dump. Muscovite forms scattered books up to 4 by 4 by 1 inch in the wall zone along the footwall.

The small parts of the pegmatite exposed contain little book mica or perthite recoverable by hand sorting. Nothing is known of the production from this mine.

TRUMAN PATTEN MICA MINE

The Truman Patten mica mine (pl. 1, no. 48) is in the town of Alexandria 4.0 miles N. 48° W. of Alexandria village. To reach it from Alexandria, follow a hard-surface road northwest for 1.0 mile to an intersection; turn left and follow a hard-surface road for 0.9 mile; continue on a gravel road for 2.5 miles to a fork; turn left and proceed 0.3 mile to a farm lane on the right. Follow the lane 0.2 mile to a farm house; take a wood road northwest about 0.5 mile to the mine. The property is owned by John Copatch, Alexandria (R. F. D. Bristol), N. H. Mineral rights are leased by the Hill Mining Co. of Bristol.

Two small opencuts were excavated near the northeastern end of the pegmatite prior to 1914. The northeastern cut is 10 to 25 feet wide, 20 feet long, and 3 to 8 feet deep. The southwestern cut is 35 feet long, 15 to 25 feet wide, and 5 to 15 feet deep. The Hill Mining Co. enlarged the southwestern cut and dug several prospect pits southwest of it during September and October 1944. About 120 tons of rock was removed from the southwest cut. The mine was mapped in October 1944 by Glenn W. Stewart and Karl S. Adams (fig. 83).

The pegmatite is exposed for 345 feet along strike and is 10 to 100 feet wide. It strikes about N. 50° E., and dips 60°–82° SE. Locally the walls have moderate to steep northwest dips. The wall rock is Kinsman quartz monzonite, the gneissic structure of which strikes N. 50°–60° E. and dips 35°–48° SE. In the immediate vicinity of the pegmatite the phenocrysts commonly present in the rock are absent.

The pegmatite has an indistinct border zone, 3 to 5 inches thick, consisting of fine-grained plagioclase, quartz, minor muscovite, and accessory garnet. The wall zone, 5 to 40 feet thick, is composed of coarse quartz, perthite, albite-oligoclase (An_{10}), minor disseminated muscovite, and accessory garnet. The intermediate zone, 3 to 7 feet thick, is composed of white or blue-green albite-oligoclase (An_{10}), quartz, sheet-bearing muscovite, biotite, and minor perthite. Sheet-bearing muscovite, intergrown with biotite, appears to be more abundant in places adjacent to the core. The core is discontinuous and consists of quartz, quartz-perthite, and quartz-perthite-graphic granite pods. The pods with graphic granite are 2 to 15 feet thick. The largest quartz pod is 15 feet long and 2 to 5 feet wide. In places subhedral crystals of perthite, 2 to 5 feet long and 1 to 3 feet wide, occur in the quartz pods.

The muscovite is light to dark rum, hard and flat. It is marred by "A" structure, reeves, and ruling and contains inclusions of magnetite or pyrite. Some books are wedge-shaped and most of them are intergrown with partly chloritized biotite. Many books are 6 by 6 inches, but some are larger. One book of intergrown muscovite and biotite 4 feet long and 5 inches thick was found.

The muscovite within and along the pods has many structural defects, and is intergrown with biotite. This mine would therefore yield only small quantities of muscovite of low quality in proportion to the rock mined. Approximately 0.8 percent of mine-run mica was recovered from rock mined in 1944.

PATTUCK MICA MINE

The Pattuck mine (pl. 1, no. 54) is in the town of Alexandria on the south slope of Hutchins Hill 2.6 miles N. 80° W. of Alexandria village. To reach it from Alexandria follow a hard-surface road northwest for 0.2 mile to a fork; turn left and proceed westward for 0.9 mile to Tenney School; continue westward on a gravel road for 2.0 miles to a mine-access road on the right; turn right and follow the access road 0.4 mile northeast to the mine.

The mine is owned by H. T. Patten and C. E. Tucker, Alexandria (R. F. D. 1, Bristol), N. H. It was worked continuously by the operators from May 1943 to May 1945. Mining began at pit A, but this working was abandoned during the summer of 1943. The pit is 40 feet long, 10 to 15 feet wide, and 5 to 20 feet deep. The deepest part, near the southwest end, is flooded with 10 to 12 feet of water and is partly backfilled. Pit B is an irregular open pit leading to an inclined open stope

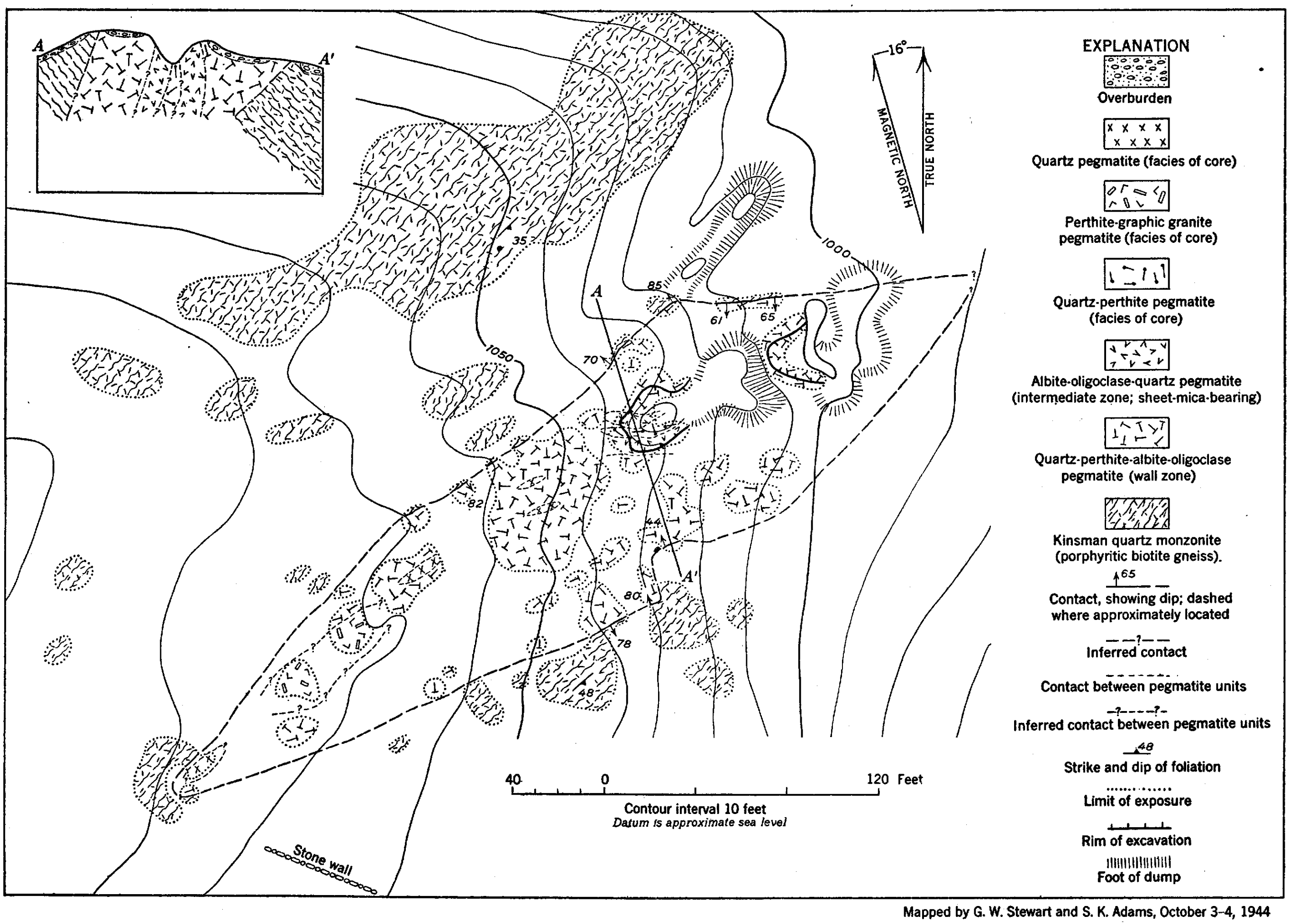


FIGURE 83. Geologic map and section of the Truman Patten mica mine, Alexandria, N. H.

that is also partly backfilled. The open pit is about 90 feet long, 12 to 25 feet wide, and 5 to 35 feet deep. The open stope is 8 to 10 feet high and 6 to 8 feet wide and extends along the hanging wall about 20 feet beyond the headwall of the pit. Other prospect pits have been made southwest and northeast of pit B. From May 1943 to May 1945 about 2000 tons of rock was removed from pit B and about 500 tons from pit A. The average yield of mine-run mica was approximately 3.3 percent. The mine was mapped in June 1943 by D. M. Larrabee, W. H. Ashley, W. M. Hoag, and H. R. Morris. It was brought up to date in July 1944, following development, by Glenn W. Stewart and Norman K. Flint. Periodic visits were made between March 1944 and June 1945 by Stewart and A. H. McNair.

Prior to 1942, two small pits were mode along the strike of a pegmatite that crops out about 200 feet S. 25° W. of pit A (pl. 28). These pits were examined in July 1944 but not mapped. The strike, dip, mineralogy, and zonal structure of the pegmatite exposed in these pits is similar to the pegmatite worked by Patten and Tucker. The two are probably parts of a single rock.

The pegmatite mined by Patten and Tucker is exposed for more than 800 feet along strike. It is 9 to 35 feet wide, strikes N. 25°–65° E., and in most places dips irregularly but steeply northwest. It is nearly parallel to the strike of the wall rock foliation, but it transects the dip. The pegmatite pinches and swells, and small rolls are common along both walls. A conspicuous roll and reversal in dip are exposed northeast of pit B along the footwall. In pit A an apophysis of pegmatite as much as 2 feet thick and 3 to 4 feet long projects into the hanging wall. The wall rock, the Kinsman quartz monzonite, has a well-defined foliation that strikes N. 25°–48° E. and dips 43°–65° SE. In pit C a small lens-like body of fine-grained biotite gneiss cuts the quartz monzonite and appears to be cut by the pegmatite.

The pegmatite shows well-defined zones in most places, but the zones are best exposed in pit B. The border zone, 2 to 10 inches thick, is composed of fine-grained quartz, muscovite, perthite, minor albite (An_{5-6}), and accessory garnet, apatite, and tourmaline. The wall zone, 2 to 35 feet thick, is composed of medium to coarse-grained quartz, albite (An_{4-5}), perthite, graphic granite, sheet-bearing muscovite, and accessory garnet, biotite, sulfides, and beryl. The hanging wall part of this zone appears discontinuous. In pit A it is either absent or so thin that it is not a distinguishable zone. About 110 feet northeast of pit A the hanging-wall part of this zone is separated from the border zone by a material similar to that of the quartz-perthite core. The explanation of this abnormality is unknown. The wall zone forms the center of the pegmatite between the entrance of pit B and the northeast face, where the core begins. The perthite is unevenly distributed through this zone but seems to be most abundant in the thicker parts and is probably in excess of the albite in many places. A few patches of perthite have a honeycomb stricture due to replacement by sericite. Blocky perthite crystals as much as 4 by 8 inches occur within 1 foot of the hanging and footwall contacts. Fine to coarse-grained graphic-granite, occurring in irregular patches, is scattered through the zone.

The outer intermediate zone, 1 to 5 feet thick, is discontinuous and is visible only in pit B. It is composed of quartz, albite (An_{4-5}), sheet-bearing muscovite, minor graphic granite and perthite, and accessory tourmaline and sulfides. The extent of this zone along strike and dip is unknown. It became visible only after considerable quantities of rock had been removed from the hanging wall in pit B. It seems to be a crescentic body surrounding the keel of the core and extending further up the hanging wall side than the footwall side (see sec. A-A′ and B-B′, pl. 29). Blue-green albite is conspicuous in places where this zone is exposed in the stope.

The core-margin zone is 1 to 3 feet thick and is likewise discontinuous. It is composed largely of wedge-muscovite, perthite, quartz, minor albite (An_{4-5}), and accessory columbite-tantalite, triphylite, and vivianite. It apparently is crescentic like the intermediate zone, and also extends around the keel of the core. It is believed, however, to be less extensive along the hanging wall side of the core than the outer intermediate zone.

The core, 5 to 25 feet thick, is composed mainly of coarse to extremely coarse quartz and perthite, wedge muscovite, strip muscovite intergrown with partly to completely chloritized biotite, beryl, and minor albite (An_{4-5}). Accessory minerals are tourmaline, pyrrhotite, chalcopyrite, arsenopyrite, and apatite. Like the intermediate zones, it is discontinuous. The keel of one segment of the core was exposed in a trench in the bottom of pit B along the strike of the pegmatite and may plunge irregularly northeast at an angle between 15° and 25°. Quartz bodies in the core reach a maximum of 20 by 15 by 10 feet. Subhedral perthite crystals as much as 8 by 4 by 3 feet are cut by narrow quartz veins in a few places. Wedge muscovite is most abundant in pit B where it occurs in clusters as much as 2 feet in diameter, or in lenslike bodies as much as 5 feet long and 1 to 2 feet thick. The quartz body in pit C has been much fractured, and strips of muscovite as much as 5 feet long, 1½ feet wide, and 3 inches thick are present along these fractures. Many strips transect, and all the muscovite is intergrown with partly to completely chloritized biotite. The distribution of the biotite in this pegmatite is noteworthy. The map gives a slanting section of the pegmatite owing to the steep slope on which it is exposed. Most of the biotite occurs 130 to 150 feet above the lowest exposures, that is, in the upper part of the pegmatite. The occurrence of the biotite here is analogous to that in many New England pegmatities typified by that in Blister mine, near Alstead, N. H.

Sheet-bearing muscovite books occur in all zones except the border zone, but most of the sheet mica was obtained from the wall and intermediate zones. In general, most of the muscovite in the wall zone and the core is medium to dark rum and ruled, and contains an abundance of pyrite inclusions. Sheet-bearing muscovite books are present only in the hanging-wall part of the wall zone. They occur as isolated books or in scattered clusters. The books are hard, flat, slightly ruled, and average 4 by 4 inches, but many are 5 by 7 inches. Sheet-bearing muscovite in the intermediate zone is hard, flat, and much ruled. The books have average dimensions of 6 by 8 inches, but books 10 by 12 inches are not uncommon. The books are unevenly distributed through the zone but appear more abundant near the core-margin zone and along the hanging wall part of the core. Most of the muscovite in the core-margin zone occurs as wedge-shaped, greenish books having average dimensions of 12 by 14 by 3 inches. They generally have a herringbone or "A" structure, but in some books these structural defects are lacking near the centers and sheet mica as much as 6 by 8 inches has been obtained.

The strip muscovite is confined mainly to the core exposed in pit C and the pits to the northeast. The strip muscovite yields only very small quantities of sheet, but it is generally hard and flat. Iron oxide stains are most abundant in the mica from the core owing to the numerous fractures and to oxidation of the abundant biotite.

About 3 tons of blue-green and golden beryl has been mined from pits B and C. The largest crystals, as much as 2 by 5 feet, were taken from pit B. All the beryl was recovered from the core with the exceptions of a few crystals 1 to 2 inches in diameter that were taken from the wall zone. One small nest of radiating and bladed crystals of columbite-tantalite was associated with albite and muscovite in the core-margin zone near the keel of the core. The crystals average 1 to 3 inches in length, ½ to 1 inch in width and generally taper from ½ to 1/16 inch in thickness. The specific gravity is 5.96.

Pyrrhotite, chalcopyrite, pyrite, and arsenopyrite are most abundant in the core. Chalcopyrite and pyrite occur in cavities as small subhedral crystals as much as ⅛ inch across, and some massive lens-shaped bodies of pyrrhotite contain small quantities of chalcopyrite and pyrite. These bodies are as much as 18 inches long, 8 inches thick, and weigh 30 pounds or more. Botryoidal and box-work structures are not uncommon in these sulphide bodies. Arsenopyrite is generally not associated with the other sulfides. It commonly occurs in cavities as euhedral crystals as much as 0.08 inch across. All of the sulfides have replaced quartz, perthite, and beryl. The sulfides are very conspicuous in the beryl crystals taken from pit C.

A series of three or four lens-shaped cavities, as much as 3 feet long and 1½ feet wide, occurred in the hanging wall part of the wall zone adjacent to the core in pit B. Two masses weighing 65 and 85 pounds, respectively, and consisting of doubly terminated quartz crystals in parallel intergrowth, were recovered from two of the cavities. Other small and single quartz crystals were found. Large amounts of a claylike material covered the bottom of the cavities.

Prospecting was done between pits A and B and between C and D, but no rich mica deposits were found in the core. Deposits in pits A and B appear most favorable for future operations, and it is believed that they could be operated profitably under economic conditions similar to those of 1943–44. Several hundred tons of high-grade potash feldspar could be recovered from the core.

W. M. PETTES PROSPECT

The W. M. Pettes mica prospect (pl. 1, nos. 39–40) is in the town of Orange 2.55 miles N. 65° E. of Canaan village. From Canaan, follow State Highway 118 for 0.6 mile northeast to a right fork; turn right and follow the paved road for 2.0 miles to the school house in Orange village; turn left and follow a gravel road for about 0.4 mile to an old wood road on the right; follow the wood road northeast for about 750 feet to an intersection at the top of a hill; turn right and proceed on an old road eastward for about 400 feet to the prospect.

The prospect is owned by Walter M. Pettes, of Orange, who worked it for about one month during the summer of 1944. A small pit 20 feet long, 9 feet wide, and as much as 7 feet deep was opened. It was visited by J. J. Page and F. H. Main in October 1944.

The pegmatite strikes N. 10° E. It is exposed for 75 feet along the strike and has a maximum outcrop width of 8 feet. The footwall dips 25° to 35° E. and the hanging wall dips 50° to 75° E. It seems to be a narrow conformable lens in biotite-quartz schist of the Littleton formation. The pegmatite is characterized by abundant biotite in thin strips as much as 2½ feet long and 1 foot wide. Quartz, greenish plagioclase, and perthite are other essential minerals, and smaller amounts of muscovite and black tourmaline are also present. Small quartz pods occur adjacent to the hanging wall, and near these perthite is more abundant than elsewhere in the pegmatite.

Muscovite is disseminated through the narrow pegmatite and is commonly intergrown with strip biotite. Small sheet mica is obtained from these intergrowths and from isolated books. The mica is very hard, clear, ruby muscovite, but nearly all is too small for commercial use. About 1.1 percent mica was recovered from rock mined in 1944. The small size of the pegmatite and its low sheet-mica content indicate that it could not long support mining in spite of the excellent quality of the product.

Mr. Pettes has also opened three small pits in a thick pegmatite 0.2 mile N. 37° W. of the one described above. This pegmatite is at least 50 feet wide and 280 feet long. It consists largely of perthite, with minor plagioclase, quartz, biotite, muscovite, and traces of apatite and tourmaline. The walls are poorly exposed. the strike of the pegmatite is about N. 15° E. and the dip is 45° to 75° E. Plagioclase is somewhat more abundant near the hanging wall than in the central part of the pegmatite. Muscovite is present adjacent to small quartz pods but is reeved and bent, and much of it is mineral-stained. No mica has been sold from these pits because of its scarcity and poor quality.

PINNACLE MICA MINE

The Pinnacle mica mine (pl. 1, no. 37) is in the town of Orange 3.1 miles N. 57° E. of the village of Canaan. To approach it from Canaan follow State Highway 118 east-northeast 0.6 mile to a fork; turn right on a hard-surface road and continue 2.6 miles to the third road on the left; turn left and follow a graded gravel road 0.8 mile to a mine road on the left; follow the mine road 0.6 mile to the Strain mica mine and continue 0.3 mile northward to the Pinnacle mine. The property and mineral rights are owned by James H. Strain, 1 Boston Post Road, New Milford, Conn.

The pegmatite (fig. 84) was first mined between 1916 and 1918 by J. H. Strain, and several cuts on the top of Pinnacle Hill and a prospect trench near the bottom of the east slope were dug at this time. In 1920 the

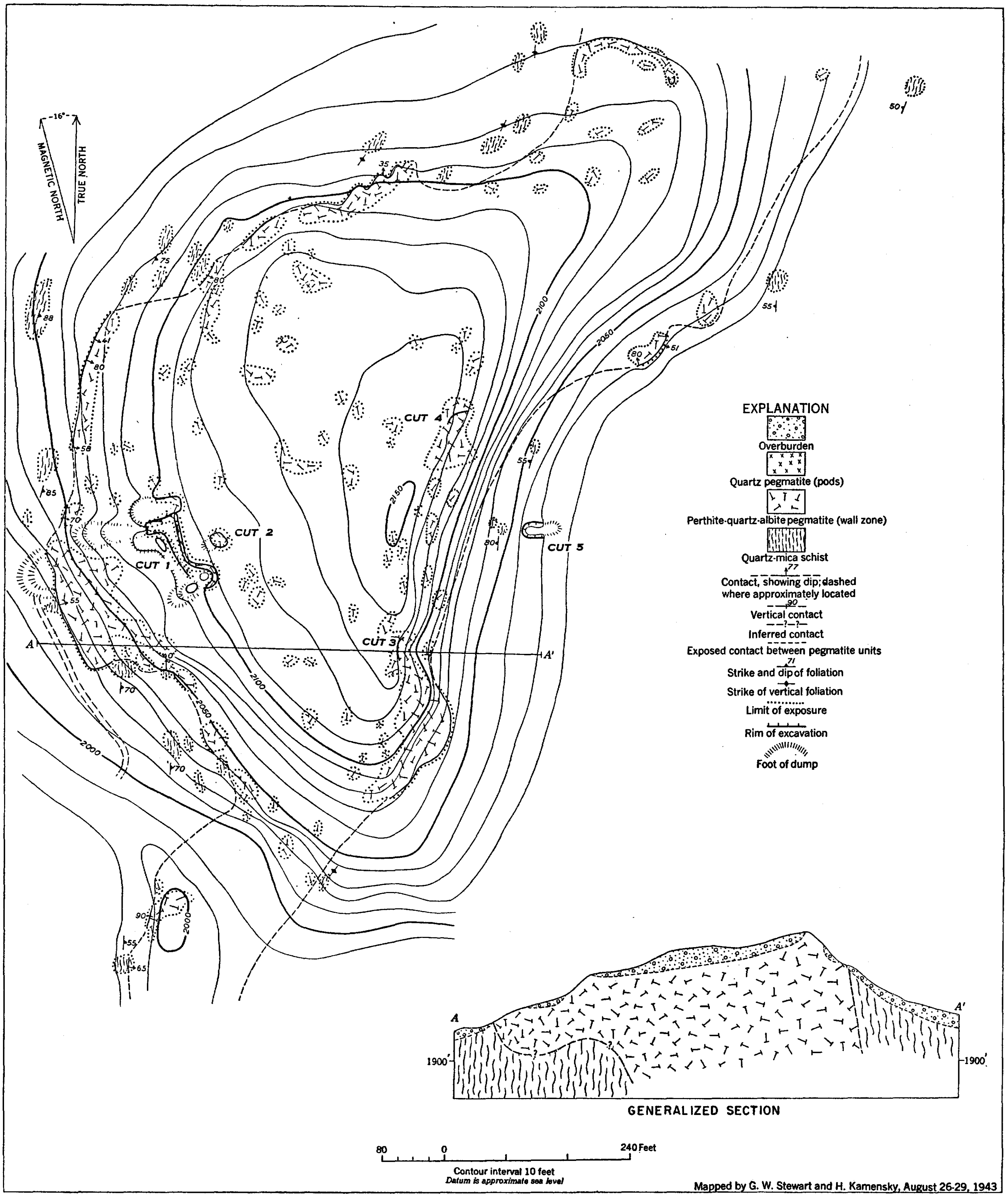


FIGURE 84.—Geologic map and section of the Pinnacle mica mine, Orange, N. H.

mineral rights were leased by E. E. Smith of Canaan, who mined the pegmatite for scrap mica. ' uts no. 3 and no. 4 were made and cut no. 1 was enlarged. During August and September 1943 the mineral rights were leased by A. C. Estey, 52 Glennview Road, Arlington, Mass., who deepened and widened cuts no. 1 and no. 2. At present (1943) cut no. 1 is 170 feet long, 10 to 40 feet wide, and 10 to 25 feet deep. Cut no. 2 is 20 feet long, 20 feet wide and 10 feet deep. Cut no. 5, 25 feet long, 16 feet wide, and 5 to 8 feet deep, was excavated in wall rock toward the hanging wall of the pegmatite. The pegmatite was mapped in August 1943 by Glenn W. Stewart and Harry Kamensky.

The Pinnacle pegmatite, one of the largest in New Hampshire, forms a conspicuous knob along a northeast trending ridge that contains many pegmatites. The pegmatite is well exposed for a distance of 2160 feet and can be traced north and south for several hundred feet farther. The exposed width of the pegmatite ranges from 165 feet at the south end to 530 feet near the center near the top of the Pinnacle, and is at least 320 feet at the north end of the area mapped. The average strike of the pegmatite is N. 30° E. and its dip is 40°-60° SE. The northward-plunging rolls of the western contact suggest that the pegmatite body has a plunge of 35°-40° in this direction. Talus conceals most of the eastern contact, but apparently the present eastern slope of the hill is approximately the dip slope of the pegmatite. The pegmatite is essentially concordant to wall rock foliation near its center but at the north and south ends, where the pegmatite is narrow the contacts cut sharply across the foliation. The wall rock is quartz-mica schist of the Littleton formation. Its foliation strikes N. to N. 35° E. and its dip ranges from 55° SE. to vertical. In two small outcrops east of the pegmatite the dip is 52° and 80° NW.

The pegmatite has a distinct border zone, 3 to 5 inches thick, consisting of fine-grained quartz, muscovite, and subordinate plagioclase. The wall zone is composed of medium- to coarse-grained perthite, quartz, albite (An_{5-7}), graphic granite, muscovite, and biotite. Accessory minerals are black tourmaline, red garnet, and green apatite. Perthite occurs in anhedral and subhedral crystals that rarely exceed 2 by 3 feet in size. Small pods consisting of quartz, quartz and albite, or graphic granite, and ranging from 1 by 3 feet to 3 by 10 feet, are scattered through the pegmatite.

Most of the muscovite is light to medium rum, but some is green. Many books are ruled, stained, and cracked, and some have a conspicuous fishtail structure. The books average 4 inches by 4 inches in size, but most of the wedge-shaped books are larger. Muscovite intergrown with partly chloritized biotite is common. The muscovite is generally associated with the quartz pods and pods consisting chiefly of quartz and albite, but some is disseminated.

During operations in 1943, mica was mined from scattered quartz pods, but the mica was of low quality because of its structural defects and its intergrowth with biotite. No attempt was made to mine the remaining pegmatite because it contains only sparsely disseminated muscovite books.

THURMAN POWELL PROSPECT

The Thurman Powell prospect (pl. 1, no. 60) also known as the E. E. Smith No. 2 prospect, is in the town of Grafton 2.7 miles S. 7° W. of Canaan village. To reach it from Canaan follow U. S. Highway 4 westward 0.55 mile to a left fork, then follow the left fork southeastward along the top of a ridge for 2.6 miles to an intersection near Height of Land School. From this intersection a road leads southwest for 0.95 mile to a cluster of buildings on the east side of the Grafton-Enfield town line. The prospect is 0.2 mile S. 25° E. of the buildings and can be reached by a truck road leading across a field. The property is owned by Thurman Powell, who lives in one of the houses near the town line. Mineral rights are held by E. E. Smith of Canaan. The prospect was opened by Smith in the winter of 1942 and operated for a short time. It was also worked for about a month in the summer of 1944. A cut 50 feet long, 35 feet wide, and 25 feet in maximum depth has been opened. Most of the work was done at the east and west ends of the cut. The prospect was visited in 1943 by D. M. Larrabee, and was mapped by J. J. Page and F. H. Main in October 1944 (fig. 85).

The pegmatite crops out for a distance of 170 feet—measured in an east-west direction—and has a maximum exposed width of 30 feet. East of the cut it strikes nearly east and has a steep north dip. In the cut the strike is similar, but the dip is 30° to 75° S. West of the cut, the strike appears to be north or northeast and the dip 30° to 60° E. The wall rock is coarse-grained biotite-plagioclase gneiss, muscovitized at some places near the pegmatite contact. The foliation of the gneiss strikes 10° to 65° NW. and dips about 40° SW.

The pegmatite consists of perthite, quartz, plagioclase (An_{16-18}), biotite, muscovite, and garnet. A zonal arrangement of minerals is indicated only by a very lean mica zone surrounding a single quartz pod. Perthite is the dominant feldspar; biotite forms strips and isolated books; quartz occurs in small pods or as smaller grains interlocked with plagioclase. Most of the mica is rum, stained, bent, and it splits poorly.

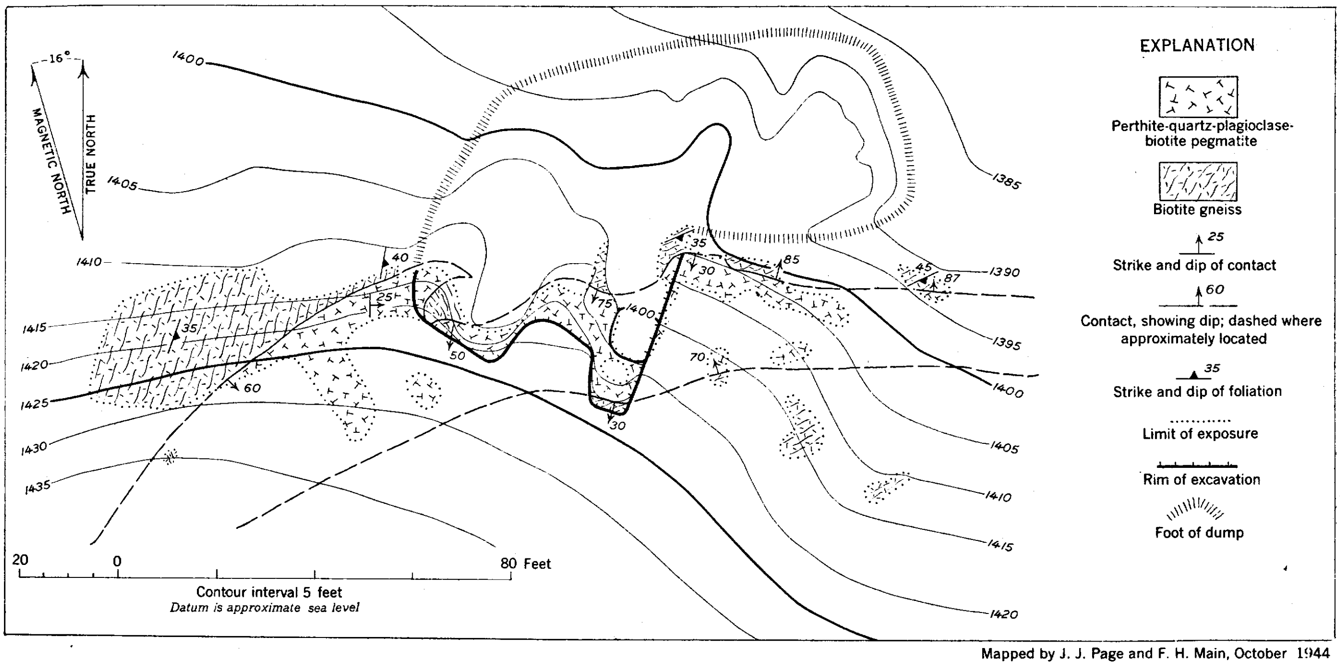


FIGURE 85.—Geologic map of the Thurman Powell prospect, Grafton, N. H.

Mica near the quartz pod is of poor quality. Sparsely scattered small books of clear, very hard, free-splitting dark ruby mica occur throughout the pegmatite.

The low mica content and the poor quality of most of the mica indicate that the yield of sheet mica per ton of rock mined was low.

PRESCOTT MICA PROSPECT

The Prescott mica prospect, also known as the Lovering or Robinson prospect (pl. 1, no. 73), is 2.4 miles S. 66° W. of Grafton. From Grafton follow a graded gravel road southwestward for 2.3 miles to Robinson Corner. Take the right fork northwest for 1.15 miles to an obscure wood road on the right; follow this 400 feet north to a quarry on the south slope of a low hill.

Mineral rights to the property are owned by Fred Austin of Sunapee, N. H. A quarry 80 feet long, 40 feet wide, and 5 to 15 feet deep yielded granite dimension stone sometime prior to 1920. Some of the stone may have been used in the construction of the New Hampshire State prison in Concord. Part of a narrow pegmatite that crops out along the face of the quarry was removed, and this pegmatite was prospected during the summer of 1943 by the Colonial Mica Corp. The quarry and surrounding area were mapped by R. P. Brundage and J. Chivers in June 1943 and were examined a short time later by A. H. McNair.

The pegmatite is exposed for 60 feet along strike and is 4 to 10 feet thick. It strikes east and seems to dip about 15° N. A small pegmatite that outcrops 60 feet northwest of the quarry apparently is part of another pegmatite. The wall rock is fine-grained Concord granite occurring as an elliptical stock-like mass at least 420 feet long and 350 feet wide. The granite contains equigranular quartz, feldspar, and minor muscovite and biotite. Contacts between the granite and pegmatite are gradational. The granite is discordant to the quartz-mica schist of the Littleton formation. The schist is intensely drag folded, especially in the vicinity of the eastern contact with the granite, and the folds plunge southwestward 55° to 75°. Foliation, in general, strikes N. 5° W. and its dip is 80° W. to vertical.

The pegmatite consists of gray quartz, plagioclase, black tourmaline, and muscovite. No zonal arrangement of minerals was observed. Rum to ruby muscovite occurs as abundant disseminated crystals that are mostly less than 2½ inches in diameter. The books are of good quality, hard, flat and nearly free from structural defects.

The small size of the pegmatite and the small size of the muscovite books indicate that little, if any commercial sheet mica could be obtained from the body. The results of prospecting in 1943 were not encouraging, and mining was not attempted.

RICE-PALERMO AREA

The Rice-Palermo area is a tract of land about ½ mile wide and 1 mile long, lying in the western part of the town of Groton and extending from the Rice mines to the Palermo mines. To reach the area from North Groton, follow an improved road south for 0.25 mile, turn right on a graded gravel road and proceed 1.0 mile to a fork. Follow the right branch, a newly constructed mine access road, for 0.2 mile. At this point a poorly graded, steep road leads left for 1.1 miles to the Rice mines (pl. 29). The access road continues 0.6 mile to the Palermo mines. The Rice and Palermo mines were studied and mapped by several Survey geologists in 1943 and 1944; these investigations are outlined in the descriptions of the individual mines and prospects below. In May, June, and July 1944, the entire area was mapped by J. B. Hadley, F. H. Main, and D. W. Caldwell (pl. 29). Mapping was done by chain-and-compass traverses tied to transit-stadia control. The relations of the pegmatites to the structure and rock types of the area were studied, comparisons of pegmatites were made, pegmatites not studied previously were examined, and four pegmatites were mapped and studied in detail.

GEOLOGIC RELATIONS

The area is underlain chiefly by quartz-mica schist, quartz-mica-sillimanite schist, micaceous quartzite, and amphibolite of the Littleton formation. The bedding and foliation are commonly nearly parallel. They have a regional strike of N. 30° E. and in most places dip 75° SE. to vertical. At many places the bedding is compressed into small, tight, steeply pitching folds. Larger folds are also present but are evident only where the bedding has an attitude consistently different from that of the schistosity.

The bedrock surface shows the effects of strong scouring and plucking by ice that moved S. 20°-40° E. and many outcrops are elongated parallel to that direction. Others are controlled by a set of widely spaced joints that strike west-northwest and dip 25°-35° SW. Most of the larger pegmatites form knobs or terraces rising 10 to 60 feet above adjacent ground.

APLITES

A few small bodies of aplite, forming parts of the pegmatites or separate intrusions, are present in the area. They are associated generally with pegmatites that are discordant with the wall rock. The aplite is equigranular and fine-textured (0.08-0.5 inch) and consists chiefly of quartz, feldspar, and muscovite, with minor black tourmaline or garnet. Where contacts are visible, pegmatite cuts the aplite.

GENERAL DESCRIPTION OF PEGMATITES

Fifty-seven pegmatite bodies are shown on plate 29. Thirty-eight important pegmatites are numbered on the map and are described individually below. Most of the larger pegmatites lie in two belts 2,000 feet apart that trend N. 30° E., parallel to the regional structure. All but one of the larger productive pegmatites are in the northwestern belt; the Palermo No. 1 mine and several small pegmatites lie between the belts. The more important pegmatites are indicated on plate 29 and described below.

The structural relations of these pegmatites to the foliation of the enclosing rocks are given in the table on page 214. The foliation of the schist at the contacts of the larger and more irregular bodies is commonly bent toward positions parallel to the surfaces of the pegmatites, especially where the angle between the foliation of the contact was originally less than 45°. The bending of the schist may persist for as much as 50 feet from the margins of a pegmatite 100 feet wide (fig. 88). The bending of the foliation around pegmatites bodies, and the almost complete absence of deformation within the pegmatites themselves, indicates that they crowded the schist aside and that the schist yielded by flow. The rarity of inclusions of schist in the pegmatites and of pegmatite apophyses in the schist also indicate that the pegmatites were injected under conditions in which the country rock yielded more by flow than by fracturing. Most of the pegmatites in schist are elongated parallel with the foliation, hence foliation planes served as important entry ways during intrusion. Some of the pegmatites cut across schist, however, and were controlled by other planes of weakness. Several pegmatites in the southeastern belt occur in micaceous quartzite; these trend northwest and cut the schistosity of the quartzite at high angles. Perhaps cross-cutting pegmatites prevail in this belt because the quartzite tended to fracture rather than flow at the time of the intrusion.

The principal minerals in the smaller, finer-grained pegmatites are quartz, sodic plagioclase, and muscovite, commonly accompanied by black tourmaline and garnet. In the larger and coarser-grained pegmatites perthite and biotite are also present. Small quantities of beryl, triphylite, graftonite and related phosphates, apatite, chalcopyrite, pyrite, and sphalerite occur in several of the larger pegmatites.

Zone sequences, relations to enclosing rock, occurrence of sheet mica, and production of pegmatites in the Rice-Palermo area

Pegmatite	Lithologic types of zones [1]							Relation to enclosing rock	Structural type of sheet-mica deposit	Output of commercial (mine-run) mica [2]
	1 Quartz, muscovite, (plagioclase)		2	3	4	5	6			
	(a) Fine-grained border zones	(b) Medium- to coarse-grained wall zones	Quartz, plagioclase, perthite, muscovite	Quartz, plagioclase, perthite, biotite, (muscovite)	Quartz, plagioclase, (perthite), muscovite	Quartz, perthite	Quartz			
1	×	[3] ×	----	[4] ×	×	×	×	Discordant	Wall zone and intermediate zone.	Large, mostly from intermediate zone.
2	×	----	----	×	×	×	----	Concordant	Intermediate zone and core margin.	Large.
3	×	----	----	×	×	----	←×(t)	do	do	Do.
4	×	×	----	----	----	----	----	Discordant	Pod	None.
5	×	×	----	----	----	----	----	do	None	Do.
6	×	×	----	----	----	----	----	Concordant	Disseminated	Unknown, probably moderate or small.
7	×	×	----	----	----	←×(t)→	----	do	Core	None.
8	----	(?)	----	----	----	----	----	Discordant	Wall zone?	Unknown, probably moderate or small.
9	×	----	(?)	----	----	----	----	Concordant	None	None.
10	×	(?)	----	(?)	(?)	(?)	----	do	Wall zone?	Very small, if any.
11	×	×	(?)	(?)	(?)	----	←(Pods) ×	Discordant	Wall zone, intermediate zone.	Probably small.
12	×	----	×	----	----	----	----	Concordant	None	None.
13	×	----	×	×	(?)	(?)	----	do	Pod	Very small.
14	×	×	----	----	----	----	----	Discordant	None	None.
15	(?)	----	×	----	×(t)→	----	←×(t)	Concordant	Pod	Do.
16	×	×	----	----	----	×	----	Discordant	Wall zone	Small.
17	([5])	----	----	----	----	----	----	Concordant	None	None.
18	×	----	----	----	×	----	----	do	Core	Small.
19	×	×	----	(?)	(?)	(?)	----	Discordant	Pod	Very small.
20	([5])	----	----	----	----	----	----	do	None	None.
21	×	----	----	×(t)→	←×(t)	×	----	do	Pod	Very small.
22	([5])	----	----	----	----	----	----	do	None	None.
23	([5])	----	----	----	----	----	----	do	do	Do.
24	(?)	(?)	----	----	----	←×(t)→	----	do	Pod	Do.
25	(?)	----	×	----	----	----	----	do	Disseminated?	Do.
26	×	×	----	----	----	←×(t)→	----	do	Core	Small.
27	×	(?)	(?)	×	(?)	×	----	do	Core-margin?	Very small.
28	×	----	----	[6] ×	×	----	----	Concordant	Core	Very small, or none.
29	×	----	----	[6] ×	×	----	----	do	do	Small.
30	×	----	----	×	×	----	----	do	do	Do.
31	×	----	----	[6] ×	×	----	----	do	do	Very small.
32	×	×	----	----	×	----	----	do	Wall zone, core	Moderate or large.
33	×	----	----	----	×	[7] ×	----	do	do	Small or moderate.
34	×	----	----	[6] ×	×	----	----	do	Core	Small.
35	×	----	----	[4] ×	----	←×(t)→	----	do	do	Small or moderate.
36	([5])	----	----	----	----	----	----	do	(?)	Do.
37	×	----	----	×	----	----	----	do	Disseminated	Do.
38	([5])	----	----	----	----	----	----	do	(?)	Very small.

[1] Minerals appearing in the name of a lithologic type of zone are the essential minerals of the zone. The order of the minerals in the name is without significance. Minerals in parentheses may or may not be present. ×—indicates that the zone is present. ?—indicates the zone may be present but the sequence could not be fully determined. ×(t)—indicates telescoped zone involving zones indicated by arrows. Thus, pegmatite 7 contains a telescoped zone combining zones 4, 5, 6; pegmatite 15 contains a telescoped zone combining zones 4 and 6.

[2] "Small" means less than 5 tons; "moderate" means 5 to 50 tons; "large" means more than 50 tons.

[3] Contains minor amount of biotite.

[4] Divisible in this pegmatite into two zones differing in mineral proportions.

[5] Zonal structure not determined.

[6] Contains no perthite.

[7] Muscovite books occur in outer part of this zone.

Internal structure of the pegmatites.—In internal structure, the pegmatites range from those that consist only of a thin border zone and a core to those with two or more zones in addition to a border zone. In pegmatites that have only a border zone and core, the core forms almost the entire pegmatite. The border zone consists of fine-grained quartz, scrap muscovite, and plagioclase. The core commonly consists essentially of medium-grained quartz, plagioclase, and muscovite—but biotite or perthite may be present. The cores show irregular variations in texture, and local concentrations of quartz, fine-grained mica, or tourmaline are common. On the whole they show no systematic distribution of the component minerals. The multizoned pegmatites contain abundant perthite and biotite, and in general contain more varied suites of accessory minerals than the simpler pegmatites. However, some of the bodies that appear to consist only of border zone and core may contain other zones which have been removed by erosion or are in parts of the pegmatites not yet exposed.

The table above summarizes available information regarding the zones present in 38 of the larger pegmatites of the area. Six lithologic types of zones have been recognized; one type has two important varieties based on texture. No pegmatite of the area has all six types of zones, but the zones present in any pegmatite occur in a sequence from the wall inward that corresponds to the order indicated from left to right at the top of the table. Thus, in pegmatite 2, only four lithologic types of zones are found, but they occur in the same order from the wall inward as the corresponding lithologic types of zones in pegmatite 1, which has 6 units. In some pegmatites, units that contain the minerals of two or more of the seven main lithologic types are present. These units are regarded as telescoped zones. In all pegmatites containing such units, the telescoped zone has the same sequential position in relation to other zones as the corresponding two or more zones have in the sequence at the top of the table. The core of pegmatite 26, for example, consists of coarse-grained quartz, perthite, plagioclase, sheet-bearing book muscovite, and black tourmaline. Quartz occurs as irregular bodies containing patches of intergrown tourmaline. This core combines lithologic characteristics of zones 4, 5, and 6 of the table. In pegmatite 15, the wall zone encloses quartz-rich pods containing scattered muscovite books. These pods combine the mineralogic and textural features of zones 4 and 6.

Five pegmatites show lithologic units that do not correspond precisely to any of the seven principal lithologic types. In pegmatites 28, 29, 31, and 34 the wall zone contains biotite but no perthite. It therefore does not correspond precisely with type 4. In pegmatite 1 the wall zone contains biotite. With these exceptions, the sequence of lithologic units in the group of pegmatites is remarkably consistent.

Of the 31 pegmatites for which zone sequences, complete or incomplete, are tabulated, 27 consist essentially of quartz, plagioclase, perthite, and muscovite, with or without biotite, in various proportions. These pegmatites differ primarily in the number of zones present and in the distinctness of zones. In some of the pegmatites zone boundaries are sharp; in most, however, the zones grade into one another. The other four pegmatites for which zone sequences are given appear to lack perthite, or perthite and biotite. However, none of these pegmatites is fully exposed, and perthite and biotite may well be present in concealed parts or in parts removed by erosion. On the whole, the resemblances among the various pegmatites are far more impressive than the differences, and it seems probable that the pegmatites belong to a single genetic group. Further work is needed to determine the causes of differences and seeming differences in zonal development.

Occurrence of sheet-bearing mica in the pegmatites.—Sheet-bearing mica is found chiefly in 2 of the 6 lithologic types of zones given in the table. In 4 pegmatites (and possibly in 2 others) it is found in zone 1–a. In 13 pegmatites (possibly 15), it is found in zone 4, and in 6 other pegmatites it is found in telescoped units that appear to be combinations of zone 4 with 1 or more other units. Sheet-bearing mica occurs in zone 2 in 1 pegmatite in which the content of sheet-bearing mica books is very low, and in zone 3 in 1 pegmatite (no. 37) in which the books are small, thin, and of questionable sheet content. Sheet-bearing mica is present in zone 5 only in 1 pegmatite (no. 33), and in this body the books occur only in the outer part of the core adjacent to zone 4. Deposits of pegmatites containing sheet-bearing mica in zones 1–a and 4 have yielded most of the output of the area.

The mica deposits fall into 5 structural types: wall zone, intermediate zone (including core-margin zone), core, pod, and disseminated. Most of the known production of sheet mica has come from the intermediate-zone deposits of the nos. 1, 2, and 3 pegmatites. One pegmatite, no. 32, has furnished a moderate or large output from wall and core deposits combined. Small to moderate amounts of sheet mica have come from several wall-zone deposits and several core deposits. In general, production from disseminated and pod deposits has been small. Data on recovery of mine-run mica from the various deposits are incomplete, and no comparison of types on this basis can be made. The richest deposits in the area seem to be those of the intermediate-zone type, but deposits of any one type appear to range widely in content of book mica.

DESCRIPTIONS OF INDIVIDUAL PEGMATITES

Palermo No. 1 mine.—The Palermo mine (pl. 29, no. 1) was formerly one of the major mica-producing mines in New Hampshire, and a well-known source of mineral specimens (Sterrett, 1914, p. 72–74; 1923, p. 130–133; Berman, 1927, p. 170–172; Verrow, 1940, p. 329–330; 1941, p. 208–211; Frondel, 1941, 145–152). Most of the underground work was done prior to 1900, during a period of intensive operations lasting at least 20 years. Sterrett (1923, p. 132) reports that at one time 85 miners were employed and that all drill work was done by hand, mostly with single-hand drills. The underground workings leading from the south opencut (pl. 30) extend northeastward 270 feet from the end of the cut. It is reported that the lower parts of the workings slope 35° and that they extend about 150 feet vertically below present water level. An inclined shaft sunk from the floor of a small opencut at the northeast end of the pegmatite extended southeastward to the lower workings. The entrance of the shaft is now backfilled. The mine was idle until 1914, when it was purchased by the General Electric Co., Schenectady, N. Y., the present owners, who pumped the workings to a depth of 60 feet below present water level and discovered that most of the pillars had been removed from the lower stopes. Apparently the General Electric Company mined the eastern part of a sheet mica-bearing zone in the upper part of the western stope during 1914–15. Waste rock was dropped into the lower part of the stope. At some time after 1920, the opencut at the north end of the outcrop was made during operations for feldspar.

In 1942–43, the General Electric Co. sank a 15-foot shaft in the bottom of the north cut and made the small cut at the northeast corner of the outcrop. The cut at the east contact and the small cut for beryl in the center of the outcrop were also made at this time, and the dumps were worked for mica that had been discarded during earlier operations.

The vicinity and surface workings of the mine were mapped by J. B. Hadley and F. H. Main in July 1944, and the accessible underground workings were mapped by A. H. McNair and F. H. Main in April 1945 (pl. 30).

The Palermo No. 1 pegmatite has a roughly oval outcrop, 160 by 220 feet, on the top and south side of a low knob. The pegmatite is apparently also broadly oval in cross section. It strikes N. 34° E., dips 40°–55° SE., and plunges NE. 35°–55°. It extends beneath wall rock northeastward along its plunge at least 100 feet beyond the northern outcrop. Most of the eastern contact is concordant with the foliation of the wall rock, quartz-mica and quartz-mica-sillimanite schist of the Littleton formation, but at other places the body is discordant. In surface plan the pegmatite is oval with a short tail-like extension formed by the pegmatite in the south cut.

The pegmatite has six zones. A border zone is present along the southeast, east, and north sides of the outcrop, is 2 to 4 inches thick and consists of fine-grained quartz, muscovite and oligoclase (An_{12}). It is absent along the western and southwestern sides of the outcrop, where the quartz-plagioclase zone described below grades into partly assimilated wall rock.

The wall zone contains medium-grained albite (An_7), quartz, muscovite, and minor biotite and tourmaline. It is present only along the eastern contact. It has a maximum thickness of 2 feet and contains small amounts of sheet-bearing muscovite. The quartz-plagioclase zone (first intermediate zone) forms a complete shell, 5 to 25 feet thick, around the inner part of the body. It is in contact with the wall rock where the border zone and wall zone are absent. The zone consists cheifly of medium-grained quartz and albite (An_7), but also contains perthite, muscovite, biotite, black tourmaline, lazulite, pyrite, and chalcopyrite. Scattered muscovite books as much as 6 inches in diameter, intergrown in part with biotite, are present in the zone at a few places.

A second intermediate zone of medium-grained albite (An_2), quartz, and sheet-bearing muscovite is exposed along the steep southern edge of the outcrop and apparently forms a spoon-shaped unit along the under side of the core. The underground workings are believed to have followed this zone. It is 2 to 3 feet thick in the northwest part of the stopes but does not crop out on the surface on the west, north, or east side of the pegmatite, and apparently it pinches between the upper part of the west stope and the surface. The zone must have been thicker and richer in muscovite in the lower part of the old stopes than it is in the upper part of the west stope, as Sterrett (1923, p. 132) reports that one room in the underground working was at least 60 feet long, 30 feet wide, and 35 feet high. It seems that mining was discontinued in the west stope as the zone narrowed and decreased in mica content, because the zone does not have a high mica content in most places in the roof of the stope. The muscovite in the zone is rum to ruby, hard, and free splitting; some books are marred by reeves and rules. The books in the upper part of the zone average 5 inches in diameter and are an inch thick. Sterrett (p. 132) reports that a few giant muscovite books, as much as 4 feet in diameter and 2 feet thick, were taken from the mine.

The core-margin zone, or perthite zone, is exposed in the north cut. It is hood- or cap-shaped, lying over the top of the core and extending farther down the west flank of the core than the east flank. Most of the zone seems to have been removed by erosion and mining. It is 25 feet in maximum thickness and consists of large perthite blocks containing small amounts of quartz and small yellow-green muscovite flakes. Most of the perthite blocks on the under side of the hood have crystal faces that project into the upper part of the quartz core.

The core is centrally located and consists of perthite euhedra as large as 4 by 8 by 6 feet embedded in massive quartz, irregular bodies of bronze-colored scrap mica, masses of triphylite and graftonite that reach a maximum of 15 by 7 by 4 feet, and scattered clusters of blue-green beryl with minor amounts of many other minerals. The chief minerals of the core are quartz, perthite, and blue-green beryl. These seem to have been the earliest formed constituents, but they are cut and apparently partly replaced by aggregates of wedge-mica and cleavelandite (An_2) and by the large bodies of triphylite, and graftonite. The rare minerals obtained by Frondel and Verrow from the dump appear to have been formed in the core in close proximity to wedge-mica and triphylite bodies. Frondel (1941, p. 145) described whitlockite (a rare phosphate) from specimens taken from the dump and identifies the following minerals: rhodochrosite, apatite, zeolite, amblygonite, lazulite, triphylite, heterosite, vivianite, dufrenite, graftonite, and cyrtolite. Verrow (1941, p. 208–211), in addition to the minerals listed by Frondel, mentioned siderite, gummite, uranophane, autunite, pyrite, lollingite, ferrisicklerite, golden beryl, fairfieldite, psilomelane, manganite, limonite, and melanterite. The triphylite masses are most abundant in the upper part of the core, immediately below the perthite zone. Blue-green beryl crystals occur in quartz chiefly in "nests" in the upper part of the core. One beryl crystal, as shown by its mold in quartz, was 3½ feet in diameter and at least 6½ feet long. The blue-green beryl crystals seem to have ended abruptly against scrap muscovite and triphylite. The golden-yellow beryl found in the scrap-muscovite bodies truncates both cleavelandite and scrap muscovite and seems, therefore, to be younger than the blue-green beryl. Sterrett (1923, p. 133) found zinnwaldite in the dump, and presumably the mineral was formed in the core.

Apparently, the Palermo mine produced a large quantity of muscovite. The underground workings are mostly either backfilled or flooded and are said to be largely unsupported by pillars. The quantity of mica-bearing rock remaining in the lower part of the pegmatite is unknown; the muscovite content of the upper part of the sheet-bearing muscovite zone in the west stope is low, and because the zone pinches out between the stope and the surface it probably contains no large quantity of muscovite. The wall zone, containing scattered muscovite books, is present in places along the southeast, east, and north sides of the outcrop, but the insufficient yield of mica in 1942–43 from this zone discouraged further mining.

Blue-green beryl occurs as scattered crystals clustered in the core. One cluster of crystals, removed from the small central cut in 1943, yielded about 35 tons of beryl. It is possible that low-cost mining of the core for beryl, scrap-muscovite, perthite, and quartz might be successful if carried out during a period when prices for one or more of the products are high.

In addition to the replacement bodies in the core, a replacement body of cleavelandite (An_2) and scrap muscovite, 2 to 4 feet thick, separates the intermediate sheet-mica bearing zone from the core in the accessible parts of the underground workings. This unit grades in texture and composition into the underlying sheet-mica zone and consists of irregular lobes of platy white cleavelandite as much as 8 feet long and 3 feet thick. Most of the lobes are bordered by rims of small bronze-colored wedge-muscovite books. The outer part of each lobe consists of cleavelandite plates normal to the surface of the lobe, which therefore has a distinct radial structure. The inner parts of each lobe contains smaller, more compact, and random-oriented cleavelandite plates and small muscovite flakes. The cleavelandite lobes in some places have irregular patches of scrap muscovite separating them, but in most places are separated by the massive quartz of the core. The lobes show all stages in the replacement of the core, from small patches containing a few plates to larger lobes that cut the quartz core, have an outer radial structure, and are rimmed by scrap muscovite. One lobe, exposed on the east side of the western stope and rimmed by wedge mica, cuts across several euhedral blue-green beryl crystals embedded in the quartz of the core and is itself cut by a thin stringer of later quartz. The quartz-cleavelandite replacement body does not outcrop at the surface, and its relations to the quartz-plagioclase and perthite zones next described are unknown.

The intermediate sheet mica-bearing zone is separated from the core along the upper part of the south face of the outcrop by a unit that is 2 to 5 feet thick and consists of medium-grained quartz and plagioclase. This unit occupies the same position as the cleavelandite-muscovite unit and might be a lateral variation of it, but because the zone does not contain cleavelandite lobes and does not seem to have formed by replacement of the core, it is described and mapped separately.

Palermo No. 2 mica mine.—A small opencut was made in the Palermo No. 2 pegmatite (pl. 29, No. 2) sometime prior to 1900. In 1942 the General Electric Co., Schenectady, N. Y., started work at the cut, enlarged it to its present size, and sank two short inclines from the floor. Work was discontinued in July 1944, and both inclines are now filled with water. The mine was examined periodically during development in 1942–43 by D. M. Larrabee, and was mapped by A. H. McNair and J. H. Chivers in May 1943. Progress maps of the workings were made by V. E. Shainin and E. N. Cameron during 1943–44 and the mine was remapped by McNair and F. H. Main in April 1945 (fig. 86).

The No. 2 pegmatite is about 1300 feet long and ranges from 20 to 150 feet in width; it is widest in the vicinity of the opencut. It strikes in general N. 20° E. and dips 80°–85° E., and it is concordant with the foliation of the wall rock, quartz-mica schist of the Littleton formation, throughout most of its length. It has several narrow apophyses that project short distances into the wall rock.

The pegmatite is zoned, but the zones are not sharply defined. The border zone, 2 to 3 inches thick and composed of fine-grained quartz, plagioclase, and muscovite, seems to grade both into the wall rock and into the wall zone. The wall zone, 2 to 8 feet thick in the vicinity of the cut, contains medium-grained plagioclase, quartz, subordinate perthite, and small muscovite books intergrown with biotite and black tourmaline. In the northern outcrops, where the wall zone constitutes all of the inner part of the body, it is fine- to medium-grained and contains much aplitic material. The zone is gradational into the outer intermediate biotite-bearing zone, which contains medium-grained perthite, quartz, biotite, and minor greenish plagioclase.

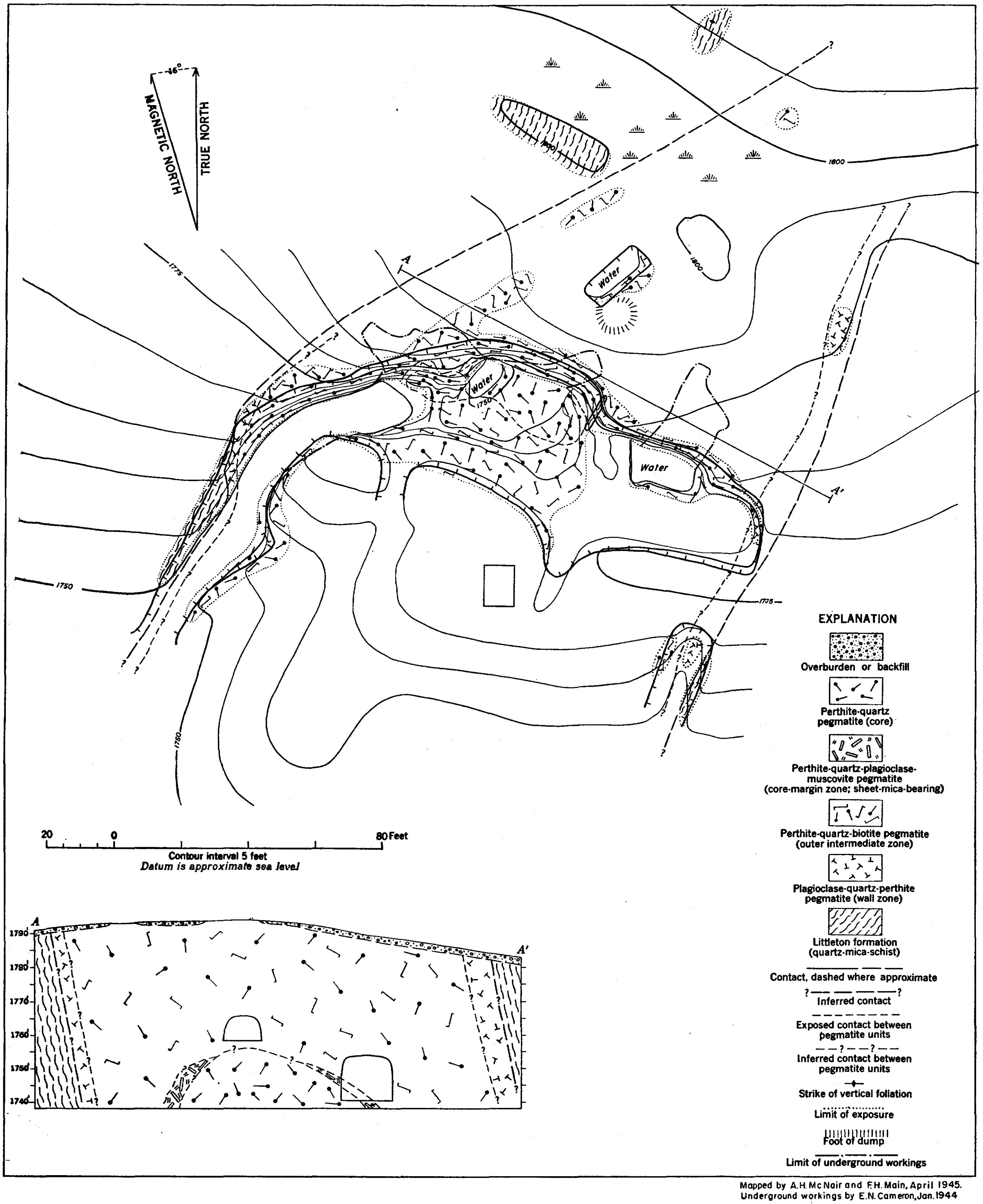


FIGURE 86.—Geologic map and section of the Palermo No. 2 mine, Groton, N. H.

The biotite zone is characterized by thin chloritized biotite strips that are as much as 6 feet long, and it contains small masses of triphylite and vivianite, together with a few blue-green and yellow beryl crystals. The biotite zone forms a complete hood over the pegmatite exposed in the bottom of the open cut and extends down the flanks of the core below the level of the lowest workings. The eastern flank of the zone is considerably thicker than the western flank.

A persistent but poorly defined core-margin zone is present along the sides of the core but does not extend over the top. It consists of medium-grained perthite, quartz, and plagioclase, irregularly scattered clusters of small sheet-bearing muscovite books, and small masses of triphylite and vivianite. Most of the mica obtained from the mine in 1942–44 was taken from this zone. The mica was rum to ruby, free-splitting, ruled, and reeved; it yielded only a low percentage of small and medium-sized sheet mica. It is estimated that the recovery of mine-run mica during 1942–44 was less than 2 percent of the total rock moved.

The core, consisting chiefly of coarse-grained perthite, quartz, and graphic granite, is exposed only in the lower part of the workings. The perthite is considerably iron stained, and most of the crystals have euhedral faces and project into adjacent quartz. Most of the staining of perthite in the upper part of the core seems to be due to iron oxide derived from the biotite zone, and it is likely that perthite relatively free from stain is present below the top of the core. The top of the core seems to plunge 10°–15° NE. and might extend northeast of the cut. The extent of the core down dip is not known.

The core-margin zone differs considerably in mica content from place to place, being richest adjacent to quartz-rich parts of the core and lean or barren adjacent to feldspar-rich parts. Further operations for mica alone would probably not be profitable under conditions comparable to those of 1942–44 for, owing to the dip of the productive zone, mining would be largely underground and costs would increase. Opencut mining for feldspar and mica might be profitable during a period of high prices for one or both of these minerals.

Palermo No. 3 mica mine.—The General Electric Co., Schenectady, N. Y., began operations at an old prospect pit in pegmatite no. 3 (pl. 29, no. 3) in June 1943 and made two interconnected opencuts, a southwest cut 78 feet deep and a northeast cut 48 feet deep. Work was discontinued in October 1944. Both cuts contain water but are not backfilled. The mine was mapped by V. E. Shainin in October 1944 and visited periodically during 1943–44 by E. N. Cameron, G. W. Stewart, and A. H. McNair (fig. 87).

The Palermo No. 3 pegmatite is not well exposed. It can be traced along strike for 480 feet and is about 35 feet thick in the vicinity of the cuts. It strikes in general N. 30° E., seems to dip steeply southeast, and is concordant with the foliation of the wall rock, which is quartz-mica schist of the Littleton formation. The contacts of the body are regular and sharp, except for a narrow projection of schist that extends into the pegmatite at the northeast side of the working. Wall rock exposed in the northwest corner of the workings seems to be the footwall; the hanging wall is exposed only in the northeast corner of the workings.

The pegmatite has a persistent but poorly defined zonal structure that was recognized only when the distribution of muscovite was plotted on production maps made during repeated visits to the mine. The sections showing the restored geology of the cuts (fig. 87) are diagrammatic, but they indicate in general the internal structure of the pegmatite.

A border zone 1 to 4 inches thick, of fine-grained quartz, muscovite, and plagioclase lies adjacent to the contacts. It grades into a medium-grained wall zone consisting chiefly of plagioclase, perthite, quartz, biotite, and muscovite with small amounts of blue-green beryl, black tourmaline, and intergrown triphylite and graftonite. Some of the plagioclase in the wall zone is blue-green when freshly broken, but most is white. In the crosscut between the two cuts, the triphylite-graftonite intergrowths, altered in part to vivianite, formed a body 2 by 3 feet in area rimmed by a band of diversely oriented biotite flakes 2 to 4 inches thick. The wall zone shows a great range in thickness, and in places where the core is absent, it extends across the whole width of the body. Most of the muscovite in the zone is in thin books and is intergrown with biotite. It could not be used for sheet.

The sheet-mica bearing core-margin zone is composed chiefly of medium-grained plagioclase, perthite, and quartz, but it contains scattered books of sheet-bearing muscovite and small amounts of intergrown triphylite and graftonite. The zone is distinguished from the wall zone by the presence of relatively large muscovite books and by the absence of biotite. Parts of the zone removed from the cut ranged from 12 inches to 6 feet in thickness and varied greatly in mica content. The zone pinches out or loses its muscovite content at both the southwest and northeast ends of the workings.

The core, consisting chiefly of coarse-grained quartz, perthite, and plagioclase, is discontinuous. In the vicinity of the cuts it has a maximum thickness of 5 feet, and it seems to have been more persistent in the upper and middle parts of the workings than in the lower part. In places irregular bodies of graphic granite, perthite, blue-green plagioclase and quartz make up most of the core, and in these places the mica zone has a relatively low mica content. The sheet-

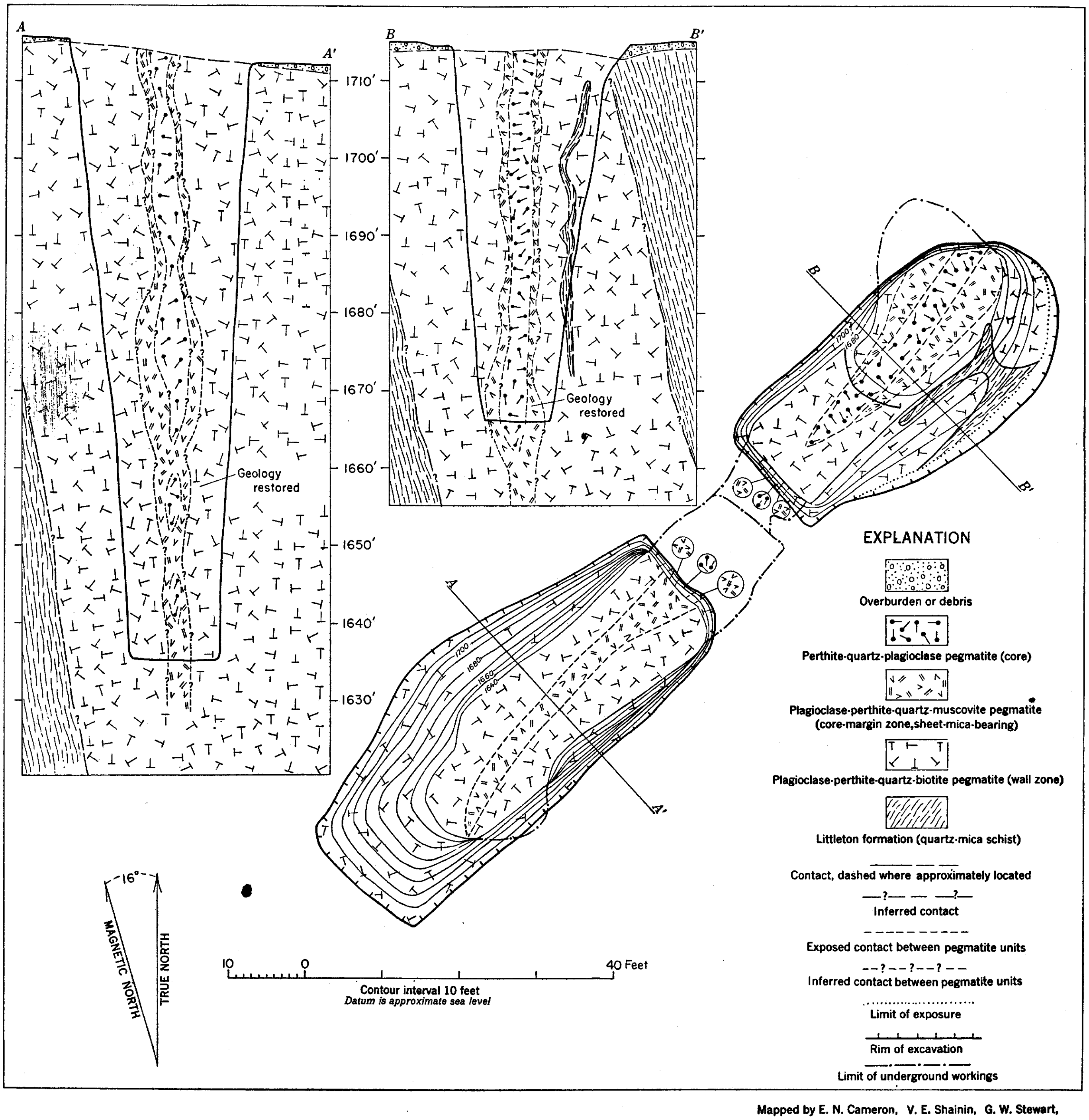


FIGURE 87.—Geologic map and sections of the Palermo No. 3 mine, Groton, N. H.

bearing mica zone is most sharply defined (and contains most mica) adjacent to the thicker and more quartz-rich parts of the core.

The muscovite obtained from the mine in 1942–44 was rum and ruby, hard, free-splitting, reeved, and ruled. Sheet mica recovered was mostly small and medium-sized. The average recovery of sheet mica from crude mica was low, and the recovery of crude mica from rock moved was low. The yield of the southwest cut was somewhat higher than that of the northeast cut.

The Palermo No. 3 mine yielded a considerable quantity of muscovite from a lean core-margin zone. As the zone appears to be richest in mica in the vicinity of the cuts, future production from the mine will probably depend on the downward extent of the mica zone. Mining costs will undoubtedly increase with the depth of the workings.

Pegmatite No. 4.—Pegmatite no. 4 (pl. 29) is 5.5 feet wide, and can be traced for 60 feet along strike. It is slightly discordant to the wall rock foliation and consists of fine-grained quartz, muscovite, plagioclase, and tourmaline. The central part, somewhat coarser grained than the margins, contains muscovite books as much as one inch in diameter in irregular patches of quartz-rich material.

Pegmatite No. 5.—Pegmatite no. 5 (pl. 29) 8 feet wide, is exposed for 30 feet along strike and is discordant to the foliation of the schist. It is composed of fine-grained quartz, plagioclase, muscovite, and black tourmaline. No sheet-bearing mica is present.

Pegmatite No. 6.—Pegmatite no. 6 is exposed in a deep opencut, 70 feet long, at the north edge of the map area (pl. 29). It is 6 to 12 feet thick, strikes N. 10° E., dips 72° SE., and is concordant with the wall rock. The footwall has strong rolls plunging 60° SSE. The northeast end is covered by dump, and the pegmatite pinches at the surface a short distance southwest of the face of the cut. A steep eastward-dipping fault lies a few feet east of the hanging wall contact. Except for a border zone, 6 inches to 2 feet thick, the pegmatite consists of medium-grained quartz, plagioclase, muscovite, and black tourmaline. Muscovite books as much as 10 inches in diameter are sparsely disseminated in the medium-grained pegmatite. Most of the books are of good quality although some are reeved and curved.

Pegmatite No. 7.—Pegmatite no. 7 (pl. 29) is 2 to 4 feet wide and can be traced by scattered outcrops along strike for 350 feet. The pegmatite is thickest at its north end, where it contains a border zone 6 inches thick, a wall zone of fine-grained quartz, plagioclase, and subordinate muscovite 1 foot thick, and a medium-grained core of quartz, plagioclase, scattered muscovite books as much as 4 inches across, and black tourmaline. The thinner southern part of the pegmatite is similarly zoned, except that the core is not continuous and contains less muscovite.

Pegmatite No. 8.—Pegmatite no. 8 (pl. 29) poorly exposed in a cut 60 feet long, was mined for a short time in 1943. It is 5 to 8 feet wide and is sharply discordant to the wall rock. Remnants of pegmatite on the walls of the cut consist of medium-grained quartz, plagioclase, and muscovite. Recovery of mica from rock mined during operations in 1943 was not sufficient to encourage further work.

Pegmatite No. 9.—Pegmatite no. 9 (pl. 29) is 6 to 30 feet wide and is exposed in places for 450 feet. It is fine- to medium-grained and appears to contain no book mica.

Pegmatite No. 10.—Pegmatite no. 10 (pl. 29), 30 feet wide, is exposed for 100 feet along strike. The eastern contact is nearly vertical, and the western contact also dips steeply, 50° to 70° E. It consists of quartz, plagioclase, perthite, and minor muscovite, biotite, garnet, blue green apatite, and black tourmaline. Book mica is said to have been recovered from small cuts made along the hanging wall in 1942. The quantity of muscovite recovered did not justify further work. No book muscovite was visible in 1944.

Pegmatite No. 11.—Pegmatite no. 11 (pl. 29) has a circular outcrop about 40 feet in diameter. It is discordant to the wall rock and has a steep northeast plunge. The border zone, 2 inches thick, contains quartz, scrap muscovite, and plagioclase. A wall zone, 1 to 2 feet wide and composed of quartz, plagioclase, and book mica, is present along the north wall of the pegmatite. The interior of the pegmatite consists chiefly of medium-grained quartz, plagioclase, perthite, and muscovite. Small bodies of quartz are scattered through this material, and there is a narrow discontinuous zone of coarse perthite near the north wall of the pegmatite. Irregular patches of aplitic material and tourmalinized schist occur in the inner part of the pegmatite. Mica books yielding good sheet mica are present in the wall zone, but books found scattered throughout the interior, chiefly in the quartz-rich parts, are too small to yield sheet mica.

Pegmatite No. 12.—Pegmatite no. 12 (pl. 29) exposed in places along strike for 400 feet is an irregular lens concordant with the foliation of its wall rock. It contains a thin garnetiferous border zone and a core composed of medium-grained quartz, perthite, plagioclase, and muscovite and is somewhat coarser grained near the center of the body than at the margins. The muscovite books are small and widely scattered, and would not yield sheet.

Pegmatite No. 13.—Pegmatite no. 13 (fig. 88) exposed sporadically for 950 feet, is about 30 feet wide, except for a central bulge as much as 100 feet wide. The body is concordant with the wall-rock foliation at most places and has many bulges around which the schist is bent. The contacts in general dip inward, and this suggests that the upper half of an originally lens-shaped body has been removed by erosion. A fine-grained border zone is present in most places along the contact with the wall rock. The wall zone, containing medium-grained quartz, perthite, and plagioclase, forms the interior of the narrower parts of the pegmatite and an irregular marginal band around the inner part of the pegmatite in the bulge. Irregular patches of quartz-perthite-plagioclase-muscovite pegmatite, containing

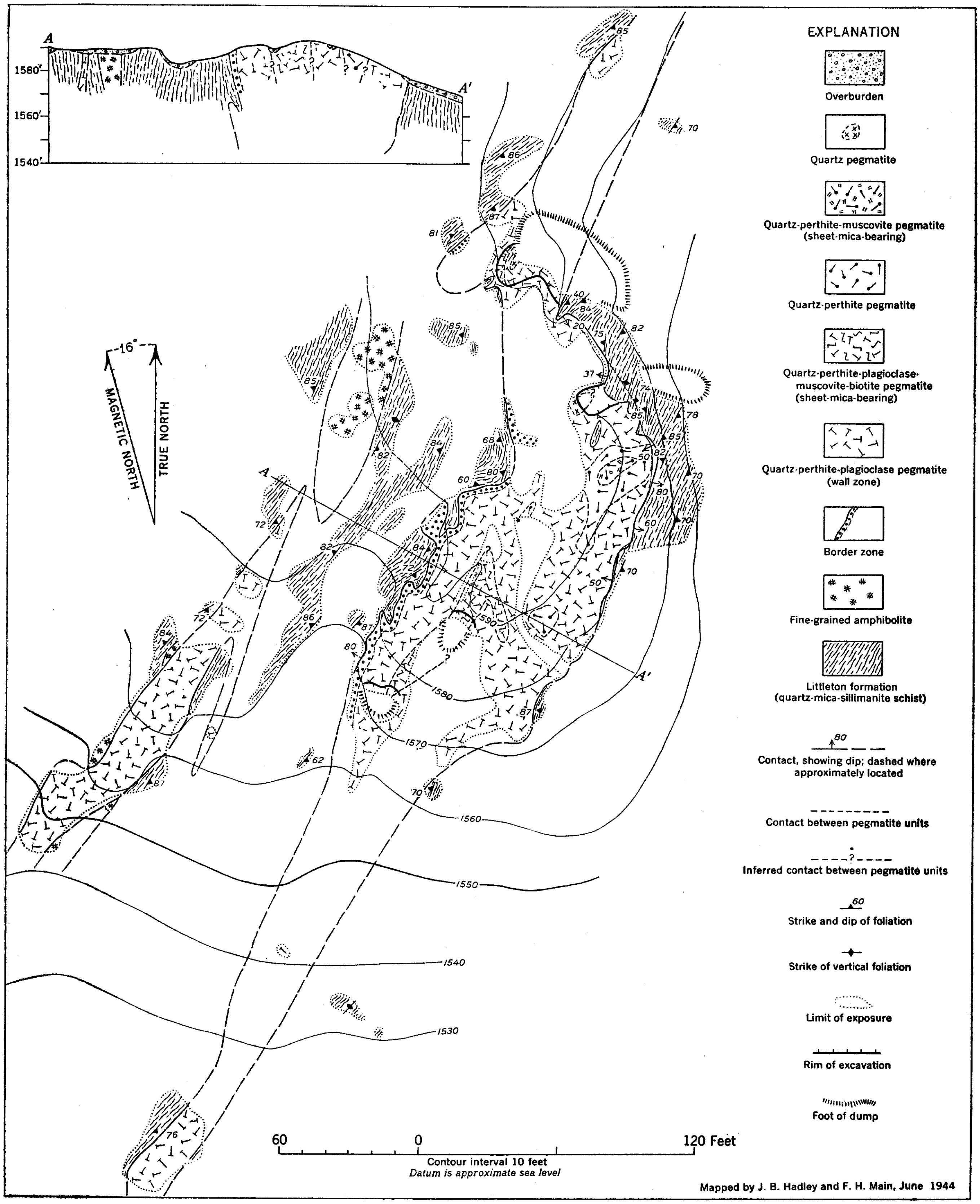


FIGURE 88.—Geologic map and section of pegmatite no. 13, Rice-Palermo area, Groton, N. H.

biotite probably represent an intermediate zone, and small pods of quartz or perthite, or both, are exposed in the central part of the bulge. Sheet-bearing muscovite, intergrown with biotite, occurs in the inner parts of the body or as separate books associated with the quartz pods. The books are small, and not much sheet mica could be obtained from them. Two small prospect pits made in 1944 did not yield sufficient muscovite to encourage further work.

Pegmatite No. 14.—Pegmatite no. 14 (pl. 29) is irregular and for most of its length is discordant to the foliation of the wall rock. The northern part consists of fine-granular quartz and feldspar containing a few patches of medium-grained quartz, plagioclase, and muscovite. The central part is medium-grained, seems to be unzoned, and contains quartz, plagioclase and small books of muscovite. The southern part of the body is covered with overburden.

Pegmatite No. 15.—Pegmatite no. 15 (pl. 29) is lens-shaped and concordant with the wall rock foliation. It consists of medium-grained quartz, plagioclase and perthite and small quartz-rich pods containing sparse muscovite books as much as 2 inches in diameter.

Pegmatite No. 16.—Pegmatite no. 16 (pl. 29) was worked for a short time when an old cut was enlarged. The pegmatite can be traced for 70 feet along strike and is at least 27 feet wide. Its trend is northwest, sharply discordant to the foliation of the enclosing mica quartzite. The pegmatite contains a thin border zone; a wall zone of quartz, plagioclase, and sheet-bearing muscovite; and a core of coarse-grained perthite, graphic granite, and quartz. Much apatite is found with the biotite, and small quantities of triphylite and sulfides were found on the dumps. Considerable crude muscovite was obtained from the cut in 1944, but the small percentage of sheet recovered from it did not justify further work.

Pegmatite No. 17.—Pegmatite no. 17 (pl. 29) is very poorly exposed. It is fine- to medium-textured, seems unzoned, and does not seem to contain sheet-bearing muscovite.

Pegmatite No. 18.—Pegmatite no. 18 (pl. 29) was worked for a short time in 1944 by extending an old cut. The pegmatite, 20 feet wide and exposed for 40 feet along strike, has a steep eastward dip. It has a thin fine-grained border zone, a wall zone composed of medium-grained quartz and plagioclase (with small quantities of scrap muscovite), and a core 1 to 10 feet thick, composed of coarse-grained quartz, perthite, plagioclase, and sheet-bearing muscovite. The muscovite books range from 3 inches to more than 1 foot in diameter and are as much as 1½ inches thick. They are mostly flat, compact, and nearly free of ruling, but some are tanglesheet. In 1944, most, if not all, of the sheet mica-bearing core was mined out.

Pegmatite No. 19.—Pegmatite no. 19 (pl. 29 and fig. 89) is 250 feet wide and cuts micaceous quartzite. It dips about 75° NE. A border zone 1 to 2 feet thick is adjacent to the southeast contact. The wall zone, composed of medium-grained quartz and plagioclase, is highly varied in thickness. The interior of the body contains a number of poorly exposed pegmatite units. Small local areas of quartz-plagioclase-biotite-sheet muscovite pegmatite are exposed in the north part of the body near irregular patches of quartz and perthite. Several small quartz bodies are also exposed. Three small test pits made in the pegmatite in 1943 yielded a small quantity of strongly ruled muscovite.

Pegmatite No. 20.—Pegmatite no. 20 (pl. 29), 220 feet long and 110 feet wide, forms a low knob southwest of pegmatite no. 19. It trends northwest and is sharply discordant to the enclosing micaceous quartzite. Only the southwest edge of the body is well exposed, but the pegmatite seems to resemble pegmatite no. 19 in structure and composition. A small prospect pit made in the northeast edge of the pegmatite in 1944 yielded only a few books of mica of poor quality.

Pegmatite No. 21.—Pegmatite no. 21 (pl. 29 and fig. 90) is irregular and sharply discordant to the foliation of the enclosing micaceous quartzite. Only the northeast contact, with the border zone of the pegmatite, is well exposed along an eastward-facing cliff, where it dips 65°–75° NE. Most of the outcrop consists of medium-grained pegmatite containing muscovite and biotite, but, apparently, muscovite is most abundant near central patches of coarse-grained perthite and quartz. Three prospect pits made in the permatite in 1944 yielded only a few badly ruled books.

Pegmatites Nos. 22 and 23.—Pegmatites no. 22 and no. 23 (pl. 29) are small irregular bodies that are sharply discordant to the wall rock, fine- to coarse-grained, and devoid of sheet-mica concentrations.

Pegmatite No. 24.—Pegmatite no. 24 (pl. 29) is a very irregular body that in places is sharply discordant to the wall-rock foliation. It crops out in two parts separated by a thin band of schist. Each part has a wall zone composed of medium-grained pegmatite and enclosing small pods of quartz and perthite. A few small muscovite books are present along the margins of one of the pods in the southern part of the body.

Pegmatite No. 25.—Pegmatite no. 25 (pl. 29), poorly exposed in an area 40 by 100 feet, is discordant to the enclosing micaceous quartzite. The pegmatite consists of medium-grained quartz, plagioclase, and perthite. without visible systematic arrangement. Muscovite is

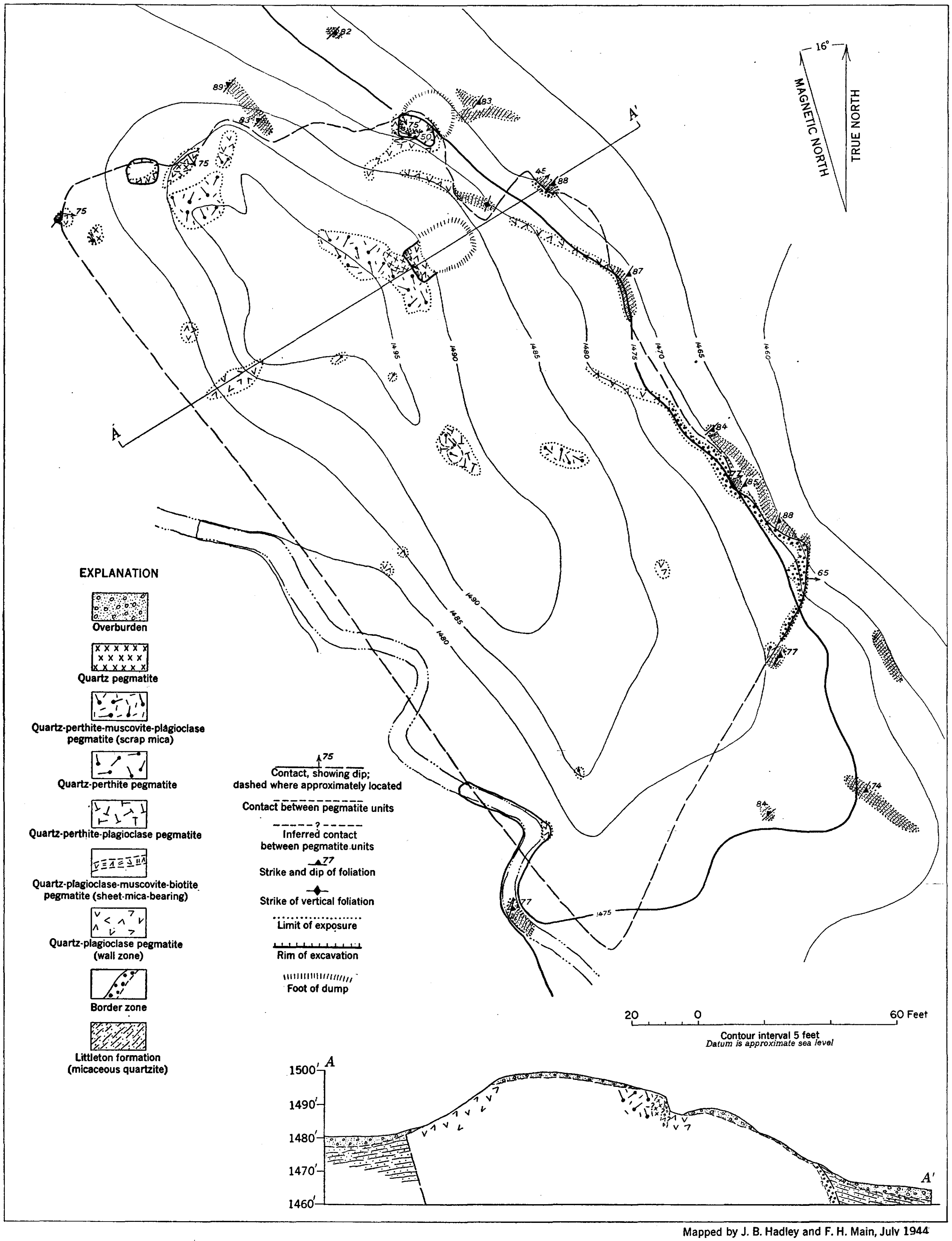


FIGURE 89.—Geologic map and section of pegmatite no. 19, Rice-Palermo area, Groton, N. H.

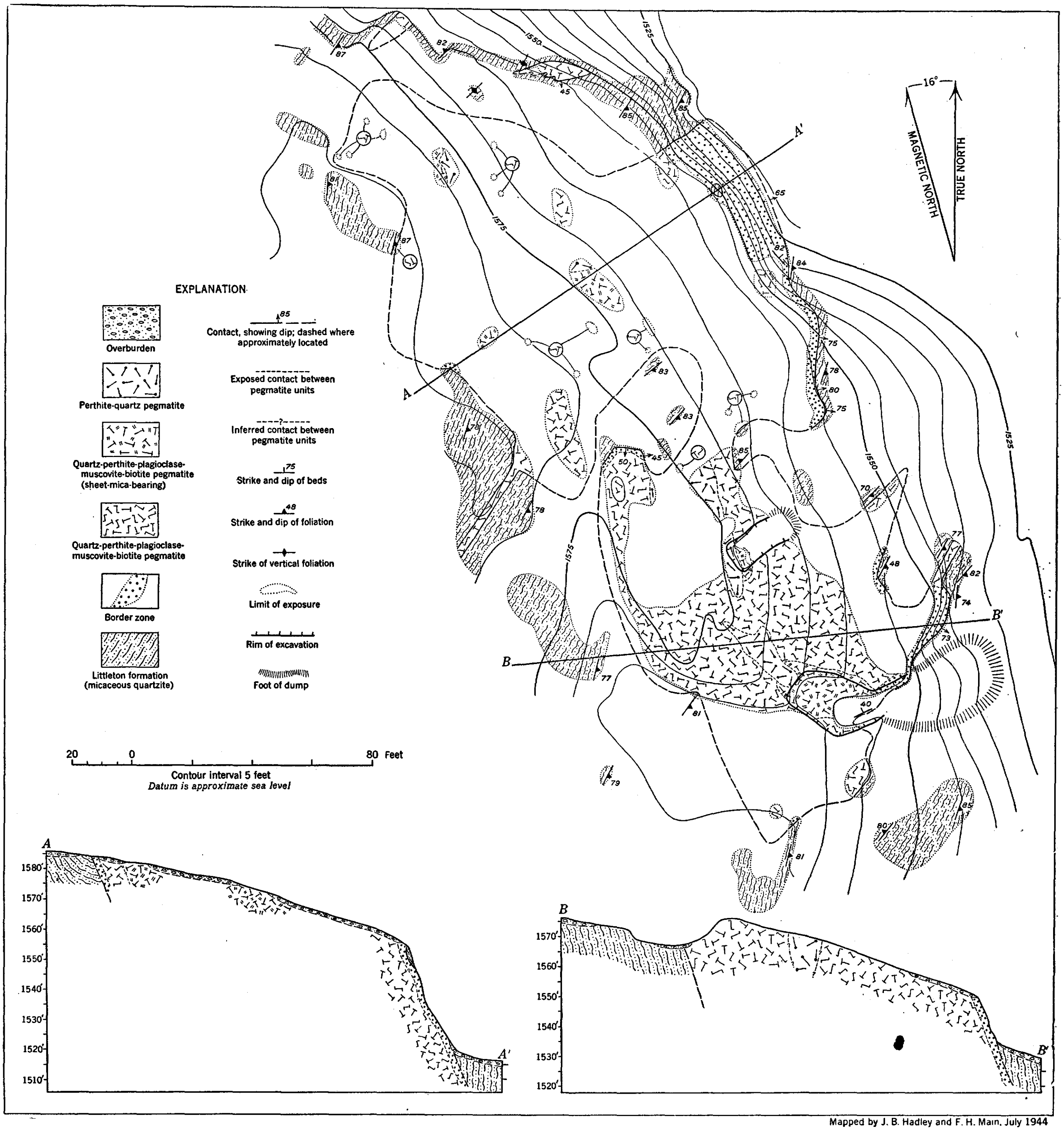


FIGURE 90.—Geologic map and sections of pegmatite no. 21, Rice-Palermo area, Groton, N. H.

not abundant, and the few books exposed are small. An aplite body 25 feet wide and 100 feet long, which borders the pegmatite on the southeast, appears to be a separate intrusive, although the relations of the two bodies are not well exposed.

Pegmatite No. 26.—Pegmatite no. 26 (pl. 29) is 270 feet long and 4.5 feet thick at its north end. It dips 85° E. and is concordant to the wall rock foliation. The border zone is 2 to 4 inches thick and composed of quartz, muscovite, and scrap mica. The muscovite nearest the contact is arranged in plumose aggregates normal to the walls. The border zone grades inward into a wall zone of medium-grained quartz, plagioclase, and muscovite. The core consists of coarse-grained quartz, perthite, plagioclase, muscovite, and black tourmaline. The quartz occurs as irregular bodies containing patches of intergrown tourmaline. Muscovite forms rum to ruby books that are 3 inches or less in diameter and are scattered throughout the core. The larger books are so reeved and cracked that only a low percentage of small-sized sheet could be obtained from them. A small prospect pit in the north end of the pegmatite was made in 1944 but yielded so little muscovite that operations were soon halted.

Pegmatite No. 27.—Pegmatite no. 27 (pl. 29), the largest pegmatite in the Rice-Palermo area, is more than 1,000 feet long and has a maximum thickness of 180 feet. It strikes N. 70° E., is almost vertical, and is sharply discordant to the wall-rock foliation. The pegmatite is poorly exposed, and although the scattered outcrops and old prospect pits reveal that the body has a zonal structure, the details are not discernible. In general, the northwest side consists of fine-grained pegmatite and aplite, whereas the center and southeast side consist of coarse-grained pegmatite. One of the old prospect pits near the center of the body contains muscovite books adjacent to a body of coarse-grained quartz and perthite. The extent of the quartz-perthite body could not be determined. If the pegmatite contains a large central perthite-rich core, it might be mined for perthite.

General description of the pegmatites of the Rice mine.—The Rice mine consists of workings in 11 pegmatites, nos. 28 to 38 of plates 29 and 31.

The mine was opened in 1897 by C. A. Smith of Groton and was operated intermittently on a small scale until 1940. The General Electric Co., Schenectady, N. Y., present owners, worked it from 1940 until the spring of 1941 and made most of the cuts. Small prospect pits in pegmatites no. 30 and no. 34 were excavated and the cut in pegmatite no. 32 was extended about 10 feet southward during the summer of 1943. The mine was not operated during most of the war period. It was mapped by A. H. McNair and J. Chivers in June 1943, and revisited by A. H. McNair in April 1945.

The pegmatites strike, in general, N. 20° E. and are nearly vertical. They are lenticular bodies that are in echelon and have strong mineralogical and structural similarities. Near the mines the foliation of the wall rock, quartz mica and sillimanite schist, strikes N. 10° E. and dips roughly 80° E. Lineation, where observed, plunges 60° SE. to 55° SW. All of the pegmatites are generally concordant to the foliation of the wall rock, and the contacts of at least three pegmatites are concordant even at the blunt ends of the bodies.

Pegmatite No. 28.—Two small prospect pits were made in pegmatite no. 28 in 1941. The pegmatite, exposed for 140 feet along strike, is 8 to 13 feet wide, strikes N. 20° E. and dips 75° E. The border zone, 2 to 6 inches thick, consists of fine-grained quartz, muscovite, and plagioclase. The muscovite commonly occurs as plumose aggregates that are arranged normal to the contact and expand inward. The wall zone, 1 to 3 feet thick, consists of medium-grained plagioclase, quartz, small thin muscovite books intergrown with biotite, and minor pink garnet in small crystals. The core, 1 to 4 feet thick, consists of medium- to coarse-grained perthite, plagioclase, quartz, muscovite, and black tourmaline. Most of the quartz occurs as irregular bodies that occupy spaces between perthite and plagioclase subhedral crystals, but some of it is graphically intergrown with perthite and black tourmaline. The core seems to be least clearly defined near the ends of the pegmatite.

Free-splitting ruby muscovite books, from 2 by 2 to 6 by 8 inches across and as much as 1 inch thick, are scattered throughout the core. Although some books are reeved and mineral stained, it is believed that a satisfactory percentage of small-sized sheet could be obtained from them. It is estimated that the core contains 3 percent muscovite in books that average 3 inches in diameter and ¾ inch thick. As the core is thin and has a low mica content, and as the wall zone does not contain sheet-bearing mica books, the pegmatite probably could not be mined profitably for mica under 1942–44 conditions.

Pegmatite No. 29.—Three small cuts and three prospect pits were made in pegmatite no. 29 in 1940–41. The pegmatite is about 400 feet long and 10 to 30 feet thick. It strikes N. 10° W. and dips 75° to 85° E. The border zone, 2 to 8 inches thick, consists chiefly of quartz, but plumose aggregates of muscovite and small amounts of plagioclase are also present. The zone grades inward into the wall zone. This zone, 1 to 6 feet thick, is present along both walls and is composed of medium-grained plagioclase, quartz, biotite, muscovite, and garnet. Some of the plagioclase is graphically intergrown with quartz. Thin strips of biotite, in part intergrown with muscovite, in some places are as much as 6 feet long. The core, 1 to 18 feet thick, consists of coarse-grained perthite, plagioclase, quartz, muscovite, tourmaline, and graphic granite. Small intergrowths of tourmaline and quartz are common, and irregular quartz bodies which range from ½ by 2 to 4 by 12 feet in area of exposure are present in the core. Some of the quartz bodies contain sparsely distributed small green crystals of beryl.

The disseminated muscovite books in the core are rum-colored, small, and badly ruled and reeved; they probably would not yield a high percentage of sheet. It is estimated that the core contains less than 1 percent of muscovite. The low content of crude mica in the pegmatite and the small size and poor quality of the muscovite books discouraged mining during 1942–44.

Pegmatite No. 30.—A cut 55 feet long, 5 to 15 feet deep, and 6 to 10 feet wide was made in pegmatite no. 30 during the summer of 1943. The pegmatite is about 110 feet long and 6 to 10 feet thick. It strikes N. 10° E. and dips 80° E. It is lens-shaped, bending eastward at its north end, and is concordant to the foliation of the wall rock. Lineation in the wall rock near the pegmatite plunges 60° SE. The zonal structure in the body is similar to that of pegmatite no. 28, except that the core contains less perthite and tourmaline and more blocky plagioclase. Some of the perthite in the core is porous and contains small flakes of secondary light-green muscovite.

The scattered muscovite books in the core are rum to ruby, small, ruled, and reeved. It is estimated that the core contains 1 percent muscovite. The mica obtained from the pegmatite in 1943 was of fair quality, but the amount recovered was so small that operations were shortly abandoned.

Pegmatite No. 31.—A small opencut was made at the north end of pegmatite no. 31 in 1940–41, and the narrow crosscut trench which leads north from pegmatite no. 32 intersects the east wall of the pegmatite for a short distance. The pegmatite is about 300 feet long and 4 to 15 feet wide. It strikes N. 28° E. and has an irregular but nearly vertical dip. It is concordant with the foliation of the wall rock even at its north end, where it bends sharply eastward. In internal structure and mineral composition the pegmatite is similar to pegmatite no. 29, except that its core contains less quartz and muscovite.

Pegmatite No. 32.—An opencut 30 feet deep and a 30 foot crosscut tunnel leading to the bottom of the cut were made in pegmatite no. 32 prior to 1940. In 1940–41 the cut was enlarged to a length of 230 feet, a width of 4 to 18 feet, and a depth of 10 to 50 feet. A narrow crosscut trench leading to the cut was made at the north end, and the cut was deepened and extended southward to a basic dike that cuts obliquely across the pegmatite. In 1943 a small prospect pit revealed that although the pegmatite continued some distance south of the basic dike, it was narrow at the surface and did not contain abundant muscovite. The pegmatite has a length of at least 210 feet and is 1 to 10 feet in thickness. It strikes about N. 10° E. and has an irregular, nearly vertical, dip. It is poorly exposed in the cut, but thin patches of pegmatite on the walls of the cut and material on the dump indicate that the pegmatite contained white plagioclase, quartz, perthite, rum to ruby muscovite, and minor tourmaline, apatite, and small light-green scrap mica-bearing muscovite. The pegmatite removed from the cut seems to have had a border zone, a wall zone that was rich in plagioclase and muscovite and extended in most places to the center of the pegmatite, and a discontinuous core of perthite, quartz, muscovite, and plagioclase. It is reported that the pegmatite mined in 1940–41 contained large muscovite books scattered across the full width of the pegmatite. This supports the belief that the wall zone as well as the core contained muscovite. The muscovite was of good quality and a satisfactory amount of sheet was obtained from it. Information concerning the percentage of crude muscovite recovered from rock mined is not available.

The quantity of mica-bearing pegmatite that remains in the body could not be determined. The shallow prospect pit made in 1943 south of the three foot basic dike revealed that the pegmatite there is about 1 foot thick near the surface. It seems to increase in thickness downward and might extend at depth some distance south of the basic dike. The old tunnel that ends in pegmatite no. 39, if lengthened 35 to 40 feet, should intersect pegmatite no. 32 about 40 feet below the surface, if the pegmatite extends so far. The pegmatite in the floor of the opencut cannot be worked by deepening the cut because of danger of caving. A cribbed shaft located in the vicinity of the tunnel and extended as a vertical shaft below the floor of the cut might permit mining the remaining pegmatite.

Pegmatite No. 33—A small cut was made in pegmatite no. 33 prior to 1941. The pegmatite is about 90 feet long and 20 feet wide (shorter and broader than most pegmatites exposed at the mine). It strikes about N. 20° E. and has a steep eastward dip. The border zone, 2 to 10 inches thick, consists of fine-grained quartz, scrap muscovite, black tourmaline, and pink garnet. At the northeast corner of the cut, the border zone is composed of three 1½-inch bands separated by very thin bands of black tourmaline, pink garnet, and thin remnants of schist. The innermost band grades into the wall zone and contains more plagioclase than the outer ones. At the wall-rock contact and on both sides of the thin schist relicts, the muscovite is arranged in plumose aggregates. The wall zone, 2 to 4 feet thick, is composed of blocky plagioclase, perthite anhedra 2 by 4 inches to 4 by 10 inches in diameter, quartz, and muscovite. The largest muscovite books are along the footwall. The core contains perthite in subhedra 1 by 2 to 4 by 6 feet across and irregular masses of gray quartz. Most of the perthite in contact with quartz has well-developed crystal faces. Minor black tourmaline and muscovite are present in the core adjacent to the wall zone. The tourmaline and muscovite crystals seem to be a part of the core and are not in a separate core-margin zone.

Production data are not available for the work done on this pegmatite in 1940–41. Mica is not abundant in the footwall part of the wall zone or in the core, and although the books are large and seem to contain a satisfactory percentage of sheet it is doubtful that the pegmatite could have supported a profitable operation during 1942–44. A small quantity of feldspar of good quality could be obtained from the core as a by-product of mica mining.

Pegmatite No. 34.—A small cut was made in the southern end of pegmatite no. 34 in 1940–41, and another cut was opened at the north end of the pegmatite in 1943. The pegmatite is exposed for 140 feet along strike and is 15 to 35 feet wide. It has a high east dip and plunges NE. 20°–60°. The wall rock contains much black tourmaline near its contact with pegmatite.

The border zone throughout the northern half of the pegmatite consists of massive quartz which contains minor scrap-bearing muscovite. The zone is 1 to 2 feet thick and forms all the surface exposures of the northern part of the body except for a small "window" in the north cut, in which the wall zone and the core are exposed. The border zone in the southern part is 2 to 4 inches thick and consists of granular quartz, scrap-bearing muscovite, and plagioclase. The wall zone, 1 to 4 feet thick, is composed of medium-grained plagioclase, quartz, muscovite, and biotite. The core contains coarse-grained quartz, perthite, irregular bodies of graphic granite, and minor muscovite. In 1943 a body of triphylite, graftonite, and vivianite, 2 feet in diameter, was found in the core. This body, where in contact with perthite, is bordered by a layer of chloritized biotite ¼ to ½ inch thick, but the layer is absent where the phosphates are adjacent to quartz.

Muscovite occurs as sparsely disseminated small books in the core. Neither cut yielded enough muscovite in 1943 to encourage further work, although the muscovite recovered was rum to ruby and of good quality.

Pegmatite No. 35.—In 1940–41 an opencut 60 feet long, 40 feet wide and 5 to 37 feet deep was made near the south end of pegmatite no. 35, and a smaller opencut leading to a short tunnel was made at its north end. The pegmatite is exposed for 280 feet along strike and ranges from 8 to 60 feet in width. It strikes about N. 25° E. and dips 75° E., but bends sharply eastward at its north end.

The border zone, 2 to 8 inches thick, is composed of fine-grained granular quartz, scrap-bearing muscovite, and plagioclase. The wall zone, 2 to 6 feet thick, is a poorly defined unit consisting of medium-grained plagioclase, quartz, perthite, muscovite, and thin strips of biotite. The perthite-quartz-plagioclase-biotite intermediate zone contains more perthite and biotite than the wall zone. It seems to form a cap or hood about 30 feet thick over the core. It does not seem to extend along the flanks of the pegmatite—although all of the outcrops between the cuts are composed of material of this zone, it cannot be recognized either in the north or south cuts. Perhaps it grades downward along each flank into the wall zone. The crest of the core is exposed in the center of the south cut and in the short tunnel leading from the northcut. The core grades outward into the wall zone and upward into the perthite-quartz-plagioclase-biotite zone. It is composed of coarse-grained perthite, quartz, and graphic granite. The perthite generally has well defined crystal faces where it is in contact with irregular bodies of gray quartz. Rum to ruby muscovite occurs in widely scattered books in the core. Although the books are of good size, they are thin. Production data are not available for the muscovite recovered in 1940–41. Muscovite books are not abundant in the parts of the core that are exposed in the cuts, hence it would appear that the core could not have been mined profitably for muscovite during 1942–44. Much of the feldspar in the core is graphically intergrown with quartz, but some no. 1 feldspar could be recovered.

Pegmatite No. 36.—An opencut 60 feet long, 5 to 16 feet wide, and of unknown depth was made in pegmatite no. 36 prior to 1943. The cut is now filled with water and no pegmatite is visible in it. Parts of the pegmatite exposed outside of the cut appear to have a slightly higher muscovite content than the other pegmatites at the mine, with the exception of pegmatite no. 32. Data are not available for the mica recovered from the opencut, and the amount of mica-bearing pegmatite remaining in the bottom of the cut is not known.

Pegmatite No. 37.—A prospect tunnel 40 feet long was driven westward to pegmatite no. 37 prior to 1940. An opencut 80 feet long, 5 to 18 feet wide and 5 to 25 feet deep was made at the south end, and a small opencut was excavated near the north end of the pegmatite in 1940–41. The pegmatite is exposed along a strike for 400 feet and is 12 to 38 feet thick. It strikes N. 20°–25° E. and dips 75° to 80° W. The zonal structure in pegmatite no. 37 is not as well defined as it is in the other pegmatites at the Rice mine. The border zone along the west wall of the southern cut is 2 to 2.5 feet thick, consists of scrap muscovite, gray-green plagiosclase, and quartz, and is separated from the interior of the pegmatite by a thin intermittent layer of wall rock. The interior of the body is composed of medium-grained white and gray-green plagioclase, perthite, quartz, biotite strips, and small, thin scattered muscovite books. The muscovite is rum to ruby and intergrown with biotite; it seems to contain only a small percentage of sheet. Probably the pegmatite could not have been operated profitably for muscovite during 1942–44.

Pegmatite No. 38.—Pegmatite no. 38 is poorly exposed in a small prospect made in 1940–41. It contains medium-grained perthite, plagioclase, quartz, and small muscovite books. Muscovite is not abundant.

RICE MINE-PIKE'S LEDGE AREA

The Rice mine-Pike's Ledge area is about 4.0 miles northwest of Groton village and extends over an area of about 1 square mile. The southeast corner of the area is 4.0 miles from Groton on the gravel road that leads northwest. The road to the Rice mine forms the eastern half of the northern boundary. During August and September 1944 the area (fig. 91) was mapped by tape and compass by G. W. Stewart, N. K. Flint, and D. W. Caldwell. Location of the 22 pegmatites mapped and studied are indicated on figure 91. The Pike's Ledge pegmatite (fig. 92), which is within the area and had been mapped by tape and compass by A. H. McNair and G. B. Burnett in August 1942, was remapped by plane-table methods and studied in detail.

The country rocks are quartz-sillimanite and quartz-mica schists, the foliation of which strikes north to N. 40° E. and dips between 75° NW. and 65° SE. Most of the pegmatites are narrow lenses that are essentially concordant with the foliation of the wall rock. However, pegmatites no. 9 and no. 14, each about 15 feet long and 3 to 5 feet wide, cut across the foliation, strike northwest; and dip steeply northeast. The other pegmatites have strikes ranging from N. 15° E. to N. 25° E. and dips ranging from 75° SE. to vertical. They are 20 to 700 feet in length and 2 to 280 feet wide.

Eleven pegmatites (nos. 1, 2, 4, 7, 8, 9, 10, 14, 15, 20, and 22), show the following combination of zones: (1) a border zone, 1 to 4 inches thick consisting of fine-grained quartz and muscovite, and (2) a core composed of perthite and quartz, with minor plagioclase, muscovite, and biotite, and accessory tourmaline, garnet, beryl, and apatite. Ten pegmatites (nos. 3, 5, 6, 12, 13, 16, 17, 18, 19, and 21) have an indistinct zonal structure comprising (1) a border zone, 1 to 4 inches thick, composed of fine-grained quartz and muscovite; (2) a wall zone composed of quartz, plagioclase, perthite, and scattered muscovite books; and (3) a discontinuous core consisting of a series of quartz or quartz-perthite pods around the margins of which muscovite books are unevenly distributed. One pegmatite (no. 11) has a border zone together with a core composed of perthite, quartz, minor plagioclase, and disseminated muscovite books.

Like the pegmatites of the adjoining Rice-Palermo area, these pegmatites show fundamental similarities in internal structure and mineralogy. They have a constant sequence of zones from the walls inward and differ only in number and distinctions of zones. The principal lithologic types of zones are zone 1–a, zone 2, and zone 3 of the table on page 214. Some of the pegmatites have, in addition, pods that are telescoped units formed by various combinations of zones 4, 5, and 6. It seems evident that the pegmatites are genetically a single group, derived from the same source and injected and consolidated under similar conditions.

Only two pegmatites in this area, the pegmatite no. 6 and the Pike's Ledge pegmatite (no. 3), have sufficient muscovite exposed to warrant exploration.

Pegmatite No. 6.—Pegmatite no. 6 is exposed for 250 to 300 feet along strike and is 4 to 35 feet wide. It strikes N. 15°–20° E., and dips 70°–75° SE. It has a border zone 1 to 3 inches thick consisting of fine-grained quartz and muscovite; a wall zone 3 to 7 feet thick of coarse-grained quartz, plagioclase, and perthite: and a core 15 to 20 feet thick and 40 to 50 feet long of quartz and perthite. The core is restricted to the widest parts of the pegmatite. Most of the muscovite occurs as sparsely disseminated books in the core or unevenly distributed along its margins. The muscovite is medium rum in color, hard and flat, and only slightly stained and ruled. The books average 4 by 4 inches, one was 8 by 8 by ½ inch. Parts of other books, 6 by 6 inches and larger, were seen in the overburden.

Pike's Ledge pegmatite.—Property and mineral rights to this pegmatite (pl. 1, no. 31; fig. 92) are owned by the Barrett-Prosser Mining Co. of New York, of which Mr. E. E. Smith of Canaan, N. H., is secretary. The Whitehall Co., Inc., of New York, has a sublease on the mineral rights. Cuts no. 2 and no. 3 (fig. 92) were made prior to the summer of 1942. During the summer of 1942 cuts no. 6 and no. 9 were made by E. E. Smith of Canaan, N. H., in search of mica. In the fall of 1943 the Whitehall Co. prospected the pegmatite for feldspar and made cuts no. 1, 4, 5, 7, and 8. An adit, 6 feet high, 7 feet wide, and 30 feet long, was driven westward from the floor of cut no. 1.

The pegmatite, which forms an isolated knob on the southeast side of a large hill, is exposed for about 700 feet along strike and is 30 to 280 feet wide. It may extend several hundred feet southwestward beneath pegmatite talus. It strikes N. 15°–30° E., and dips steeply southeast. Local variations in dip occur at the northeast end and along the west wall of the southern half of the pegmatite. Small rolls, one of which plunges northward, occur along the east wall. The

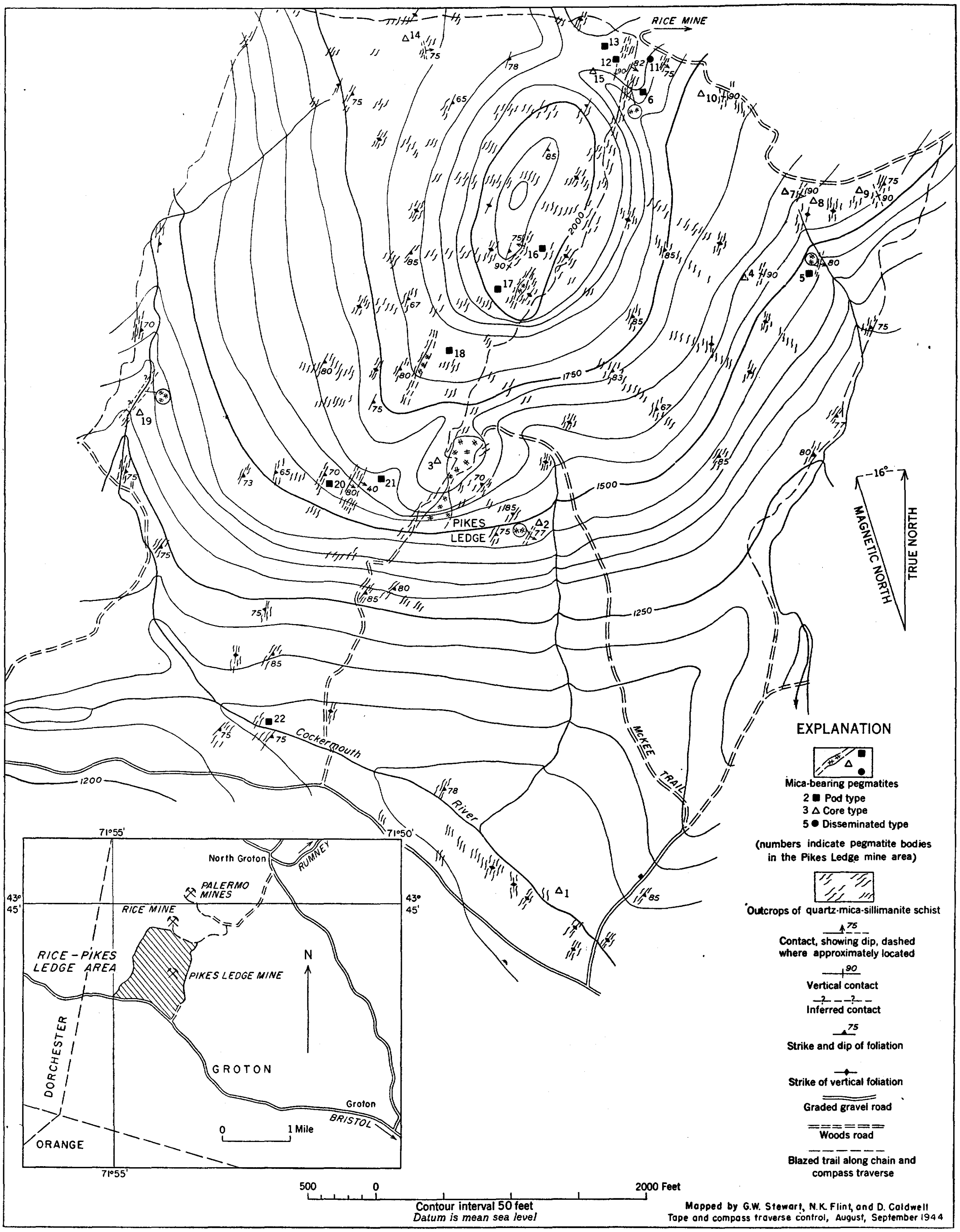


FIGURE 91.—Map showing the pegmatites of the Rice mine-Pike's Ledge area, Groton, N. H.

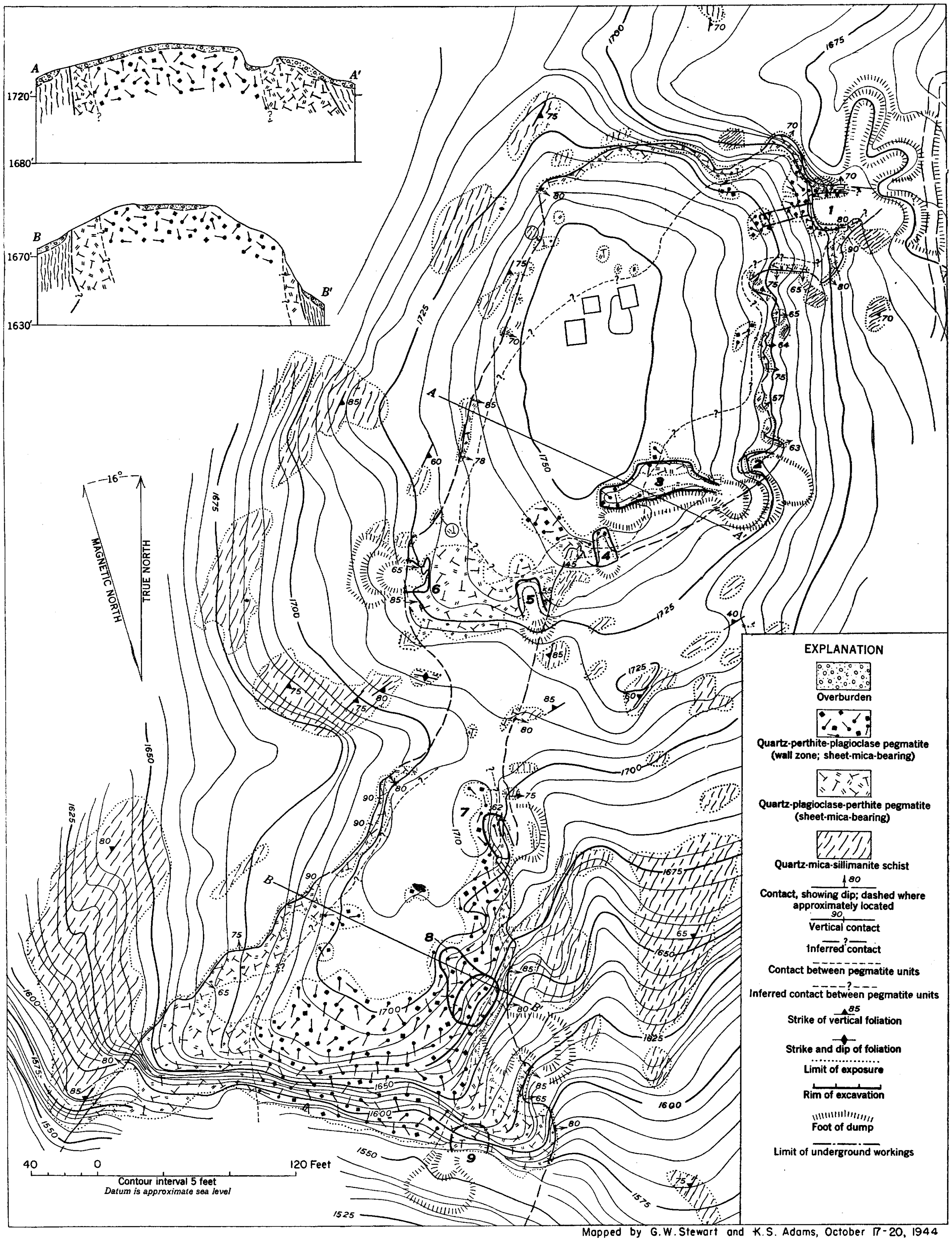


FIGURE 92.—Geologic map and sections of the Pike's Ledge pegmatite, Groton, N. H.

elongated muscovite aggregates, 6 to 8 inches long, occur at the outer edge of the border zone at the southwest end of the pegmatite, and this feature suggests that the crest of the southern part of the pegmatite likewise plunges southward. The trend of the pegmatite is generally parallel to the foliation of the wall rock but contacts range from concordant to sharply discordant and, whereas the pegmatite appears to dip east, the prevailing dip of the foliation of the schists is to the west. The wall rock is quartz-sillimanite schist of the Littleton formation. Its foliation strikes N. 10°–25° E. and dips 75° NW. to 75° SE.

The pegmatite has an indistinct zonal structure. In general, the pegmatite is richer in perthite and coarser-grained toward the center. Plagioclase is most abundant near the wall. The border zone, 2 to 12 inches thick, is composed of fine-grained quartz, muscovite, small amounts of plagioclase, and accessory garnet and tourmaline. The zone is well exposed along both contacts at the northeast and southwest ends of the exposed part of the pegmatite. The wall zone, 3 to 80 feet thick, is composed of quartz, plagioclase, perthite, graphic granite, sheet-bearing muscovite, biotite, secondary chlorite, and accessory tourmaline and garnet. The hanging and footwall parts of the zone apparently unite upward and form the total exposed width of the narrow part of the pegmatite near its center. The core, 20 to 135 feet thick, contains the same minerals as the wall zone, but is coarser and has more perthite than plagioclase. Unevenly distributed anhedral and subhedral crystals of perthite 1 to 16 feet long and 1 to 5 feet thick, quartz bodies 1 by 2 to 2 by 5 feet, and irregular bodies of graphic granite 2 by 3 feet across, are common in the core. Small patches of blue-green plagioclase associated with biotite and tourmaline occur at irregular intervals along the walls, roof, and end of the drift in cut no. 1. Many of the perthite crystals exposed in cut no. 1 contain inclusions of red garnet, ⅛ to ¼ inch in diameter.

Sheet-bearing muscovite books are unevenly distributed through the wall zone and core. The books are most abundant in patches rich in quartz and plagioclase. In cut no. 9, the muscovite books are associated with quartz and plagioclase in a lens-shaped body, 10 to 12 feet long and 1 to 1½ feet thick. Most of the muscovite is light to medium rum but some (in perthite) is green. Most books are hard, flat, much cracked, and ruled, and they contain inclusions of magnetite(?) or pyrite(?). Some books are wedge-shaped and have either an "A" or herringbone structure. Much partly chloritized biotite is intergrown with the muscovite. The books average 3 by 4 inches; some are 8 by 10 inches and 2 to 3 inches thick.

Perthite is most abundant in the core as anhedral and subhedral crystals intermixed with quartz, plagioclase, and graphic granite. Prospecting during 1943 did not expose large bodies of high quality. It seems likely that very small amounts of small-sized sheet mica of good quality could be recovered from this pegmatite, but the recovery per ton of rock moved would be low.

ROGERS (WHEAT) FELDSPAR PROSPECT

The Rogers (Wheat) feldspar prospect (pl. 1, no. 8) is 1.0 mile N. 38° E. of West Rumney. To reach it from West Rumney follow a graded gravel road northward across Baker River for 0.5 mile to a fork at a cemetery; take the right fork 0.2 mile to a left fork; follow the left fork for 0.7 mile to the prospect.

Mineral rights are owned by the town of Rumney and are leased by the Golding-Keene Co. of Keene, N. H. Small-scale prospecting for mica was first carried out by Joseph Rogers in 1928. The Golding-Keene Co. made two opencuts in the upper pegmatites during the summer and fall of 1942 and removed about 70 tons of feldspar and ¾ ton of beryl from the middle pegmatite. The prospect was mapped by A. H. McNair and G. B. Burnett in August 1942 (fig. 93).

Three lenticular pegmatite bodies crop out at the prospect. The lowest pegmatite is 300 feet long, has an outcrop width of 75 feet and trends N. 70° W. It cuts across the foliation of the wall rocks and seems to plunge northward. The footwall contact (the only one exposed) is fluted and grooved and suggests that the body was emplaced along a fault. At the southeast end of the body it strikes N. 60° E. and dips 30° NW.

The middle pegmatite is 300 feet long, 20 feet thick, strikes N. 10° W., and extends almost horizontally into the hillside. The upper pegmatite is exposed over an area 600 feet by 300 feet. It caps a low hill. It is about 125 feet thick, and seems to dip 20° to 30° SW. The middle and upper pegmatites are sharply discordant to the wall rock.

The wall rock is well foliated quartz-mica and quartz-mica-sillimanite schist of the Littleton formation. Foliation, in general, strikes N. 10° E. and dips 70° E., but locally it has a steep westerly dip.

The lower pegmatite consists essentially of irregularly distributed perthite, quartz, tourmaline, biotite, and scrap muscovite. The central pegmatite shows a poorly developed zonal structure. The wall zone, 5 to 15 feet thick, consists of fine-grained perthite, quartz, biotite, and tourmaline. The wall zone surrounds a small core containing large crystals of perthite and masses of gray and rose quartz. Blue-green beryl crystals and scattered books of wedge mica occur at the

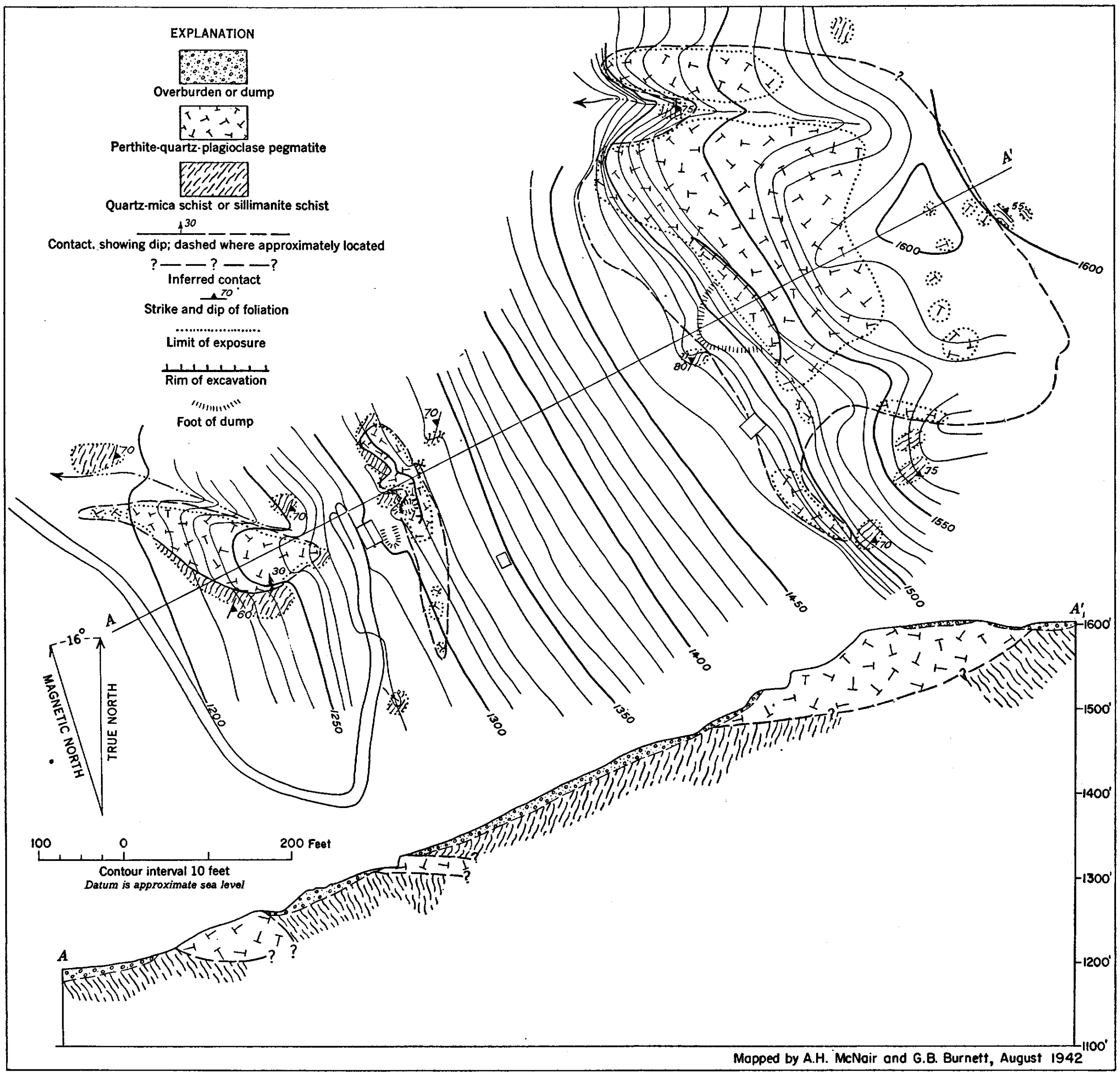


FIGURE 93.—Geologic map and section of the Rogers feldspar prospect, Rumney, N. H.

margins of the core. The core was almost completely removed during feldspar operations in 1942.

The upper pegmatite also has a vague zonal structure. The wall zone is fine grained and consists of perthite, quartz, biotite, muscovite, tourmaline, and irregular masses of graphic granite. The inner zone or core contains small perthite masses and graphic granite. Nests of large wedge-shaped mica books are scattered through the core. Most of the core consists of graphic granite, and there is little, if any, recoverable No. 1 feldspar.

None of the pegmatites contains much muscovite. The books present are wedge-shaped, badly ruled, and cracked. The perthite from the upper cut is commonly intergrown with other minerals and does not occur in masses large enough to sustain feldspar mining.

RUBY AND BARNEY MINES

The Ruby and Barney mines (pl. 1, no. 61) are in the town of Grafton, 3.1 miles S. 34° E. of Canaan village. To reach them from Canaan, follow U. S. Highway 4 southeastward for 3.1 miles to a gravel road on the right; turn right on the gravel road and follow it 0.25 mile to a house on the left; turn left on a farm road leading southward through pasture and fields for 0.25 mile to the base of a steep slope where an inclined trackway, 500 feet in length, extends uphill to the Ruby mine. The Barney mine lines just east of the Ruby.

The property is owned by Mrs. Ethel P. Hutchinson, R. F. D. Canaan, N. H. The Ruby mine is leased by the New England Mineral Co., Waltham, Mass., and the Barney mine by the General Electric Co., Schenectady, N. Y. The Ruby mine was worked for mica in 1929 and for feldspar in 1934. The mines were studied by C. S. Maurice, J. B. Headley, Jr., and J. B. Thompson in October 1942, and by J. J. Page and F. H. Main in October 1944 (pl. 32). The history of operations at the Barney mine is not known.

The Ruby mine is an opencut that is 180 feet long and as much as 50 feet wide and passes downward into a narrow inclined stope that is accessible for 70 feet down the dip. A crosscut trench 75 feet long, driven southward, intersects the center of the cut. East of the crosscut, reportedly, water-filled stopes extend down dip for 40 feet below the present floor level. The Barney mine consists of an opencut 120 feet long, 15 to 27 feet wide, and 40 feet deep. At its west end, a 20-foot stope has been driven westward along the mica-rich part of the pegmatite. The floor of the Barney cut is about 15 feet above the main floor of the Ruby. A small prospect pit has been opened midway between the two cuts. Another small pit lies 40 feet south of the Barney cut.

About 300 feet northwest of the Ruby cut, an opencut 120 feet long, 25 feet wide, and 8 feet deep has been driven S. 55° W. into the hillside. The walls of the pegmatite in which the cut has been made are not exposed, hence the attitude of the pegmatite is unknown. It does not seem to be a part of the Ruby and Barney pegmatite.

The wall rocks are interbedded medium- to coarse-grained amphibolite and fine-grained quartz-biotite schist of the Littleton formation. Exposures are not abundant near the pegmatite. Quartz-biotite schist that crops out south of the pegmatite has an average strike of N. 60° E. and dips 35°–70° SE.

The Ruby and Barney pegmatite is at least 150 feet thick and 900 feet long. It can be traced about 400 feet along strike west of the Ruby mine. It strikes N. 80° W. and dips 65°–70° N. Its contacts with wall rock are exposed in only a few places.

A fault that strikes N. 72° W. and dips 60°–77° N. is exposed on the hanging wall side of the stopes in both the Ruby and Barney workings. The fault is very tight, does not contain gouge, and is visible only where the underlying pegmatite has been removed by mining. Striations plunge 15°–25° eastward and suggest that the pegmatite north of the fault moved east in relation to the pegmatite on the south. An extension of the fault westward from the Ruby mine might explain the sharp irregularity in the hanging wall contact that occurs 60 feet west of the Ruby cut.

Several sets of cross-faults (not shown on plate 32) cut the main fault. The set best exposed strikes NE. and dips almost vertically NW. The faults of this set offset the main fault slightly. Along each cross-fault the east block has moved northeast or upward in relation to the west block. Some of these faults are filled with narrow quartz veinlets. The cross-faults can be traced for several feet north of the main fault but do not extend far south of it.

The Ruby and Barney pegmatite contains four zones and an unusual fracture-controlled replacement body. The border zone, best exposed in the crosscut at the Ruby mine, is about one-quarter of an inch thick and consists of fine-grained quartz, muscovite, plagioclase, and garnet. The wall zone, 20 to 60 feet thick, consists of medium-grained quartz, perthite, plagioclase, and minor muscovite, biotite, garnet, black tourmaline, and green apatite. Small mica books are most abundant within 2 to 3 inches of the border zone and most are oriented normal to the contact. Streaks of small dark red to red-brown garnet crystals as much as one-half inch in diameter are common in the wall zone near the wall rock contact and along the hanging wall of the fault. The footwall part of the zone is richer in quartz than the hanging wall part.

The core-margin zone, along the south side of the core in the Barney opencut, consists of small discontinuous patches of quartz, plagioclase, and sheet-bearing muscovite. The core has a maximum exposed thickness of 15 feet and an inferred thickness of 30 feet. It is near the center of the pegmatite and is bounded on the north by the replacement body. It contains large blocks of perthite (mostly intergrown with light gray quartz), biotite, muscovite, plagioclase, and minor garnet and tourmaline. Biotite occurs as thin strips as much as 8 feet long and 6 feet wide. Muscovite, intergrown with biotite, is associated with small patches of gray quartz, and green wedge mica is present at the margins of small bodies of milky quartz.

The fracture-controlled replacement body lies between the core and the fault. It is exposed for 450 feet along strike and ranges from 2 to 11 feet in thickness. In general it is thicker in the Barney mine than in the Ruby. The body contains quartz, sheet-bearing muscovite, plagioclase, and minor perthite, green apatite, and tourmaline. Light gray quartz is the most abundant mineral. Small books and flakes of muscovite are closely associated with small irregular quartz bodies. Most of the large muscovite books are adjacent to the quartz bodies but few are enclosed in them.

The replacement body is in sharp contact with the fault surface but grades into the core. The mica books at the fault are not sheared or contorted and therefore seem to have been introduced after the fault was formed. The persistence of the sheet-mica bearing unit along the fault also suggests that the fault determined its location. It seems unlikely that the mica-bearing unit was a core-margin zone faulted along its outer margin.

Muscovite is abundant in the replacement body but mica recovered during past operations is reported to have been largely scrap and punch with a very low percentage of small sheet. The mica is ruby to rum and is mostly clear, hard, and free-splitting. The books are small on the average and most of the larger books are badly cracked.

If reports of past operations are correct, the mica is so small and its content of sheet mica so low that mining would be profitable only during a period of exceptional demand for punch and the smaller sizes of sheet. Much low-grade muscovite-bearing rock remains in the pegmatite.

RUGGLES FELDSPAR-MICA MINE

The Ruggles feldspar-mica mine (pl. 1, no. 65) is in the town of Grafton on the steep south slope and top of a hill 1.5 miles N. 40° W. of Grafton Center (Cardigan Station). From U. S. Highway 4 at Grafton Center, a graded road leads 1.4 miles westward across a meadow and up the valley of Manfeltree Brook. At this point, a good mine-access road, about 1.5 miles in length, turns north across the brook and extends up a steep hill to the mine.

Commercial production of mica in New Hampshire began at the Ruggles mine in 1803. Operations for mica, and more recently for potash feldspar, have been carried out intermittently to the present time. In 1841, the mine was operated by a Mr. Ingalls of Boston, Mass. (Jackson, 1844, p. 115) who mined about 16 tons of mica worth from $2 to $3 a pound when trimmed. Production about 1840 was only 600 to 700 pounds annually and in 1869 was 26,250 pounds, worth perhaps $60,000 (Hitchcock, 1878, p. 90). Sterrett (1923, p. 143) reports that several men worked the old dumps in 1912, and that mineral rights to the property were owned by Joseph Rogers of Rumney Depot, N. H. At that time, the American Minerals Company was preparing to begin work for feldspar, and the English Mica Co., of New York, had begun working the dumps for scrap mica. The rock was crushed on the dumps and then washed down a 3,200-foot flume to a mill on Manfeltree Brook.

The Whitehall Co., Inc., of New York, present owners and operators, worked the mine for a short time in 1932, and have operated it steadily since 1936. The New Hampshire United Mining Co., Andover, N. H., worked pit 32 (pl. 33) under lease during August and September 1944.

In 1940 Bannerman (p. 3–4) discussed the mineral occurrences of the Ruggles pegmatite. In 1943 (p. 13–16) he described and illustrated the geology of the mine workings and discussed the internal structure of the pegmatite and the distribution of valuable minerals in it.

The underground workings and larger opencuts were mapped in December 1943 and January 1944 by J. J. Page and E. Ellingwood 3d (pls. 33–35, fig. 94). The

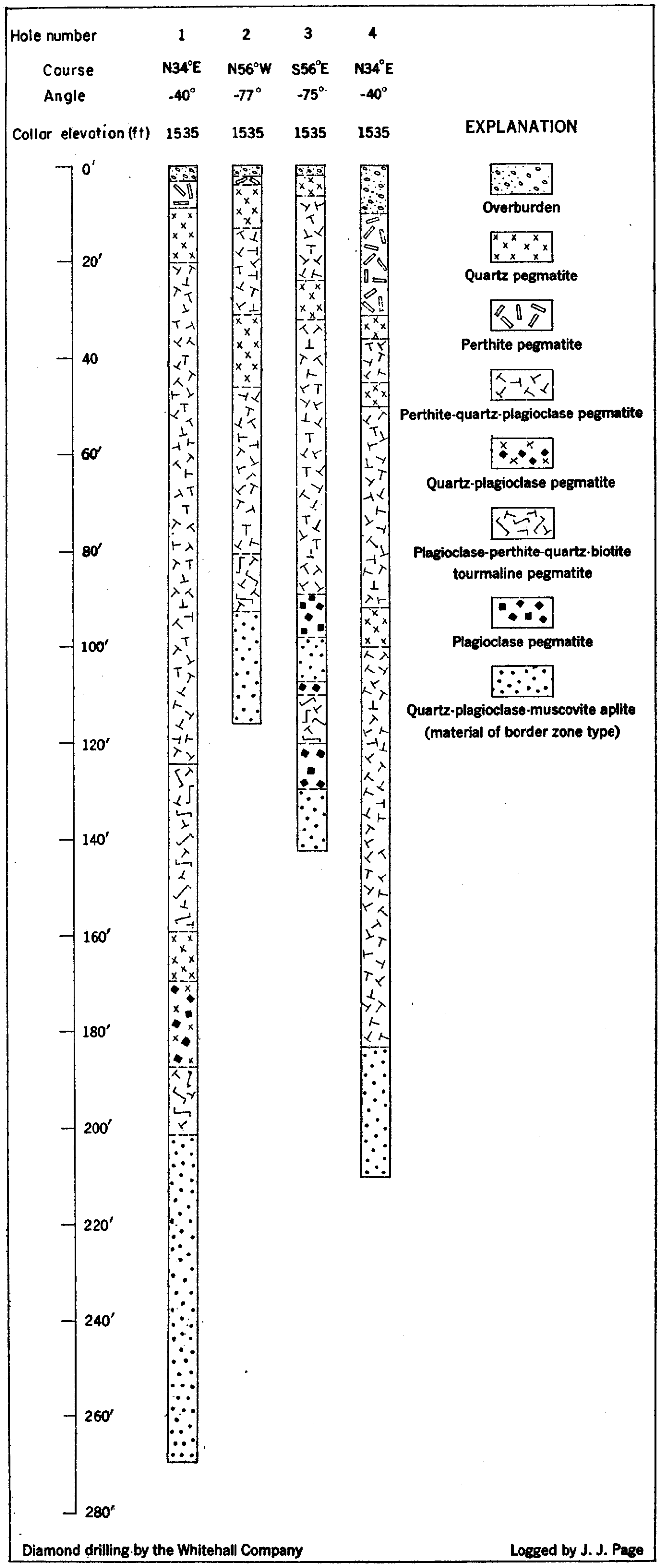


FIGURE 94.—Logs of diamond-drill cores, Ruggles feldspar-mica mine, Grafton, N. H.

workings were mapped by Page and F. H. Main in August and September 1944. The maps and sections show the workings as of October 1, 1944. Cores recovered during exploratory diamond drilling in 1940 by the Whitehall Co. were made available for examination.

The Ruggles pegmatite has been worked for 1,550 feet along strike, practically the entire exposed strike length. Most of the workings are on the top and steep south slope of the hill and range in elevation from 1,270 to 1,600 feet. The earliest work was done near the bottom of the slope. In general, each succeeding operation was opened at a slightly higher elevation, and the waste rock was dumped into the earlier cuts. At present, all work is being done near the top of the hill.

WORKINGS

The south prospect drift is 70 feet long and extends N. 15° E. from the north end of a small opencut. It is the southernmost working and was opened by the Whitehall Co. The southwest cut is about 50 feet long and as much as 35 feet wide. P. K. Brown, manager of the mine, reports that the cut is 30 feet deep. From the floor, a drift was driven about N. 25° E. The southeast cuts are south of the old road crossing the hillside. The larger cut is 140 feet long and as much as 55 feet wide and 40 feet deep. The face of a steep cliff has been blasted off east of this working, revealing pegmatite capped by schist.

The old stope, known also as stope no. 1, begins at the north end of an opencut 160 feet long and as much as 70 feet wide and 40 feet deep. The cut trends N. 15° E. The stope branches about 130 feet north of the portal. One part extends 60 feet N. 60° E.; the other extends northward to a point under an old filled shaft 70 feet deep. Back-filled stopes on the west side of the working extend downward along the wall.

In the area bounded by pit no. 32 and the cuts described above, there are other old workings almost completely buried. One large cut is believed to have extended from near the south prospect drift to the opencut at the entrance to the old stope. Another large cut or series of small cuts apparently was worked south of pit 32.

Several shallow, interconnected opencuts were dug northward into the hillside during early operations at the present location of pit 32. From these cuts, the flat stope at the south end of the 140-foot level was driven northward. In 1932, the Whitehall Co. mined feldspar here and excavated the present cut. Operations for mica were later begun along the west wall of the pegmatite, and an incline, now flooded, was driven N. 10° E., at an angle of about 20°, down the wall for about 160 feet. The altitude of the bottom of the incline is believed to be 1,385 feet. In August and September 1944, the New Hampshire United Mining Co. leased pit 32 and drove northward to drain it. They also removed part of the pegmatite wall and took part of the roof of the incline.

Operations in pits A and C began in 1936, and pit A is still operated occasionally. The two pits form a single large opencut, 280 feet long and 60 feet in average width, which trends N. 35° E. Pit C is separated from pit A by a wall of pegmatite 20 feet thick and 45 feet high. Pit A includes an older one, pit B. The wall separating pit A from pit B has been removed. The floor of pit A is a series of benches rising in elevation to the northeast. Three large crosscuts have been driven to the east wall, and from them short drifts extend along the wall. On the west side of the pit, a drift has been driven 150 feet northward from the center of the west wall of the pit. A crosscut 30 feet long was also driven westward high above the present floor but did not reach the west wall. Near the northeast end of pit A, a shaft 45 feet deep, the north shaft, was sunk. The south shaft is 72 feet deep. From pit C headings have been driven eastward to the schist wall and also northward under the opencut rim.

The 120-foot level was worked from the south shaft and is about 50 feet below the collar. Two high crosscuts were driven about 60 feet eastward and westward to the walls of the pegmatite, and drifts were run along the walls. Other workings on this level consist of stopes, drifts, and crosscuts that extend 120 feet southward from the south shaft to the crest of the pegmatite.

The 140-foot level was driven 80 feet south from the bottom of the south shaft to connect with the north end of the old flat stope. This old stope is 175 feet long and as much as 110 feet wide. It was originally 10 feet high but has been partly filled by caving. From the main drift, 50 feet south of the shaft, an irregular crosscut (east crosscut) with several short drifts was driven 100 feet eastward under the gently dipping schist roof. A crosscut 40 feet long (west crosscut) was also driven westward to the wall. A drift from this crosscut was run southward along the wall to a point at which the pegmatite plunges under the schist. Here an incline, 70 feet long, was driven southward under the roof at an angle of 15°. The bottom of the incline is at an altitude of 1,450 feet. A drift, 180 feet long, also extends northward from the end of the west crosscut along and in the wall. It is in the footwall schist for 75 feet. This drift broke through to an older drift extended from the north shaft. Workings from this shaft consist of a crosscut, 80 feet in length, extending east, and a crosscut, 60 feet long, trending N. 70° W. From its west end, drifts extend along the wall and connect with the drift driven from the south.

Pit D is at the top of the hill, and a short crosscut extends 30 feet N. 65° W. from the southwest corner of the cut floor. From the end of this crosscut, short drifts have been run northeast and southwest. Another crosscut near the northwest corner of the cut had been driven 18 feet by October 1944.

On the north slope of the hillside, an opencut has been driven S. 30° W. From the opencut, the north prospect drift, a narrow drift inclined to the south, extends 65 feet farther. A crosscut 20 feet long near the bottom of the incline extends westward almost to the wall of the pegmatite.

WALL ROCKS

The wall rocks of the pegmatite are medium-grained quartz-mica schist, coarse-grained biotite gneiss, and amphibolite of the Littleton formation, and fine- to medium-grained biotite granite. Schist is the most abundant rock type. It is rich in biotite, except near the pegmatite contacts, where muscovite commonly is the more abundant mica, and the schist is heavily tourmalinized. Some layers of schist contain needles of sillimanite, and others contain brownish-black staurolite. Small lenticular bodies of coarse-grained biotite gneiss and amphibolite occur west of the pegmatite. The gneiss seems to have been formed by alteration of the amphibolite. Thin comformable bodies of biotite granite lie adjacent to or in the gneiss. The granite is probably intrusive into the schist and gneiss, but its relations to the pegmatite are unknown.

The average strike of the wall-rock foliation is about N. 25° E., and the average dip is about 65° SE. The bodies of biotite gneiss, amphibolite, and granite have their long axes parallel to the average strike of foliation.

Basic dikes ranging from less than a ¼ inch to 3 feet in thickness cut the pegmatite. They strike about N. 60° E. and dip steeply southeast or are vertical. Most of them fork. They do not appear to extend into the wall rock.

SIZE AND EXTERNAL FORM

The Ruggles pegmatite crops out or has been exposed by mining for 1,640 feet along strike. Its maximum outcrop width is 335 feet, and it ranges from a few feet to at least 160 feet in thickness. The trend of the pegmatite on the surface is about N. 20° E. and the average strike is N. 35° E. The body has an extremely varied southeast dip.

The pegmatite is an irregular lens that has not been deeply eroded. Its apex is between pits A and C. North of pit C the pegmatite plunges northeastward 15°–20°; south of pit C it has an irregular southwestward plunge. (See sec. A–A′, pl. 35.) The north end of the pegmatite resembles roughly an ancient battle-axe in plan. The tabular main part of the pegmatite, in which the major workings are located, forms the shaft of the axe. The blade is formed by a lobelike eastward dipping sheet, which is connected to the main body near the southeast side of pit D.

The pegmatite pinches out at the surface in the opencut at the north prospect drift, but it widens rapidly south of this working. A few feet east of the north end of pit C, a narrow tongue of schist which also widens southward splits the pegmatite into two parts. East of this schist wedge, the pegmatite forms an eastward-dipping sheet that dips less steeply and is progressively thinner southward. Erosion has exposed the bottom of this sheet on the steep slope south of the top of the hill. A smaller pegmatite body underlies the main east sheet. The lower pegmatite pinches out up dip in a sharp crest.

In pits A and C, west of the schist wedge, the pegmatite has a maximum width of 120 feet on the surface, but it thickens downward to at least 160 feet. At the south end of pit A, the pegmatite plunges southward under schist, although a narrow apophysis of pegmatite extends into the schist. Pegmatite is also capped by schist in the north wall of pit 32, (pl. 33).

South of pit 32, outcrops of schist and marginal zones of pegmatite suggest that here also gently dipping schist covered the pegmatite. Dips along the west wall are steep. Remnants of the schist capping can be seen throughout the southern part of the map area, and the abundance of fine-grained aplite and the numerous apophyses extending southward into the schist at the south end of the pegmatite suggest a plunging structure similar to the one south of pit A.

COMPOSITION AND INTERNAL STRUCTURE OF THE PEGMATITE

Because the Ruggles pegmatite is well exposed it has been possible to map in detail the unusually large number of pegmatite units present in it. The pegmatite shows a well-defined zonal arrangement. The pegmatite units are listed below, in the general order of occurrence inward from the walls:

1. Plagioclase-quartz-muscovite border zone.
2. Plagioclase-quartz pegmatite (wall zone), composed of the following units:
    a. Plagioclase pegmatite.
    b. Cleavelandite pegmatite.
    c. Plagioclase-quartz pegmatite.
3. Muscovite-quartz-plagioclase pegmatite, first intermediate zone.
4. Plagioclase-perthite-quartz-biotite-tourmaline pegmatite, second intermediate zone.
5. Quartz-plagioclase pegmatite, third intermediate zone.
6. Plagioclase-muscovite-quartz-perthite pegmatite, fourth intermediate zone.
7. Perthite-quartz-plagioclase pegmatite, fifth intermediate zone.

8. Graphic granite pegmatite, core of east-dipping sheet.
9. Perthite-quartz pegmatite, sixth intermediate zone of main part of pegmatite.
10. Perthite pegmatite, core of main part of pegmatite.
11. Quartz lenses and veins.
12. Muscovite-plagioclase replacement bodies.
13. Sericitized perthite-plagioclase-quartz replacement body.

Plagioclase-quartz-muscovite border zone.—A discontinuous aplitic border zone commonly is adjacent to the schist walls. It generally is less than 5 feet thick, but has a maximum thickness of at least 40 feet. It is thickest and most persistent along both walls north of pit A and in apophyses extending into schist at the south end of the pegmatite body. It consists essentially of fine-grained equigranular plagioclase (An_7) and quartz with interstitial muscovite. Accessory minerals are garnet, tourmaline, apatite, and microcline. Thin irregular stringers consisting of quartz and plagioclase with scattered muscovite and perthite cut the aplite.

A rock megascopically similar in composition and texture to the border zone occurs in the east crosscut from the north shaft on the east side of pit A, and in drill hole 3. It seems to lie inside the main parts of the pegmatite.

Plagioclase-quartz pegmatite wall zone.—Inside the border zone three units are found in different parts of the mine. All consist of plagioclase, quartz, and muscovite, but they differ markedly in proportion of minerals.

A discontinuous unit of blocky plagioclase occurs inside the aplitic border zone or, where the border zone is absent, against the schist wall. The unit is found chiefly southwest of pit A. Its thickness is commonly less than 3 feet. It consists almost entirely of blocks of white plagioclase, 6 by 8 inches in maximum dimension, with small amounts of quartz and muscovite. Similar material also occurs in drill hole 3 and in the east crosscut from the north shaft. In drill hole 3 it seems to lie between the plagioclase-perthite-quartz-biotite-tourmaline zone and the border zone. In the east crosscut of the north shaft, a plagioclase unit similar in all respects to that found elsewhere in the pegmatite lies between the perthite-quartz-plagioclase zone and the biotite-bearing unit.

The cleavelandite unit is commonly less than 3 feet thick at most places and consists essentially of coarsely bladed cleavelandite with minor quartz, greenish muscovite, and blue-green apatite. The cleavelandite is commonly stained by iron and manganese oxides. The unit shows much the same relationship to the wall rock and the border zone south of pit 32 as the blocky plagioclase unit north of it.

The plagioclase-quartz unit contains plagioclase (An_{4-5}), gray quartz, and minor muscovite and black tourmaline. It is exposed in the eastern sheet-like part of the pegmatite and continues northward to the North Prospect drift. It commonly is inside the border zone but also occurs along the bottom and top of the sheet-like part of the pegmatite.

Muscovite-quartz-plagioclase zone (sheet-mica-bearing).—The muscovite-quartz-plagioclase zone is a discontinuous intermediate zone of the pegmatite. Muscovite is the most abundant mineral, and commonly 50 to 75 percent of the zone consists of large books oriented normal to the margins of the zone. Quartz and plagioclase (An_2) are also essential minerals, and black tourmaline, commonly intergrown with muscovite, and green apatite are accessories. It is best exposed under the schist capping on the 120- and 140-foot levels and on the steeply dipping west wall of the pegmatite. On the 120-foot level, it is thickest on the nose of the pegmatite and extends back along the walls for about 150 feet from the nose itself. The old stope at the south end of the 140-foot level was developed in this zone under the flat-lying schist roof. More recently, mica has been obtained from the zone on the steeply-dipping west wall of the pegmatite. The location of workings down hill from pit 32 suggests a similar localization of the mica-rich zone there. The zone occurs inside the plagioclase unit or against the schist where the plagioclase unit is absent. It is discontinuous where the border zone is thick.

Plagioclase-perthite-quartz-biotite-tourmaline zone.—The plagioclase-perthite-quartz-biotite-tourmaline zone forms a thick capping over and around the central zones at the northeast end of the pegmatite. It thins down dip and southward along strike. Only scattered small bodies of this material were seen south of pit A. It occurs most commonly between the border zone or plagioclase zone and the perthite-quartz-plagioclase zone. Pendants and apparently isolated bodies of biotite-rich material occur in the latter zone.

The mapping of this zone was based on the presence of biotite, and several minor mineralogic variants are included in it. In general, it consists essentially of plagioclase (An_{4-5}), perthite, gray quartz, biotite, and black tourmaline. Muscovite is an abundant though minor constituent. Plagioclase is more abundant than perthite in most exposures and commonly is somewhat stained. In pit A and in drill holes 1 and 3 most of it is green. Quartz occurs as anhedral grains between other minerals. Biotite commonly occurs in strips as much as 3 feet long and 6 inches wide, but less than ½ inch thick. Muscovite is in isolated books or intergrown with strip biotite. Black tourmaline may occur in small tabular bodies which, viewed from a distance, seem to be biotite. Some of the biotite strips pass lengthwise into tourmaline, but individual books of biotite and crystals of tourmaline are also present. Sulfides are locally abundant in the green plagioclase.

Quartz-plagioclase zone.—Irregular quartz grains that average 1 inch across make up at least 75 percent of the quartz-plagioclase zone. The rest is mostly interstitial white plagioclase (An_2) that appears to be fine-grained cleavelandite. Isolated books of muscovite, light-green beryl crystals, and perthite are accessory minerals. This unit lies between the border zone, the muscovite-quartz-plagioclase zone, or the plagioclase unit of the wall zone and the central perthite-rich zones. It is exposed south of the west crosscut from the north shaft and in, and south of, pit 32.

Plagioclase-muscovite-quartz-perthite zone (*sheet-mica-bearing*).—The plagioclase-muscovite-quartz-perthite zone consists essentially of plagioclase (An_2), muscovite, gray quartz, perthite, and minor tourmaline and biotite. The mica books are large and extend into the adjoining zones. The mica-rich shoots occur at the inner margin of the zone and have been mined in the long drift on the west side of pit A and in the crosscut in pit D. The plagioclase-muscovite-quartz-perthite zone lies between the biotite-rich zone described above and the no. 2 feldspar zone described below. Commonly, it is 3 to 5 feet thick. The mica-rich shoots are discontinuous, and found only along the northwest (footwall) side of the no. 2 feldspar zone in pits A and D. The shoots appear to have definite vertical limits. Widely spaced mica books of large size occur at the outer edge of the no. 2 feldspar zone elsewhere in pit A. These scattered books are believed to be in small isolated segments of the zone.

Perthite-quartz-plagioclase zone.—The perthite-quartz-plagioclase zone, known locally as the no. 2 feldspar zone, is exposed in pits A, C, and D and in the underground workings from them. It has a maximum thickness of 120 feet and completely encloses, or almost so, the large perthite pegmatite lens in the pits. It consists largely of perthite, but gray quartz and plagioclase are abundant and considerable parts of this zone may consist entirely of plagioclase and quartz. Small areas of graphic granite are present and muscovite, in small books, is an abundant accessory mineral. Scattered crystals of green beryl, as much as 5 feet long and 2 feet in diameter, occur in this zone at the margin of the perthite pegmatite in pit A.

Graphic granite zone.—The center or core of the sheet-like eastern part of the Ruggles pegmatite consists of graphic granite. The angular quartz spindles of the intergrowth commonly are less than one-half inch in length. Perthite also occurs in quartz-free crystals.

Quartz-perthite zone.—The quartz-perthite zone is best exposed in the walls of pit 32 but it occurs also in the southeast cuts. Its relation to the perthite pegmatite mined out in pit 32 is uncertain. It consists essentially of milky to light gray quartz which contains large blocks of perthite. One or more of the boundaries of the perthite blocks usually is straight and sharp. Contacts of this unit with the perthite pegmatite probably are gradational, like the contacts with quartz bodies.

Perthite zone.—The large lens of perthite pegmatite mined in pits A, C, and D is at least 400 feet long, 60 feet wide, and 50 feet high. It has been the principal source of no. 1 feldspar. A large part of it has been mined out in pits A and C. It pinches out south of pit A and seems to be thinning northeast of pit D although considerable feldspar is believed to be available under the present workings. A similar smaller lens was reported to have been mined in pit 32. These lenses seem to represent the discontinuous core of the pegmatite, although the relationship of the perthite pegmatite in pit 32 to the quartz-perthite unit is obscure. The perthite zone consists almost entirely of perthite. Plagioclase is almost lacking, except in the perthite intergrowths. Small quartz stringers cut the perthite but are not abundant. Sericite is present locally along fractures in the feldspar.

Quartz bodies.—Gray to milky quartz occurs in irregular lenses associated with the large lenses of perthite pegmatite, in isolated lenticular bodies inside various zones of the pegmatite, and in late cross-cutting veins and stringers. Irregular lenticular bodies of quartz are present adjacent to or enclosed in the perthite zone in pits A, C, and D. One lens in pit A is 200 feet long and extends diagonally under the large perthite lens. Other irregular quartz bodies occur in various positions within the pegmatite but apparently have no definite relation to the enclosing units. Quartz veins up to 4 feet thick cut the central parts of the pegmatite in pits A, C, and D, but apparently do not extend into the schist walls. Many of these veins have strikes perpendicular to the strike of the pegmatite. They have steep south or southeast dips.

The quartz is commonly light gray but is white and milky in the center of the thicker bodies. Small amounts of muscovite, garnet, sulfides, and uranium minerals occur in places. In pits A and C, a fine-grained aggregate of albite is found with the late quartz veins.

Muscovite-plagioclase unit (*scrap-mica-bearing*).—Adjacent to the perthite pegmatite, irregular muscovite-plagioclase replacement bodies are present. They consist largely of greenish-rum wedge muscovite in closely packed aggregates of diversely oriented books with small amounts of interstitial plagioclase and traces of quartz. The mica books are less than 2 inches across and commonly "A", reeved, or herringbone. The plagioclase associated with the muscovite seems to be fine-grained cleavelandite.

Sericitized perthite-plagioclase-quartz unit.—A perthite-plagioclase-quartz unit containing an abundance of heavily sericitized perthite is exposed at the southwest corner of pit A. Associated with the sericitized perthite are unaltered perthite blocks, white blocky plagioclase, finer-grained areas of interlocking plagioclase and quartz, and small scaly muscovite crystals in granular smoky quartz. Quartz also occurs as larger irregular bodies. Occasional large rum-colored muscovite books, and isolated, somewhat rounded bodies of aplitic material resembling that of the border zone, are also present.

The outer limits of this unit are difficult to define, because sericitization of the perthite, on which mapping of this unit was based, ranges from minor alteration to almost complete replacement, and because the unit has been produced by the sericitization of parts of several zones. Isolated perthite blocks along the margins of the no. 2 feldspar zone in the west drift of the 140-foot level are sericitized; the main exposures of this unit are in the southwest corner of pit A and on the 120-foot level vertically below it. With decrease in the intensity of alteration, it grades into the no. 2 feldspar zone and also into the aplitic border zone. Muscovite and plagioclase are most abundant near the pegmatite wall. The few large mica books may represent an extension of the marginal muscovite-quartz-plagioclase zone.

On the east side of pit A, in the east crosscut from the north shaft, and in drill hole 3, pegmatite units comparable in composition and texture to those found elsewhere in the dike are exposed, but the units have peculiar structural relations to the other units. No satisfactory explanation of the structural relationships of these units can be offered at present. Possible interpretations include the presence of a second pegmatite intrusion, or the presence of abrupt rolls in the schist wall.

PEGMATITE EAST OF RUGGLES PEGMATITE

A small pegmatite lens is exposed east of the sheetlike projection of the main Ruggles pegmatite. The small pegmatite pinches out up dip in a sharp crest and has no surface connection with the sheetlike projection. It contains three zones. An aplitic border zone forms most of the surface outcrop, but apparently is restricted to the crest of the lens. The zone is mineralogically similar to the aplitic border zone of the main pegmatite. The wall zone contains blocky plagioclase, quartz and muscovite and is exposed only along the footwall. The core consists of almost equal quantities of pinkish perthite and quartz.

MICA AND FELDSPAR

Sheet mica is obtained from two intermediate zones of the pegmatite. The muscovite-quartz-plagioclase zone near the walls has been the major source of the mica produced by the Whitehall Co., Inc., but considerable production has come also from the mica-rich shoots on the northwest side of the perthite-quartz-plagioclase zone. Mica occurs in books as much as 3 by 5 feet in area and is rum, flat, mostly cloudy and free splitting. It is "soft" and commonly badly cracked and ruled, but a satisfactory percentage of large sheet can be recovered. Many books show iron oxide stains, but these can usually be removed during rifting and trimming. Mica along the west wall on the 140-foot level has a higher content of sheet than that in the eastern part of the zone exposed at this level. In 1944 the recovery of mine-run mica from rock mined in the mica-bearing zones was approximately 12 percent.

The Ruggles mine is operated chiefly for potash feldspar. The feldspar produced is used in soap or scouring agents and must be white and almost completely free from mineral impurities. The central perthite units consist almost entirely of this type of feldspar. Material from the no. 2 feldspar zone is crushed and sized, and the better grades of feldspar are sorted out on picking belts.

Uraninite and its associated alteration products are found in the pegmatite and are of particular interest to collectors. Schaub (1937, p. 156; 1938, p. 334–341) described the occurrence, crystal habit, and composition of uraninite from the mine. Some secondary uranium minerals are also present. These and uraninite are associated with late veins and irregular bodies of quartz, which commonly has a dark smoky color near the small masses of radioactive minerals. Uranium minerals are best exposed at or near the west side of the perthite pegmatite near the south end of pit A and in the roof of the 120-foot level.

The largest reserves of no. 1 feldspar apparently lie under pit D and between pits D and C. The wall between pits A and C and the part of the perthite lens south of pit A contain additional reserves. Much larger reserves of no. 2 feldspar are present. This material would have to be milled to separate the other minerals from the perthite before it could be used in cleansers. The largest reserves of mica seem to lie south of the west wall drift in the 140-foot level and between this working and the flat stope.

SAUNDERS MICA MINE

The Saunders, sometimes known as the Haile or Buckley mica mine (pl. 1, no. 72), is in the town of Grafton, 3.7 miles S. 70° W. of Grafton village. To reach it from Grafton follow a graded road southwestward 2.3 miles to Robinson Corner; take the right fork northwestward, passing two left forks, for 2.0 miles to a crossroad; take the left fork over a newly constructed mine-access road for 0.9 mile to the left fork; proceed along the left fork for 0.3 mile to the mine.

The mine (fig. 95) is owned by Mrs. Mildred S. Braley of Grafton Center, N. H. Operations prior to 1914 resulted in an opencut about 120 feet long and 10 to 20 feet deep that is now partially filled with debris. A tunnel, 80 feet long, was driven to intersect the lower part of the opencut, but was not completed. It was operated under lease from September 1943 to November 1944 by Freedom Mines, Inc., of Grafton. The southwestern end of the opencut was enlarged and deepened, and a tunnel was driven 20 feet southwest from the end of the opencut. An incline was sunk from the floor of the cut to the head of the old tunnel, and the tunnel was extended westward about 20 feet, where it encountered backfill from the earlier operations. Waste rock from the opencut and incline was removed by a derrick. Most of the rock removed from the tunnel was backfilled into the old part of the tunnel.

The mine was studied by J. B. Headley, Jr. and J. B. Thompson in October 1942, visited several times by E. N. Cameron during the winter of 1943–44, and studied again by A. H. McNair and A. H. Chidester in June 1944.

The Saunders pegmatite is poorly exposed. Scattered outcrops indicate that in general it extends northeast, parallel to the foliation of the enclosing quartz-mica schists of the Littleton formation. It can be traced along strike at least 370 feet and appears to be about 150 feet wide in the vicinity of the mine. The walls of the body are not exposed, hence neither its dip nor relationship to the wall rock can be determined. Probably the pegmatite dips eastward about 50°, parallel to the foliation of the schist. Exposures of fine-grained quartz-mica schist that are not close to the pegmatite, have a well-developed foliation striking N. 20° E. and dipping 40°–70° E.

Pegmatite near the mine is stained, fractured, and crossed by joints that strike northeast and dip southeast. One joint is occupied by a thin, persistent, basic dike that can be seen along the east wall of the old tunnel and in the sides of the opencut. The dike is 4 to 18 inches thick, strikes N. 80° E., and dips 50°–60° SW.

The pegmatite consists of quartz, buff and green-gray perthite, and graphic granite, with minor biotite, muscovite, plagioclase, apatite, beryl, and black tourmaline. Zonal structure is not apparent in any of the outcrops. The walls and faces of the workings, however, show a persistent tabular concentration of muscovite that is 2 to 4 feet thick and extends at least 120 feet, parallel to the southeastern face of the workings. The northeastern part of this mica shoot strikes about N. 60° E. and dips 40° to 45° SE. It has ill-defined boundaries and consists of perthite, muscovite, oligoclase (An_{23}), and quartz. There is no obvious bilateral symmetry in the arrangement of its minerals. Graphic granite seems to be slightly more abundant on the hanging-wall side of the mica shoot than on the footwall side. The position and attitude of the eastern part of the mica shoot is shown in section B–B′ (fig. 95).

The southwestern part of the mica shoot is 2 to 4 feet wide, and extends along the southeastern edge of the opencut and along the floor of the tunnel. It becomes indistinct near the tunnel face, where its presence is indicated by a few scattered muscovite books. The hanging-wall side of the shoot is a body of perthite 35 feet long and at least 10 feet thick. An irregular body of gray quartz, 6 feet long by 4 feet wide, lies in perthite a short distance southwest of section A–A′ (fig. 95). Mining did not extend through the perthite to its southeastern margin and the possibility of a mica concentration next to it was not determined. There is no well-defined concentration of mica at the upper edge of the perthite body in the face of the cut, suggesting that should any mica shoot occur on the hanging wall of the perthite body it would have a relatively low muscovite content.

The muscovite is dark rum to ruby. Most of the books are of moderate size, free splitting, and not excessively stained, ruled, or reeved. The books yielded a satisfactory percentage of good sheet mica. Operations in 1943 and 1944 indicate that approximately 3.3 percent mica was recovered from rock mined.

The tabular character of the mica-bearing unit, particularly in its northeastern part, indicates that the deposit is fracture controlled and that the mica-bearing pegmatite was introduced after the bulk of the pegmatite had solidified. Absence of bilateral symmetry in the arrangement of the muscovite books and their associated minerals may indicate that the mica did not fill the space of a previously formed cavity, but replaced the host pegmatite. The relationships of the perthite-quartz body in the southwestern part of the cut are not clear. If a mica concentration exists on the southeast margin of the pegmatite body, there are two possible interpretations: first, the perthite pegmatite, its marginal mica bearing unit, and the tabular mica shoot extending northeastward from the perthite body represent a fracture-controlled replacement deposit that contains a central body of perthite and quartz. Absence of a border zone would be taken to indicate that the filling of the fracture was accompanied by replacement of its walls. Second, the perthite-quartz body represents a pod or small core of the pegmatite with a core-margin zone around it. The northeastern and upper (tabular) part of the mica "shoot" would

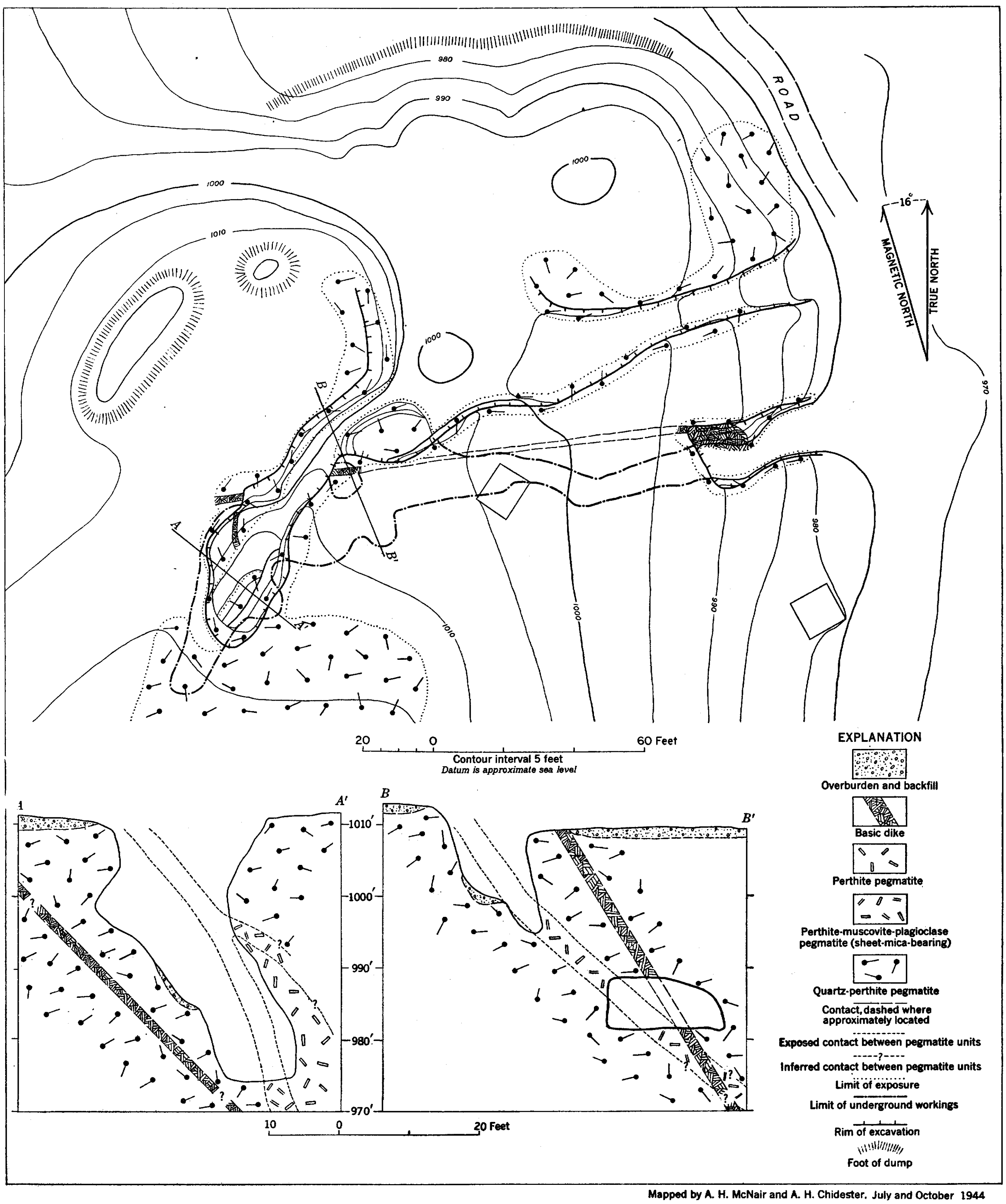


FIGURE 95.—Geologic map and sections of the Saunders mica mine, Grafton, N. H.

then be a fracture-controlled deposit projecting from the core-margin mica zone. The second interpretation seems improbable as the perthite-quartz core or pod appears to be small. However, only part of the upper and footwall sides of the perthite-quartz body is exposed.

If a mica concentration is absent on the southeast margin of the perthite-quartz body two other explanations are possible: first, that the perthite represents the central part of a fracture-controlled replacement body having a marginal mica zone only along the footwall of the perthite-quartz body; second, that the perthite-quartz body is a previously formed pod or core that has been fractured and is intersected by the fracture-controlled body along its western margin.

In summary, the Saunders mine has a concentration of mica that extends 120 feet along strike and down dip at least 40 feet. The southwestern part of the concentration seems to end near the face of the tunnel leading from the opencut. The northeastern end may have terminated or diminished in mica content a score or more feet northeast of the incline, because mining was not carried beyond old operations. Future production will depend on the down-dip extent of the tabular mica concentration below the level of the part of the workings between the head of the old tunnel and the southwest end of the cut.

E. E. SMITH MICA MINES

The E. E. Smith mica mines (pl. 1, no. 53) are on the east spur of Hutchins Hill, 2.2 miles N. 75° W. of Alexandria village. From the village, take the road that leads past Tenney School up the valley of Patten Brook; at 1.9 miles from Alexandria, a graded dirt and gravel road turns right; follow this for 0.8 mile to the mines.

The property is said to be owned partly by the town of Alexandria, partly by an individual. The upper mine (fig. 96), once known as the Bullock mine, was opened prior to 1941. E. E. Smith, Canaan, leased the property in December 1941, and operated it until August 1944. Early in 1942, pegmatite was discovered lower down the hill. Another mine was opened and operated intermittently until November 1944. In 1943, a third pegmatite lying between the two mines was prospected.

The main working at the upper mine is an opencut 105 feet long, 14 to 35 feet wide, and 12 to 35 feet deep. Near the entrance to the cut, a pit—now flooded—leads into a high narrow stope. The floor of the stope is at an altitude of approximately 1,562 feet. The north end of the stope, when last examined, in July 1944, was 63 feet north of the north edge of the flooded pit. Two smaller opencuts are shown on the map north of the mine, and north of the area mapped there are shallow pits scattered along what is probably the extension of the pegmatite worked in the mine.

The lower mine consists of a cut 145 feet long, 6 to 23 feet wide, and 4 to 30 feet deep, that is open except for a pillar near the north end. A crosscut near the southwest end leads to the dump. In April 1945, four inclines extended steeply downward to the west from the floor of the cut. The inclines were flooded, but they are probably not more than 25 feet deep. The cut crosses the bed of a small brook, and inflow of water has hampered operations considerably.

The mines were visited periodically by D. M. Larrabee in the winter of 1942–43 and were mapped by E. N. Cameron and J. Chivers in August 1943. Later in 1943 and in 1944, the mines were examined by Cameron and G. W. Stewart, and the workings at the upper mine were mapped in greater detail by K. S. Adams, F. H. Main and Cameron (pl. 36).

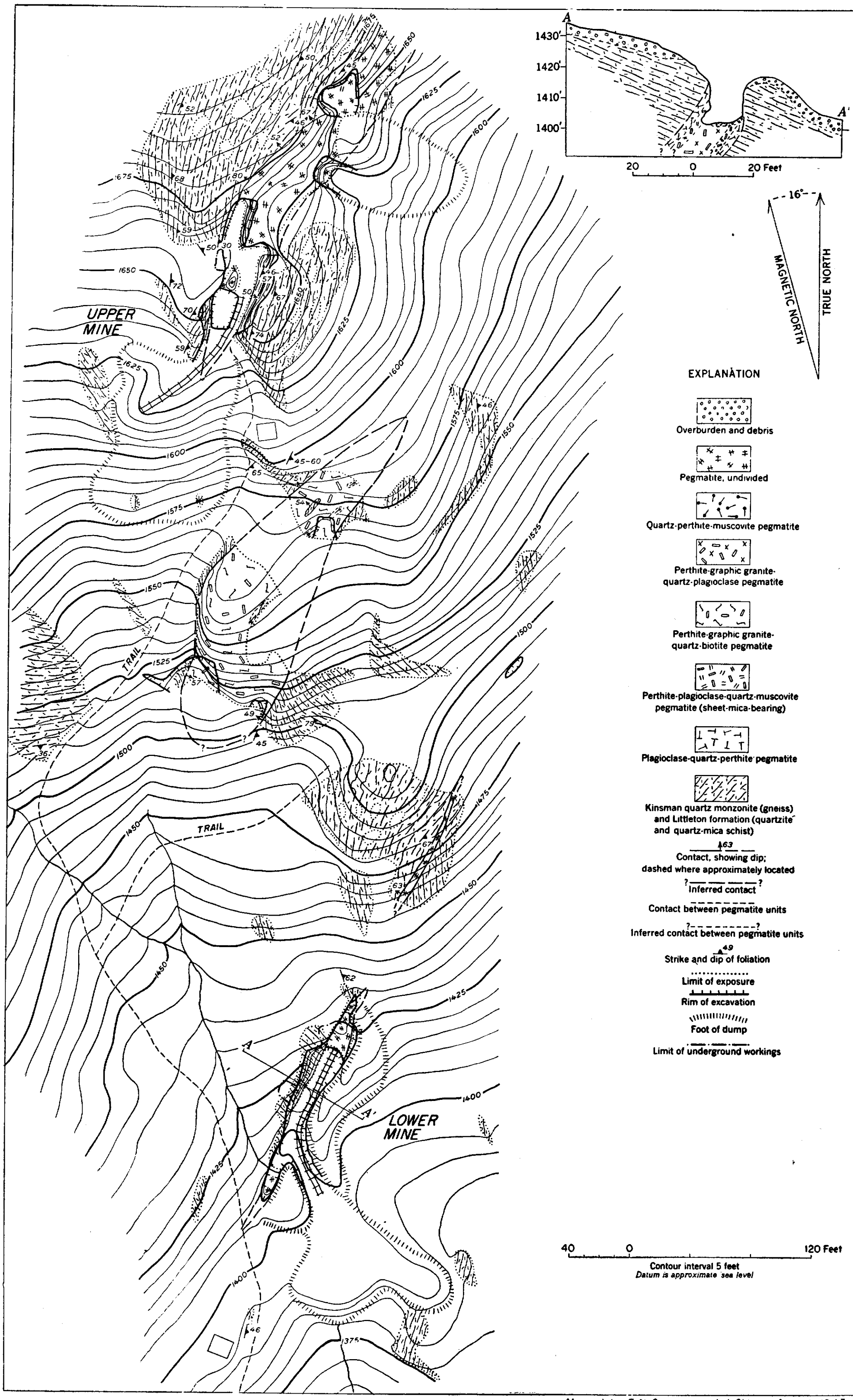
GEOLOGIC RELATIONSHIPS

Three large pegmatite lenses trending N. 35° E. to N. 40° E. and dipping steeply westward are exposed on the property. The lenses lie in echelon and were intruded into a contact breccia zone between Kinsman quartz-monzonite gneiss and quartzite and quartz-mica schist of the Littleton formation. The different kinds of wall rocks are not distinguished on the map of figure 96, but gneiss is the dominant type. The foliation of the wall rocks shows a wide range of attitude, but over much of the area it strikes north to northeast and dips east or southeast at moderately steep angles. The relationships between the two rocks in the vicinity of the middle and lower pegmatites are complex, and the gneiss has many inclusions of rocks of the Littleton formation. Adjacent to the pegmatites the wall rocks are tourmalinized, and the gneiss is rich in muscovite.

The echelon arrangement of the pegmatites and their closely comparable attitudes suggests that they were intruded along a set of tension fractures in a shear zone. Probably, the pegmatites are derived from the same source and were intruded at about the same time. The three pegmatites are fundamentally similar in composition, though they differ markedly in the degree to which zoning is developed and in details of mineral arrangement and habit.

LOWER MINE

The pegmatite at the lower mine ranges from 8 feet to about 15 feet thick. It probably pinches out a short distance southwest of the cut. Northeast of the cut are outcrops of a pegmatite 1.5 to 3 feet thick that is nearly in line with the pegmatite mined but differs markedly in composition and may be a separate body.



Mapped by E. N. Cameron and J. Chivers, August 1943

FIGURE 96.—Geological map and section, E. E. Smith mica mines, Alexandria, N. H.

The lens mined strikes N. 37° E. and its walls dip 48°–63° W. In general, its walls are parallel but uneven and marked by angular bends controlled by joints in the country rock. Wall-rock inclusions are present in the lens. In the northeast end of the cut the lens is offset about 5 feet by a fault (not shown on pl. 36) that strikes N. 75° W. and dips 46° S. Slickensides on the fault surface plunge S. 43° E. at an angle of 26° and indicate an oblique movement of the hanging wall downward to the southeast.

The pegmatite is distinctly zoned. The sequence inward from the wall is as follows:

1. Border zone, 3–12 inches thick. Composed of quartz, scrap muscovite, and plagioclase. Along part of the wall, the zone includes a narrow aplitic layer ¼ to 3 inches thick.
2. Plagioclase-quartz-perthite wall zone, 1 to 2 feet thick. Chiefly medium-grained plagioclase and quartz, with subordinate perthite and scrap muscovite, and accessory garnet.
3. Perthite-plagioclase-quartz-muscovite intermediate zone. Coarse perthite, plagioclase, and quartz, with scattered books of muscovite, 1 to 12 inches broad and ¼ to 3½ inches thick, and accessory garnet.
4. Perthite-graphic granite-quartz-plagioclase intermediate zone, 2 to 8 feet thick. This zone consists chiefly of perthite and graphic granite and is much coarser-grained than the other zones. It contains perthite crystals, 4 inches to 1 foot in length. Scattered crystals of garnet are present, and fine-grained muscovite occurs along fractures in feldspar.
5. Quartz core, a lens of massive quartz about 20 feet long and 1 to 2 feet wide, measuring 7 feet parallel to the dip. It is present in the pillar and the northeast end of the opencut. Along the core is a thin layer of green, wedge-shaped muscovite books that are rooted in the perthite-graphic granite zone and project into the core. The mica is all of scrap quality. Comparison of this mica with the wedge mica of the upper mine suggests that the layer may be a replacement body.

Mica from the productive intermediate zone is light ruby, hard muscovite. Some books show mineral staining, others are clear. Ruling and cross fractures are conspicuous defects, and it is probable that most of the sheet mica produced was small. Past operations, and evidence from the small parts of the zone accessible, indicate that it was richest on the hanging-wall side of the pegmatite between the crosscut trench and the pillar. The crude mica content of the rock mined to the end of 1944 is roughly estimated to be 0.13 percent.

UPPER MINE

The pegmatite worked in the upper mine is a lens 5 to about 35 feet thick. It is exposed for 240 feet within the area mapped, and may extend more than 400 feet farther to the northeast. The pegmatite strikes N. 28° E. to N. 45° E. In the main working it dips steeply northwestward to nearly vertical. North of the main working the dip of the wall ranges from 50° to 75° NW. The walls have conspicuous rolls and, locally, sharp bends along joints in the Kinsman quartz monzonite. The keel of the pegmatite was exposed in the flooded pit, where it plunged northeast at an angle of 15° to 20°. The pitch of the keel steepens abruptly just inside the underground workings. At the southeast corner of the 1604-foot level, it was 33° in the direction N. 30° W. In the nearly vertical south end of the stope between the 1,604- and 1,589-foot levels the keel is not exposed, hence between these levels the plunge must be vertical or, possibly, even southward.

The pegmatite consists of 6 units. In the main working the sequence of units inward from the walls is as follows:

1. Border zone, 2 to 6 inches thick. Composed of quartz and scrap muscovite with accessory garnet.
2. Plagioclase-quartz-muscovite wall zone, 1 to 4 feet thick. Composed chiefly of coarse plagioclase and quartz, with subordinate muscovite and accessory garnet and tourmaline. Perthite crystals are present in places, particularly north of the main cut.
3. Plagioclase-quartz-perthite outer intermediate zone, 3½ to 22 feet thick. Essentially medium-grained plagioclase and quartz, with small books of muscovite, scattered crystals of perthite, and accessory tourmaline and garnet.
4. Plagioclase-muscovite-quartz-beryl middle intermediate zone, 1 to 3 feet thick. Composed of coarse plagioclase, wedge muscovite, and quartz, with minor columbite-tantalite. Scattered crystals of beryl, the largest 4 inches by 4 inches by 1 foot, are present along the inner margin of the unit, and in the same position in the north end of the cut there are crystals of triphylite up to 1.2 feet by 3 feet in cross section. The wedge-shaped books of muscovite are 2 inches to 3 feet long, and 1 inch to 1 foot broad. Traces of autunite are associated with columbite-tantalite, and triphylite is partly altered to vivianite and other unidentified alteration products.
5. Perthite-quartz intermediate zone, 5 feet to about 20 feet thick. Composed essentially of perthite in stout crystals as much as 6 feet long and 4 feet thick. This zone is discontinuous in the main cut and is developed chiefly above the quartz core next described, but it is represented by scattered crystals of perthite that project into the flanks of the core and are inside the wedge muscovite-bearing zone.
6. Quartz core, 5 feet to about 9 feet thick. Massive, coarse quartz.

Northward from the main cut the wall zone is progressively richer in perthite and also progressively less distinct, ending along the hanging wall near the south edge of the north cut. The plagioclase-quartz-perthite zone likewise becomes progressively richer in perthite northward, and perthite is more abundant than plagioclase in the middle and north opencuts, where the zone also contains graphic granite and strips of intergrown muscovite and biotite. Some of the perthite crystals show alteration to pseudomorphs composed of albite and greenish muscovite. The wedge muscovite-bearing unit is discontinuous north of the cut. It is noteworthy that the zone is present chiefly where masses of quartz occur in the perthite-quartz intermediate zone, and is generally absent along perthite-rich parts. The wedge mica unit may be of secondary origin, as similar wedge mica occurs in other parts of the pegmatite. In the north cut, wedge mica has developed along fractures in the plagioclase-quartz-perthite zone, and small bodies of quartz rimmed by wedge muscovite are found in this zone. Quartz, muscovite, and fine-grained greenish muscovite have likewise been formed as fracture fillings in perthite.

The perthite-quartz zone is thickest between the north cut and the main working. North of the north cut this zone and the wedge-mica unit appear to be represented by central pods of quartz and perthite with subordinate plagioclase and wedge muscovite, and scattered beryl crystals.

The relationships of the various units in the pegmatite are not fully understood. Some replacement after development of the zonal structure is indicated, but how much is not clear. Detailed study of the variation in proportions of the minerals in the units and petrographic studies of the sequence of mineral development are needed.

The wedge mica from the deposit is all scrap. Sheet mica has been obtained only from the wall zone, where hard ruby books are 1 to 12 inches broad and ½ to 3 inches thick. Ruling, cross fractures, tangle sheet, and quartz films mar the books, but some yield sheet of both small and large sizes. Much of the sheet is mineral stained and rust stained, and has pinholes. Owing to these defects, the average quality of the sheet produced is below the average for New England.

Most of the sheet muscovite mined has come from a shoot definitely related to the keel of the pegmatite. The wall zone has consistently been richest along the hanging wall in the vicinity of the keel. As various levels were carried northward along strike away from the keel, the yield of the wall zone decreased. The average yield of crude mica from rock mined in the underground workings was approximately 3.8 percent.

Beryl from the deposit is green and massive to columnar. Megascopically it appears pure. Most of the small output of beryl was produced in the winter of 1943–44, when the wedge-mica zone was being mined for scrap. The average beryl content of this zone is uncertain. Crystal counts of an area 6 feet wide and 19 feet long on the west side of the core in the main working indicated a beryl content of approximately 0.7 percent. However, as beryl is very unevenly distributed, the area available is considered too small to be representative. The beryl crystals in the zone can be separated by hand cobbing.

The perthite-quartz zone contains a high proportion of coarse perthite separable by hand cobbing. The zone extends 120 feet along strike and has an average thickness estimated at 10 to 15 feet. However, the quartz core plunges northward beneath the zone and so may not extend far down dip; therefore the bulk of the feldspar reserves may be down the plunge. The structure of the pegmatite is such that although beryl and scrap mica would be recovered as byproducts of feldspar mining, sheet-mica mining would necessarily be a separate operation. As the mine is far from railroads, feldspar mining has not been considered practical, even under wartime conditions. The yield of scrap mica would be less in the feldspar-rich part of the pegmatite. The content of columbite-tantalite in the zone is probably less than 0.1 percent.

Future operations probably would depend on the market for sheet mica. The reserves of mica present in the wall-zone deposit are unknown, but there is no indication that the shoot along the keel has been exhausted. In future operations the keel should be located and mining planned with reference to its position. The parts of the shoot already mined were fairly rich in book mica, but the yield and quality of sheet mica were low. The wall zone, apart from the shoot, appears to be lean and contains books lower in content of sheet mica.

MIDDLE PEGMATITE

The Middle pegmatite was prospected by Smith in 1943 by means of three small opencuts (fig. 96). The results were discouraging, hence no mining was attempted.

The pegmatite is a thick lens that trends N. 37° E. and dips steeply northwest. Dips of the contact at the southwest end of the pegmatite suggest that there the keel is not far below the surface. The pegmatite has been traced for 165 feet along its trend and has a maximum outcrop width of about 65 feet.

In structure this pegmatite resembles the other two. It has a border zone, an incomplete wall zone, an intermediate zone, and a discontinuous core. The border zone resembles those of the other two pegmatites. The wall zone (not shown), is indicated only by a greater concentration of plagioclase and muscovite next to the northwest wall. The intermediate zone forms the bulk of the pegmatite. It is a coarse mixture of graphic granite, perthite, quartz, and strips of intergrown "fish-scale" biotite and muscovite—with accessory tourmaline and garnet, and rare beryl. Its inner parts are very coarse textured near the southwest end of the pegmatite. The core is represented by four pods along the middle of the pegmatite. The pods consist of coarse quartz, perthite, muscovite, and beryl.

Between the xenolith shown on the map and the northwest wall, the pegmatite has a remarkable small-scale banding perhaps due to injection of pegmatite between thin screens of gneiss. Between adjacent screens, the zoning of the main pegmatite is repeated.

The sheet-muscovite content of the pegmatite is extremely low, and coarse perthite separable by hand is scarce. A count of beryl crystals in the southwesternmost pod indicates that it carries about 1.3 percent beryl, but the other pods contain little beryl, and the average content of the central part of the pegmatite is undoubtedly very low.

STANDARD MICA MINE

The Standard mica mine (pl. 1, no. 41) is in the town of Orange, 2.9 miles N. 69° E. of Canaan village. From Canaan follow State Highway 118 for 0.6 mile east-northeast to a fork; turn right on a hard-surfaced road and continue for 2.6 miles to the third road on the left; follow a graded gravel road approximately 0.4 mile to the mine road on the left; turn left and proceed 0.2 mile to the mine. The property and mineral rights are owned by Dr. E. G. Baum, of Wellesley Hills, Mass. The mine (fig. 97) has been operated intermittently for more than 75 years. From 1910 to 1914 it was operated by the Canadian-owned Standard Mining Co., which excavated two large open pits and drove several short adits that extended from the west and southwest faces of the larger pit. The larger pit is about 200 feet long, 65 to 160 feet wide, and 10 to 50 feet deep. The smaller pit is 120 feet long, 30 to 75 feet wide, and 5 to 20 feet deep. Ralph H. Peaselee of Orange, N. H., a foreman for the Standard Mining Co., reports that the mine produced 3 to 5 tons of mica per day. The company employed 30 to 50 men. Waste-rock was removed by 3 overhead carriages, each carrying a 1-ton bucket. Since 1914 mining has been intermittent and confined to mica-rich parts of the pegmatite. Operations by the Standard Mica Mining Co., owned by Dr. Baum, began September 1943 and ended in November 1944. The larger pit was mined along its northern and western faces, but much of the mica was obtained during the enlargement of an old adit in the southwest face of the larger pit. The enlarged adit is 35 feet long, 20 feet wide, and 10 to 15 feet high. Waste rock was removed by a derrick and carried to the dump in mine cars hauled by a gasoline locomotive. An undetermined thickness of backfill covers a large part of the floor of both pits.

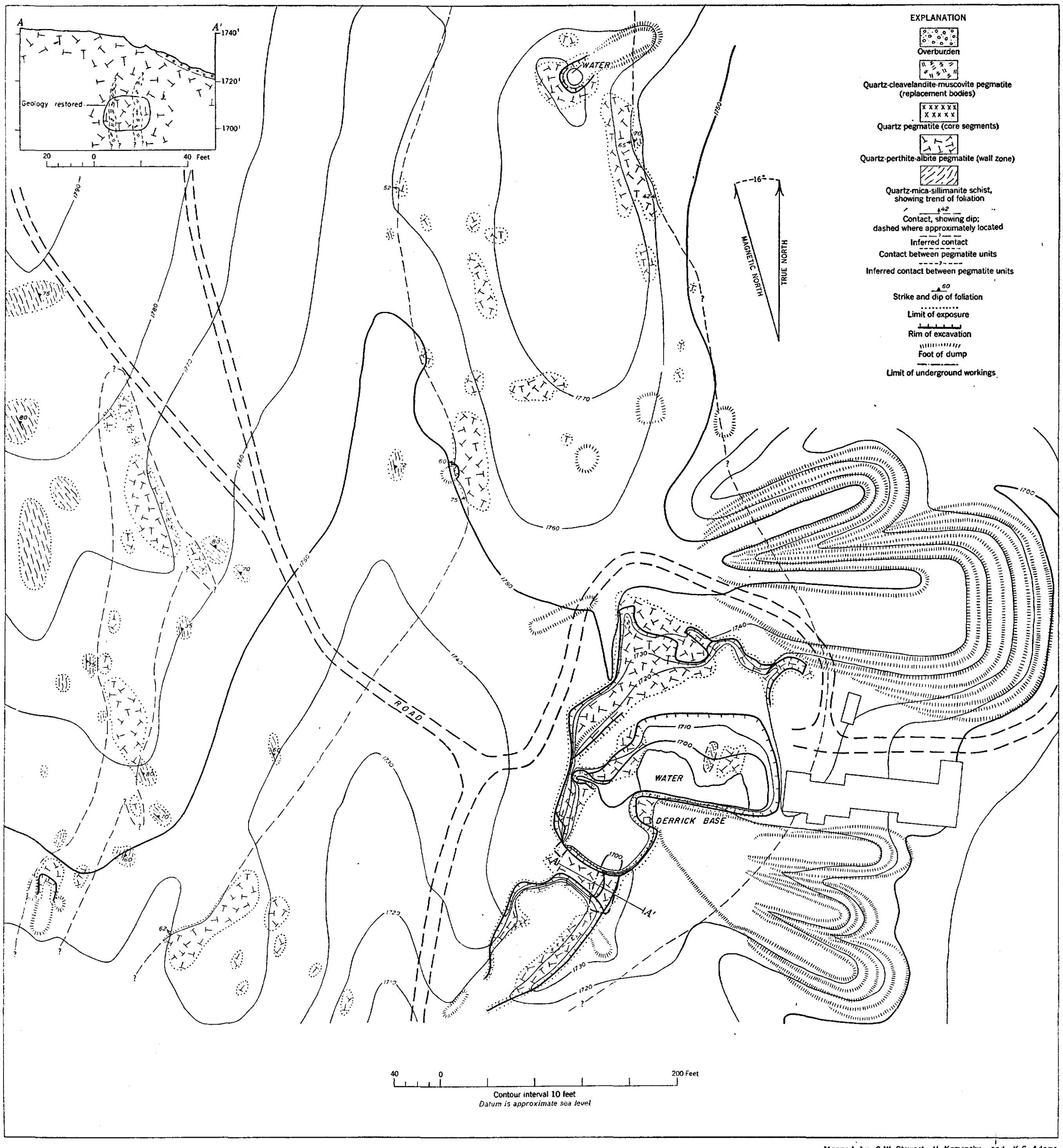
Equipment for a mica-grinding mill is housed east of the larger pit but is not completely installed. It consists of a jaw crusher, gyratory crusher, rotary screens, ball mill, and a shaking and washing table. Machines, forge, and rifting shops are at the mine. Brief descriptions and sketches of the mine have been made by Sterrett (1923, pp. 136–137) and Olson (1942, p. 388). The mine and prospects were mapped by Glenn W. Stewart and Harry Kamensky in July 1943, and later visits were made by E. N. Cameron and G. W. Stewart. Parts of the main pit were remapped by Stewart and Karl S. Adams in November 1944.

The main pegmatite is exposed for about 950 feet, and is probably 360 to 370 feet wide near the middle of its outcrop area. It is about 200 feet wide at the north end of the map area, 220 to 240 feet wide at the south end. The pegmatite is arcuate. The southern half strikes about N. 40° E. and the northern half roughly north. The contact between the schist wall rock and the pegmatite was found only along the eastern edge of the pegmatite near the north end. Here the pegmatite dips 65° W. Fifty feet south of this point the schist has been stripped off by erosion, but the dip measured on the surface of the border zone is 42° W. Other border-zone surfaces along the hanging wall have dips ranging from 52° to 75° W. The southern half of the pegmatite seems to cut across the strike of the foliation, whereas the northern half is essentially parallel to it. The pegmatite everywhere transects the dip of the foliation.

The country rock is quartz-mica schist of the Littleton formation in the vicinity of the two larger pegmatites, but this grades into quartz-sillimanite schist west of them. The strike of the foliation of the schist ranges from north-northeast to northwest and the dip ranges from 35° to 80° E. Several xenoliths of schist, with foliation essentially parallel to the foliation of the wall rock, occur in the pegmatite.

The main pegmatite has a border zone 2 to 5 inches thick composed of fine-grained quartz, muscovite, and minor plagioclase. The wall zone, 200–350 feet wide, is composed of quartz, perthite, albite (An_{3-4}), graphic granite, muscovite, biotite, and accessory tourmaline, garnet, apatite, and beryl. Quartz bodies containing minor perthite and ranging from 2 by 5 feet to 8 by 30 feet in size, are scattered throughout the exposed parts of the wall zone and probably are segments of a discontinuous core. Layers 6 to 18 inches thick composed of albite (An_{4-5}), cleavelandite (An_{1-3}), and muscovite border these quartz bodies in places and probably represent a discontinuous intermediate zone. Several tabular fractured-controlled replacement bodies cut the wall zone of the pegmatite. They are essentially parallel to the strike of the pegmatite and are nearly vertical. They are composed of albite (An_{4-5}), cleavelandite (An_{1-3}), muscovite, and accessory tourmaline and apatite. Some are at least 35 feet long and 3 to 5 feet thick. (See fig. 97, sec. A–A′.)

In the main pegmatite most of the muscovite is associated with the quartz bodies and fracture-con-



Mapped by G.W. Stewart, H. Kamensky, and K.S. Adams, July 21–26, 1943. Revised November 20, 1944

FIGURE 97.—Geologic map and sections of the Standard mica mine, Orange, N. H.

trolled replacement bodies. The muscovite is confined to the margins of the quartz bodies and is associated with albite and cleavelandite. In the fracture-controlled replacement bodies the muscovite is intergrown with the albite, cleavelandite, and quartz. Elsewhere in the pegmatite the muscovite is sparsely disseminated.

During 1943–44 an attempt was made to mine the fracture-controlled replacement bodies and quartz bodies selectively. Some of the bodies mined were rich in muscovite, but the recovery of sheet was low, and the mica was of poor quality. The quartz bodies and replacement bodies are widely spaced and only very small quantities of disseminated mica were found in the pegmatite separating them. Further operation would have required removal of large quantities of rock poor in sheet mica in search of mica-rich bodies.

A small pegmatite crops out from about 70 to 200 feet west of the main pegmatite. It is exposed for 420 feet and is 30 to 70 feet wide. It strikes approximately north, and has an irregular steep dip. It was prospected near its southern end about 1910 to 1914, and near its northern end during 1943–44. The pegmatite has a border zone 2 to 4 inches thick, made up of fine-grained quartz and muscovite, with minor plagioclase and accessory garnet and tourmaline. The wall zone, 29 to 69 feet thick, is a coarse mixture of quartz, perthite, plagioclase, minor muscovite and biotite, and accessory tourmaline. Quartz pods that reach a maximum of 2 by 10 feet are scattered throughout the wall zone. Prospecting in 1943–44 did not yield enough muscovite of good quality to encourage mining.

There are two opencuts 1,200 feet S. 65° W. of the mica-grinding mill. The cuts probably were made between 1910 and 1914. They are in separate pegmatites that strike approximately N. 10° E. and dip 50° SE. The opencut in the easternmost pegmatite is about 55 feet long, 15 to 20 feet wide, and 5 to 10 feet deep. The pegmatite is about 140 feet long, and is 3 to 5 feet thick. It has a border zone 2 to 4 inches thick, consisting of fine-grained quartz, muscovite, and minor plagioclase. A wall zone 1 to 3 feet thick is exposed along the hanging wall. The zone is composed chiefly of muscovite and contains minor quartz and plagioclase. The core of the pegmatite is 1 to 4 feet thick and is composed of plagioclase and quartz. The western pegmatite is exposed only in the second cut, which is 55 feet long, 8 to 10 feet wide, and 5 feet deep. The zonal structure of the pegmatite is essentially the same as that of the eastern pegmatite, except that the wall zone, which contains the muscovite, is only 6 to 12 inches thick.

Muscovite is present only along the hanging wall of the pegmatites. It is light rum to green, soft, badly ruled, and slightly stained. Many books contain "A" structure and are wedge-shaped. The books average 6 by 6 inches, but many are 10 by 12 inches.

The pegmatites were not prospected in 1942–44 and no information is available concerning the value of the muscovite in them. The size and quantity of muscovite in the wall zones of the pegmatites might justify further prospecting under conditions comparable to those of 1943–44, but the softness and numerous structural defects of the muscovite indicate that the recovery of sheet mica from crude mica would be low.

STONE FELDSPAR PROSPECT

The Stone prospect (pl. 1, no. 59) is in the town of Canaan, 1.3 miles west of Canaan Center. To reach it from Canaan follow the left fork just north of Canaan Center for 1.2 miles to an intersection at the top of Sawyer Hill; proceed southward for 0.25 mile to an intersection, then continue southward about 0.5 mile to the crest of a knoll; at this point a thickly overgrown wood road bears S. 80° W. from the dirt road; follow the wood road about 900 feet to the prospect. The property is owned by the heirs of Edward Stone, formerly of Orford, N. H.

Many pits were dug in 1931 or 1932. The main pit is 45 feet long, 20 feet wide, and at least 20 feet deep. Two other smaller excavations are west of the main pit, and some feldspar may have been removed from them. The prospect was mapped by F. H. Main and K. S. Adams in April 1945.

As there are very few outcrops, the extent of the pegmatite and its internal structure cannot be determined fully. The pegmatite walls, where observed, strike about N. 70° E. At the east end of the main pit the walls appear to be nearly vertical. The wall rock is granodiorite gneiss of the Mascoma dome. Its foliation strikes N. 5° E. and dips 40° E. The pegmatite body is sharply discordant to the foliation.

The pegmatite consists of pink perthite, quartz, biotite, and minor plagioclase, muscovite, garnet and tourmaline. A zonal structure is shown in the pegmatite at the east end of the main pit. A fine-grained border zone was not recognized at any of the contacts with wall rock. The wall zone, 2 feet thick, consists of medium-grained quartz and pink perthite containing accessory biotite and muscovite. This zone grades abruptly into a coarse-grained core of pink perthite and quartz with accessory biotite and muscovite. The perthite forms subhedral to anhedral crystals. Quartz occurs as irregular masses or as veins occupying fractures in the perthite. Biotite is commonly found as deformed books or as strips on joint planes in the perthite and quartz. The pegmatite lens southwest of the pits is partly exposed but shows no massive perthite core. It is composed chiefly of medium-grained quartz and perthite.

The small size of the perthite-rich core and the abundance of biotite in the core indicates that the prospect is capable of producing only limited amounts of hand-sorted commercial feldspar. The deposit is interesting geologically because it is one of the few pegmatites that have been found in rocks of Billings' Oliverian magma series.

STRAIN MICA MINE

The Strain mica mine (pl. 1, no. 38) is in the town of Orange, 2.9 miles N. 60° E. of Canaan village. To reach it from Canaan follow State Highway 118 for 0.6 mile northeast to a road on the right; turn right on a hard-surfaced road across the Indian River; continue for 2.6 miles to the third road on the left; turn left and follow a gravel and wood road for about 0.8 mile to a wood road on the left; turn left and proceed 0.6 mile to the mine.

The property and the mineral rights are owned by James H. Strain, 1 Boston Post Road, New Milford, Conn. The mineral rights were leased by A. C. Estey, 52 Grandview Road, Arlington, Mass., from August to November 1943.

The main working, pit A (fig. 98), is an inclined open pit 130 to 140 feet long, 5 to 25 feet wide, and 10 to 30 feet deep. It was first opened and worked in the early 1900's by Sargent and Varick of Canaan, N. H. About 50 tons of mine-run mica was recovered. Pit B, an extension of the main working, is 30 feet long, 20 feet wide, and 3 to 17 feet deep. Pit C is 70 feet long, 10 to 35 feet wide, and 10 to 22 feet deep. From August to November 1943 the mine was operated by A. C. Estey. Pit A was extended about 15 feet northward and 10 to 20 feet down dip. About 200 tons of rock was moved, yielding about 1.3 percent mine-run mica. Pit B was deepened 6 to 10 feet and widened 5 or 10 feet along the north face.

The pegmatites were mapped in August 1943 by G. W. Stewart and Harry Kamensky. Subsequent visits were made in 1943 by E. N. Cameron and Stewart.

Two pegmatites are exposed in the vicinity of the mine. Number 1, the larger pegmatite, is the southern part of the Pinnacle pegmatite. (See Pinnacle mica mine, p. 209.) This pegmatite has been mapped for 2,160 feet along strike and traced for several hundred additional feet. It is 15 to 120 feet wide in the vicinity of the mine, strikes approximately north, and dips from 70° W. to 58° E. An offshoot extends outward from pegmatite no. 1 at pit B. The offshoot is exposed for 130 feet along strike and is 10 to 23 feet wide. It is essentially parallel to pegmatite no. 1 and dips 40°–60° E. The keel of the schist wedge separating the offshoot from pegmatite no. 1 plunges 30°–40° N. The crest of the offshoot plunges 20°–30° N. beneath the wall rock. Pegmatite no. 2 is exposed for 350 feet along strike and is 20 to 100 feet wide. It trends parallel to pegmatite no. 1, but may dip steeply westward. The contacts of both pegmatites are concordant in some places to the wall rock foliation, discordant in others. The strike of the offshoot pegmatite is parallel to the wall rock foliation but transects it down dip.

A small shear plane, visible on the east face of pit C, strikes N. 30° W. and has a steep and irregular southwest dip.

The wall rock is quartz-mica-sillimanite schist of the Littleton formation. Its foliation in general strikes N. 5°–10° E., but the strike ranges from N. 25° E. to N. 10° W. The foliation dips 55° NE. to 65° NW. In places along the pegmatite contacts the wall rock has been tourmalinized.

Pegmatite no. 1 has a border zone, 2 to 6 inches thick, composed of fine-grained quartz, muscovite, with minor plagioclase and accessory garnet. The remainder of the main part of the pegmatite body is composed largely of medium- to coarse-grained quartz, perthite, plagioclase, and muscovite, with partly chloritized biotite and accessory tourmaline and garnet. This material, shown as quartz-perthite-plagioclase pegmatite on figure 98, encloses irregurlarly distributed quartz pods as large as 8 by 10 feet. In pit B some of the perthite has been partly replaced by sericite and is porous. Quartz veins as much as 4 inches thick and several feet long are common.

In the offshoot mined in pit A, the border zone contains apatite and pyrite in addition to the other minerals. The quartz-perthite-plagioclase pegmatite contains much less perthite and lacks biotite, and between it and the border zone is a wall zone, 1 to 2 feet thick, composed of medium- to coarse-grained quartz, plagioclase, sheet-bearing muscovite, and accessory garnet and tourmaline. The wall zone was the source of the mica recovered. At the south end of pit A and along the north face of pit B, where the zone is best exposed, the muscovite books are unevenly distributed. At the north end of pit A the books are more abundant and more evenly distributed. The zone extends along the walls of the offshoot and around the keel of the schist wedge separating the offshoot from the main body of the pegmatite.

Most of the sheet-bearing muscovite mined came from part of the wall zone along the hanging wall and along the keel of the schist wedge in pit B. The books are light-rum, hard, slightly marred, ruled, and cracked. They average about 4 by 4 inches in size. Green stains (iron oxide) are present in many of the books. Small amounts of muscovite occur with the quartz pods and as thin fish-scale books along joints and

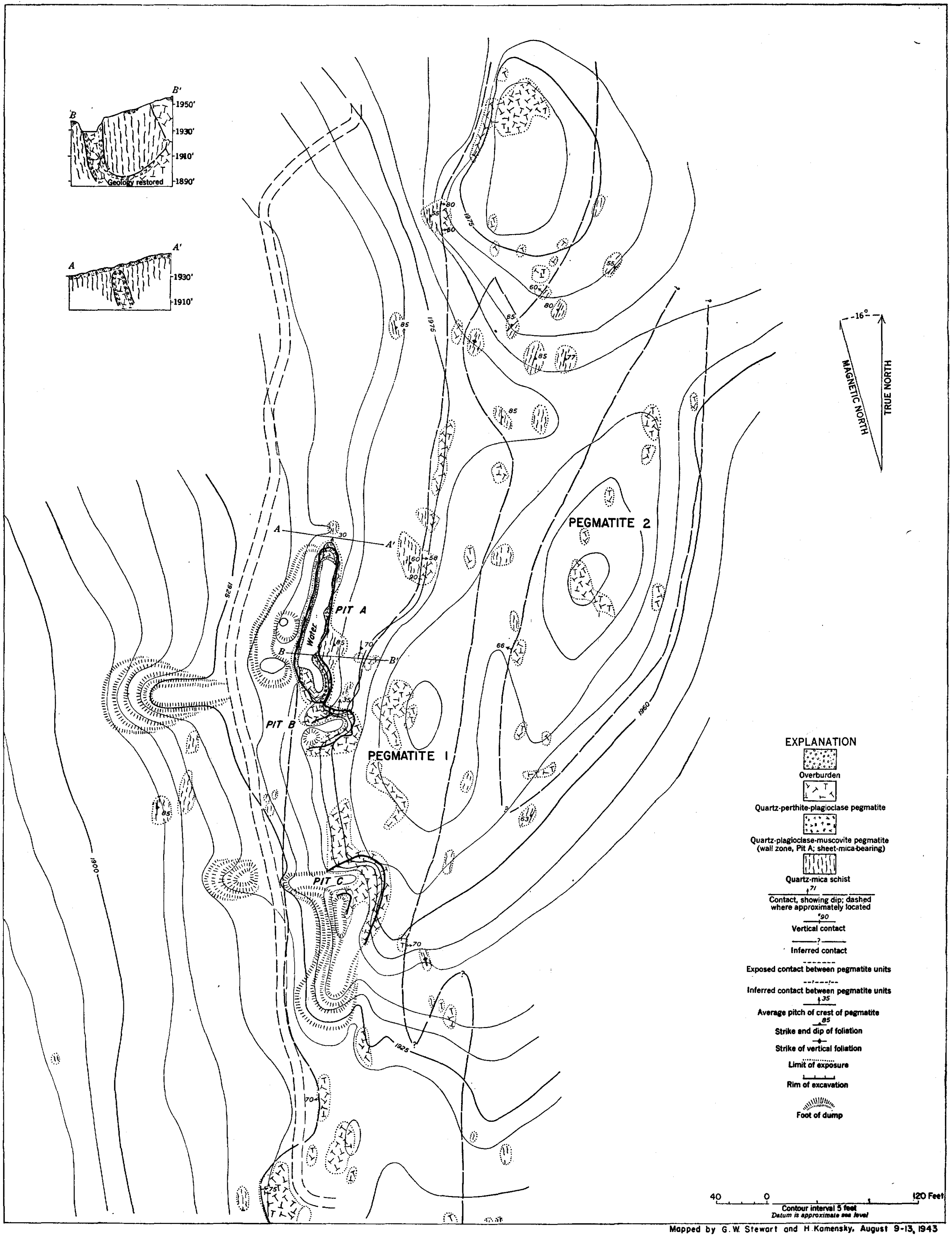


FIGURE 98.—Geologic map and sections of the Strain mica mine, Orange, N. H.

cleavage surfaces in perthite, but little, if any, sheet muscovite is present in these books.

Operation of pits A and B in 1943 is said to have been unprofitable, although a satisfactory percentage of sheet mica was recovered from mine-run mica, and the content of mine-run mica in rock moved ranged between 2 and 3 percent. The crest of the offshoot pegmatite plunges 20°–30° N. and the pegmatite seems to be thinning at the north end of pit A, but down plunge and down dip from this part of the working there may still be appreciable reserves of book mica. Additional mica might be recovered by following the keel of the schist wedge down plunge. Operations in 1943 were carried nearly to the limit of practicable opencut mining.

Pegmatite 2 is similar to pegmatite 1, except that no sheet-mica-bearing wall zone has been found in it. Exposures show only very small amounts of book muscovite.

UNION MICA MINE AND PROSPECTS

The Union mine and prospects (pl. 1, no. 19) are in the town of Groton, 1.4 miles N. 3° W. of the village of North Groton. To reach them from North Groton follow a graded gravel road east-northeast for 1.1 miles along Halls Brook to a woods road on the left; follow the woods road northwest for 0.3 mile to an intersection; turn right and continue northeast 0.2 mile to a woods road on the left; take the left fork and go about 1 mile northwest to the mine. The property and mineral rights are owned by the General Electric Company of Schenectady, New York.

The mine has not been worked since 1888 (Sterrett, 1923, p. 128–129). The main working is an opencut about 150 feet long, 8 to 30 feet wide, and 5 to 35 feet deep, with a shaft 50 feet deep, near the widest part of the pegmatite. Stopes and drifts were made near the bottom of the workings. Several nearby pegmatites were prospected at about the same time. In September and October 1944 the General Electric Company lowered the water level in the mine until it was about 25 feet below the rim of the opencut, and the top of a pillar, 5 by 7 feet, was exposed. Pumping also revealed that much of the opencut is filled with slabs of schist. No additional work was done at the mine, but two pegmatites, west and southwest of the mine, were prospected. The mine and prospects were mapped in October 1944 by Glenn W. Stewart, and Karl S. Adams. The pegmatites are numbered on the accompanying map, plate 37.

The wall rock is quartz-mica schist of the Littleton formation. In general, its foliation strikes N. 30° E. and dips 70°–90° SE. but its attitude is extremely varied near the contacts of the schist with the pegmatites.

Old Union mine, Pegmatite No. 1.—Pegmatite no. 1 is limited to the cut itself, and the main body could not have been more than 120 feet long. According to Sterrett (1923, p. 128–129) the pegmatite ranged from 10 to 18 feet in thickness. An offshoot at the southwest end of the cut was 30 to 35 feet long, 5 feet thick at the surface, and 3 feet thick at a depth of 15 feet. The pegmatite strikes N. 50°–60° E., dips steeply southeast, and has a nearly vertical plunge. It is discordant to the foliation of the wall rock in most places, but the schist extends around the ends of the pegmatite. Both hanging wall and footwall are marked by numerous rolls. The exposure in the upper part of the pillar indicates that the pegmatite has a border zone and a wall zone composed of quartz and plagioclase with abundant books of muscovite. The massive quartz found in the dump suggests that the pegmatite may have had a quartz core (sec. A–A′, pl. 37) bordered by a sheet-mica-bearing quartz-plagioclase zone. Mica seen in the pillar and dump was dark-rum to ruby, very hard, nearly flat, and free from mineral stains and inclusions. Most of the books showed ruling. The books average 4 by 6 inches.

The condition of the old workings below the water level and the extent of the pegmatite down dip are unknown.

Pegmatite No. 2.—Pegmatite no. 2 is exposed about 390 feet along strike and is 15 to 70 feet wide. It strikes approximately N. 65° E., and probably dips 60° to 70° SE. It is discordant to the foliation of the wall rock and is zoned. The border zone, 2 to 4 inches thick, is composed of fine-grained quartz, muscovite, and subordinate plagioclase. The wall zone, 10 to 30 feet thick, is composed of quartz, perthite, plagioclase, small disseminated muscovite books, and accessory tourmaline and garnet. Plagioclase is more abundant than perthite adjacent to the pods. The core consists of several pods, the largest 30 by 45 feet, which are composed of anhedral and subhedral crystals of perthite, 2 by 4 feet or smaller, subordinate plagioclase, and several small bodies of graftonite and triphylite associated with smoky quartz. Muscovite books, 3 by 4 inches across, occur unevenly distributed through the pods. The muscovite is hard, flat, slightly ruled, and nearly free of mineral stains or inclusions.

One pod was mined prior to 1888, and during September and October 1944 another pod was prospected. Rock moved in 1944 yielded only 0.6 percent mine-run mica. The yield was too low to repay operation, although the mica received was of satisfactory quality.

Pegmatite No. 3.—Pegmatite no. 3 has a strike length of 260 feet and is 5 to 30 feet wide. It strikes N. 20°–30° E., dips 55°–80° SE., and appears to plunge 65° NE. Its strike is essentially parallel to the foliation of the wall rock except at the hook-shaped northeast end. The border zone, 2 to 4 inches thick, is composed of fine-grained quartz, muscovite, and plagioclase. The wall zone, 2 to 15 feet thick, is composed of quartz, perthite, plagioclase, subordinate small disseminated muscovite books, and accessory tourmaline and garnet. The core, consisting of pods 10 to 20 by 8 by 45 feet, is composed of quartz and anhedral and subhedral crystals of perthite and some disseminated muscovite books. Three prospect pits were made in the pods before 1888. The most promising exposure, at the southwest end of the hook-shaped part of the pegmatite contains a few muscovite books of good quality, but considerable rock would have to be moved to recover them.

Pegmatite No. 4.—The irregular pegmatite no. 4 is exposed for 350 feet along strike and is 15 to 90 feet wide. It strikes N. 50°–60° W., dips 50°–80° SW., and in most places cuts the foliation of the wall rock.

The border zone, 3 to 5 inches thick, contains fine-grained quartz, muscovite, and subordinate plagioclase. The wall zone, 7 to 45 feet thick, is composed of quartz, perthite, plagioclase, muscovite in disseminated books, and accessory tourmaline and garnet. The core consists of scattered pods of quartz with or without perthite, with sparsely disseminated muscovite books 3 by 3 inches in diameter. Adjacent to the pods plagioclase is more abundant than perthite. Tourmaline crystals are most numerous along the western margin of the pod exposed in the pit than elsewhere in the prospect. The muscovite is hard, flat, slightly ruled, and nearly free from mineral stains or inclusions. The muscovite is of strategic quality, but the quantity is small. Approximately 0.6 percent of mine-run mica was recovered from rock moved in 1944.

Pegmatite No. 5.—Pegmatite no. 5 is exposed for 85 feet along strike and is 5 to 10 feet wide. It strikes about N. 40° E., dips 67°–78° SE., and is nearly parallel to the foliation of the wall rock. The border zone, 1 to 3 inches thick, consists of fine-grained quartz and muscovite. The probable core, 4 to 9 feet thick, is composed of quartz, perthite, and plagioclase with a little scrap muscovite in disseminated books. This pegmatite seems to contain no sheet mica.

Pegmatite No. 6.—Pegmatite no. 6 is exposed for 25 feet and is 5 feet wide. It strikes about N. 20° E., dips 85° SE., and is parallel to the foliation of the wall rock. The border zone, 1 to 3 inches thick, consists of fine-grained muscovite and quartz. The probable core, 4 to 4½ feet thick, is composed of quartz, plagioclase, and a little scrap muscovite.

Pegmatite No. 7.—Pegmatite no. 7 is exposed for 145 feet along strike and is 30 to 40 feet wide. It strikes about N. 30° W., and dips 45°–70° SW. It is discordant to the foliation of the wall rock in most places. The border zone, 2 to 4 inches thick, is composed of fine-grained quartz, muscovite, and minor plagioclase. The wall zone, 10 to 20 feet thick, is composed of quartz, perthite, plagioclase, and minor small muscovite in disseminated books. The core, 5 to 10 feet thick, consists of one distinct pod of quartz and perthite, 10 by 40 feet in surface area, and several smaller and less distinct pods, which have muscovite in books 3 by 3 inches or less. The pods are composed of coarse quartz grains interstitial to anhedral and subhedral crystals of perthite measuring 1 by 2 feet.

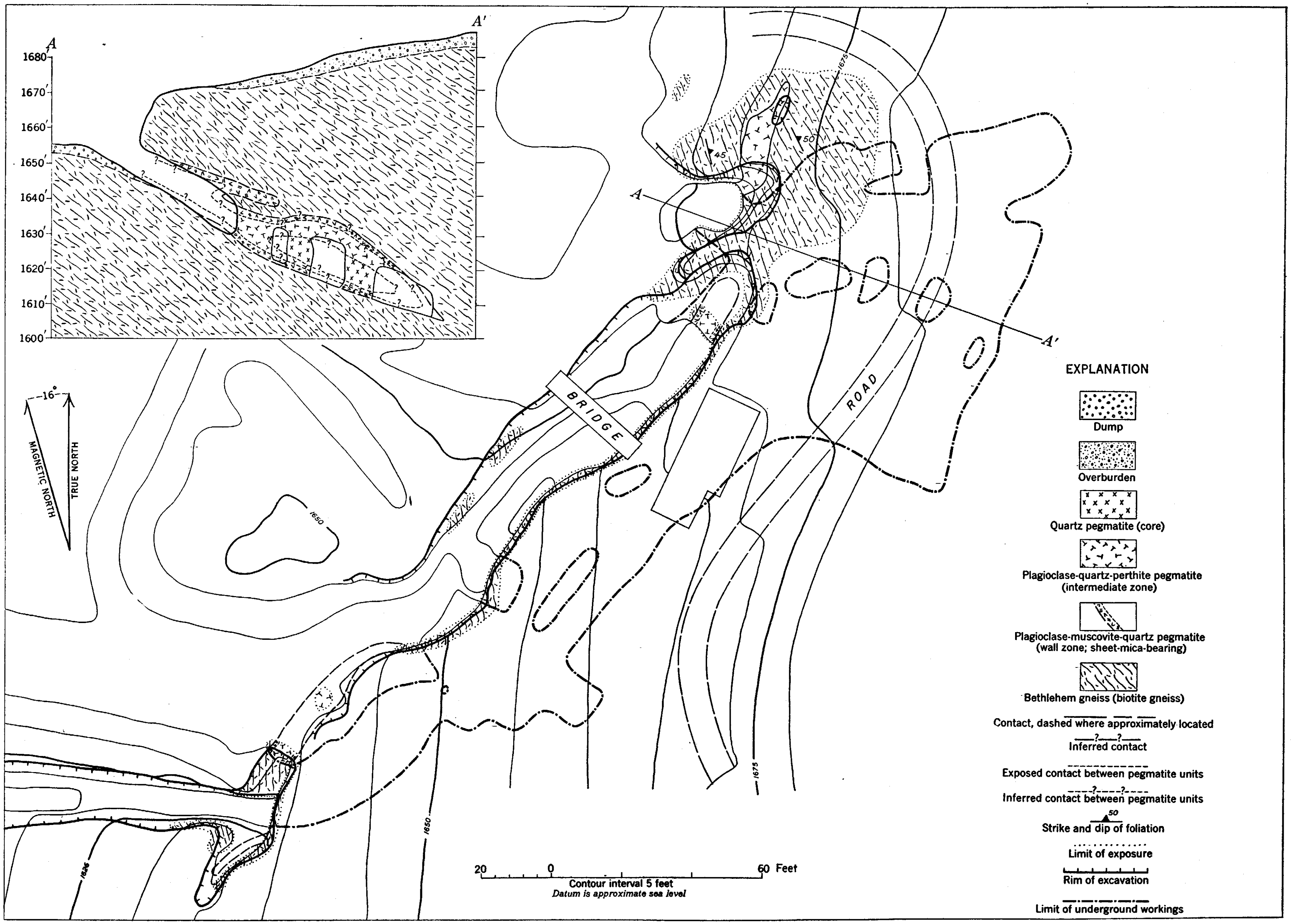
Pegmatite No. 8.—Pegmatite no. 8 is exposed for 75 feet along strike and is 10 to 45 feet wide. It strikes about N. 35° E., dips 80°–85° SE., and is essentially parallel to the foliation of the wall rock. The border zone, 1 to 3 inches thick, consists of fine-grained quartz and muscovite. The wall zone, coarser grained, contains quartz, plagioclase, and muscovite in disseminated books. A quartz pod 10 by 15 feet in surface dimensions is present in the center of the pegmatite. No sheet-bearing muscovite is exposed.

Summary.—It is uncertain whether sheet-bearing muscovite could be recovered from pegmatite no. 1. Muscovite of satisfactory quality is abundant in the exposed pillar, and is probably representative of the muscovite in the unmined parts of the pegmatite. The plunge of both ends of the pegmatite is nearly vertical, hence the pegmatite may continue some distance below the bottom of the old shaft. In each of two additional pegmatites prospected, muscovite is disseminated in quartz-perthite pods. A small quantity of good muscovite was recovered, but the rock moved in 1944 yielded only about 0.6 percent mine-run mica. Other, similar pods appear to contain even less muscovite.

UNITED MICA MINE

The United mine (pl. 1, no. 71) is in the town of Grafton, 3.7 miles S. 78° W. of Grafton village. To reach it from Grafton drive southwestward 2.3 miles to Robinson Corner, turn right and travel 2.0 miles to a crossroad. Follow the left branch, a newly constructed mine-access road, 0.9 mile to a fork, follow the right fork 0.2 mile to the mine.

The longest period of operation of the mine (fig. 99) was prior to 1920, when it was worked by the United Mica Co. of Grafton Center. It was operated for a short time in 1936–37 by A. W. Bennett of Canaan, N. H. The surface workings consisted of an opencut 140 feet long, 20 feet wide and 5 to 25 feet deep; an adit north of the cut; and a crosscut trench south of the cut. Interconnected inclined underground workings of the room-and-pillar type extended 20 to 80 feet eastward from the surface workings. The mine was purchased



Mapped by A. H. McNair, F. H. Main, and L. M. Sadler, October 1943 and May 1945

FIGURE 99.—Geologic map and section of the United mica mine, Grafton, N. H.

from Bennett by the New Hampshire United Mining Co. of Andover, N. H., and was operated by that company from August 1943 to July 1944. The northeastern part of the underground workings was enlarged and the incline near the south end of the opencut was extended eastward about 20 feet. Rock was removed from the west side of the workings that extend northward from the crosscut trench, and from the roof of the old workings at the north end of the opencut. With the exception of rock removed from the incline, the rock broken in 1943–44 was dumped into the lower part of the workings. The mine was mapped by G. W. Stewart, R. P. Brundage, and H. Kamensky in June 1943. The underground workings were mapped by A. H. McNair and L. M. Sadler in October 1943, and a revised map of the opencut and upper, accessible parts of the underground workings was prepared by McNair and F. N. Main in May 1945.

The United pegmatite is about 280 feet long and as much as 20 feet thick. It is an irregular lens that strikes about N. 40° E., and dips 30°–40° SE. The pegmatite ends in the southeast corner of the crosscut trench and a short distance beyond the north surface workings. It also terminates down dip both in the northeast end of the underground workings and in the face of the incline. The upper contact of the pegmatite is very irregular, and many offshoots from the main body project into the wall rock and extend down dip, roughly parallel to the dip of the body. They terminate in rounded ends. The footwall contact is regular and has a uniform eastward dip. The pegmatite is discordant to the foliation of the wall rock, the biotitic Bethlehem gneiss, which strikes N. 20° W. and dips 45°–50° E. The gneiss is in sharp contact with the pegmatite.

The pegmatite contains four zones. The border zone, 1 to 4 inches thick, contains mottled red and green oligoclase-andesine, quartz, and muscovite. The wall zone, 8 inches to 3 feet thick, contains white oligoclase, gray quartz, sheet-bearing muscovite, apatite, and some biotite. The footwall part of the zone has yielded a higher percentage of muscovite than the hanging-wall part, and both parts of the zone yielded considerably more muscovite in the workings near the quartz core than elsewhere. The muscovite books were arranged roughly normal to the wall. They were hard, flat, and rum to ruby. Some books were marred by "A" structure and ruling, but a high percentage of sheet was recovered from the mica mined during 1943–44. The books ranged from 2 by 2 inches to 8 by 10 inches.

The core-margin zone, 1 to 6 feet thick, consists of white oligoclase, gray quartz, and perthite. Blocks of perthite and scattered muscovite books are most abundant in the inner part of the zone, adjacent to the core. The core consists of granular milky quartz and is present only in the thicker part of the pegmatite. It has a maximum thickness of 10 feet and its position conforms roughly to that of the thickest part of the pegmatite. The south end of the core is closer to the hanging wall than to the footwall, whereas the northern end of the core is closer to the footwall.

The United pegmatite yielded large amounts of muscovite prior to 1920, when most of the mica-bearing rock was removed from the mine. The yield of mica from rock moved during 1943–44 was low. Both ends of the pegmatite pinch at the surface a short distance beyond the workings, and the pegmatite ends down dip in the northeast face of the underground working and in the incline. The pegmatite between the points of pinching has a maximum thickness of 5 feet and seems to thin abruptly eastward (down dip). If the thinning is real, only a very small tonnage of mica-bearing pegmatite remains east of the working face. The lower workings contain much backfill, and future operation of the mine would require the removal of some of it. Profitable operation of the mine under economic conditions comparable to those of 1943–44 appears unlikely.

VALENCIA MICA MINE

The Valencia mine (pl. 1, no. 21) is in the town of Groton, approximately 2.0 miles N. 73° E. of North Groton village. To reach the mine from North Groton follow a graded gravel road east-northeast for 1.5 miles along Halls Brook to a mine-access road on the right; turn right and follow the access road eastward for about 0.8 mile to a fork; turn left and go northeastward for about 0.7 mile to the mine. The mine is 300 feet south of the Hackett mica mine. Mineral rights are owned by the town of Groton and are leased by E. E. Smith of Canaan, N. H.

The mine was opened in 1880 and was worked on an extensive scale for 10 to 12 years, until a cave-in occurred in the main stope. Stopes extended to a depth of 50 feet in places along the east side of the opencut, which was approximately 150 feet long and 40 to 50 feet wide (Sterrett 1923, pp. 124–125). Since Sterrett's visit, about 1906, the mine has been operated intermittently for mica and feldspar, and parts of the dumps have been worked for mica. At present the main working is an open pit approximately 300 feet long, 40 to 100 feet wide, and 10 to 50 feet deep (fig. 100). The entrances of two old stopes can be seen along the eastern wall of the pit. The limits of the stope near the center of the pit are unknown. The stope in the southeast corner of the pit is 6 to 12 feet high, and was excavated about half way between the floor and the rim of the pit. The exact location and extent of the caved main stope are unknown. Underground workings are shown on Sterrett's sketch map

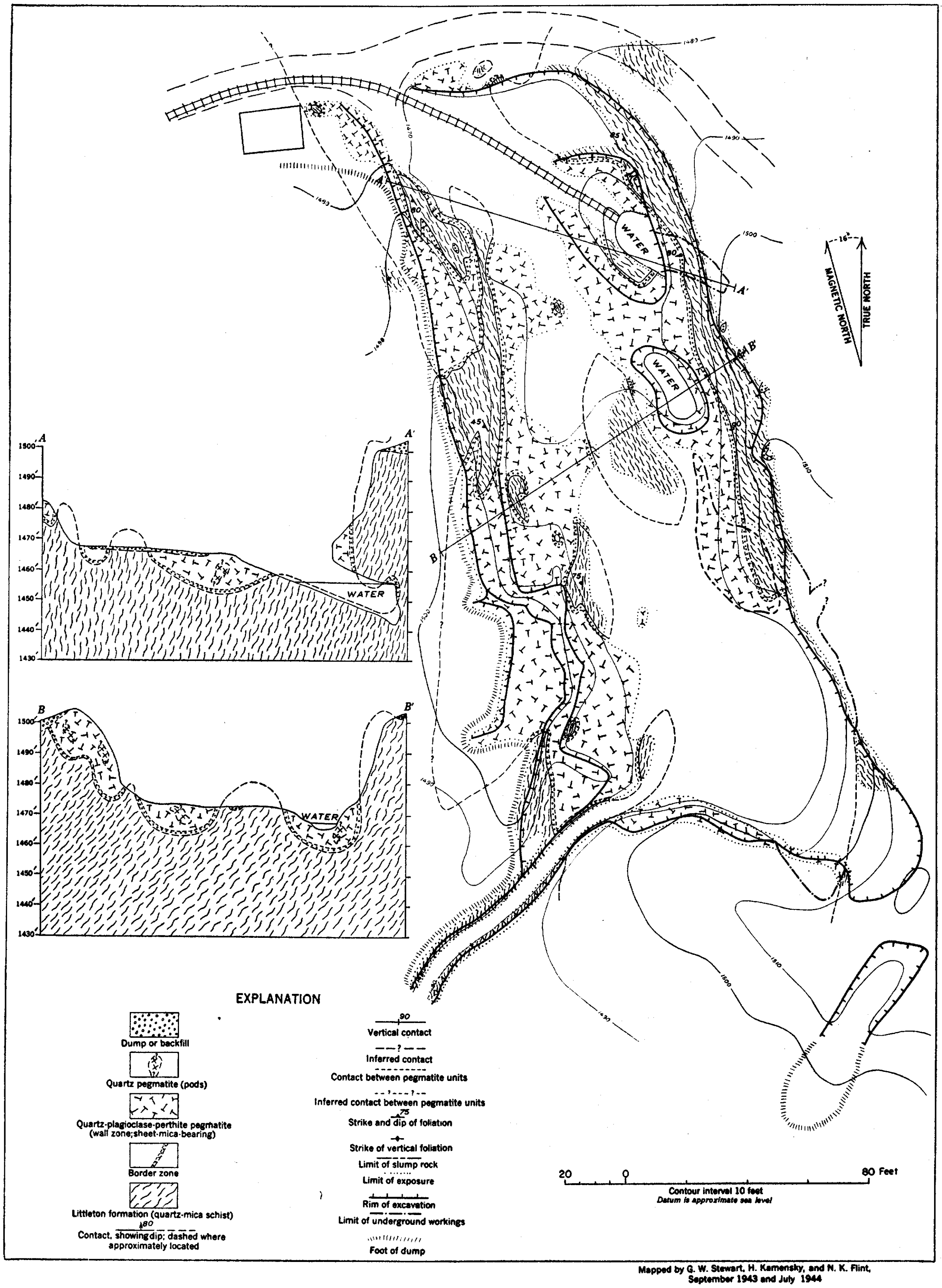


FIGURE 100.—Geologic map and sections of the Valencia mica mine, Groton, N. H.

in the northeast corner of the pit, which contains considerable slumped rock. From June to December 1942 the mine was worked for mica by Mullins and Glennon of Canaan, N. H. Most of the work was done along the west wall of the pit; waste rock was not removed. From July 1943 to April 1944 the mine was operated by V. J. Farrell of Canaan, N. H. Several months were spent removing waste rock with a bulldozer and a gasoline-powered shovel. Most of the mining was done in the west wall of the pit, but an inclined open stope was driven about 25 feet eastward from the east face of the pit. The stope is 6 to 12 feet wide and 12 to 15 feet high. During August and September 1944 the mine was operated by the Hill Mining Co. of Bristol, N. H. The entrance of the inclined stope was enlarged 5 to 10 feet on both sides, and much pegmatite was removed from the west wall. No waste rock was removed from the pit.

The mine was studied in July 1942 by C. S. Maurice and J. B. Headley, Jr. In September 1943 mapping was done by G. W. Stewart and Harry Kamensky, and this map was revised in July 1944 by Stewart and N. K. Flint. Periodic visits were made during 1943 and 1944 by E. N. Cameron and Stewart.

The pegmatite has a strike length of at least 280 feet and is 60 to 100 feet wide. It strikes about N. 20° W. and dips and rolls irregularly eastward. Perhaps the pegmatite extends several hundred feet northward to the Hackett mica mine. The well-defined rolls of the pegmatite walls, exposed on the east and west walls and bottom of the pit, plunge irregularly northeast at angles of 10° to 15°, and indicate that the pegmatite occupies a troughlike structure in the enclosing schist. Minor crumpling in the wall rock is essentially parallel to the rolls Isolated remnants of the pegmatite along the eastern rim of the pit indicate that the probable hanging wall in the inclined stope reverses its dip directly overhead (fig. 100, secs. B–B′ and A–A′). The schist extends around the pegmatite on the south face of the inclined stope (sec. A–A′).

The wall rock is quartz-muscovite-biotite schist of the Littleton formation containing scattered sillimanite crystals. The strike of the schist in the area surrounding the mine ranges from N. 10° to 35° E., but in the vicinity of the pegmatite it ranges from north to N. 25° W. The dip of the foliation ranges from 45° to 90° but commonly is between 75° and 80° W.

Present studies, together with Sterrett's sketch map, suggest that the pegmatite probably has a well-defined zonal structure, but at present only a border zone and a wall zone are exposed. The wall zone contains quartz pods bounded in places by narrow poorly defined layers containing sheet-bearing muscovite.

The border zone, 4 to 24 inches thick, is composed of fine- to coarse-grained quartz, muscovite, and plagioclase, with accessory garnet, apatite, and tourmaline. The wall zone, 10 to 40 feet thick, is composed of medium- to coarse-grained quartz, blocky albite (An_6), subordinate perthite, cleavelandite, sheet-bearing muscovite, and accessory tourmaline, apatite, garnet, and beryl. Isolated quartz pods, as much as 1 by 4 feet, are unevenly distributed through this zone.

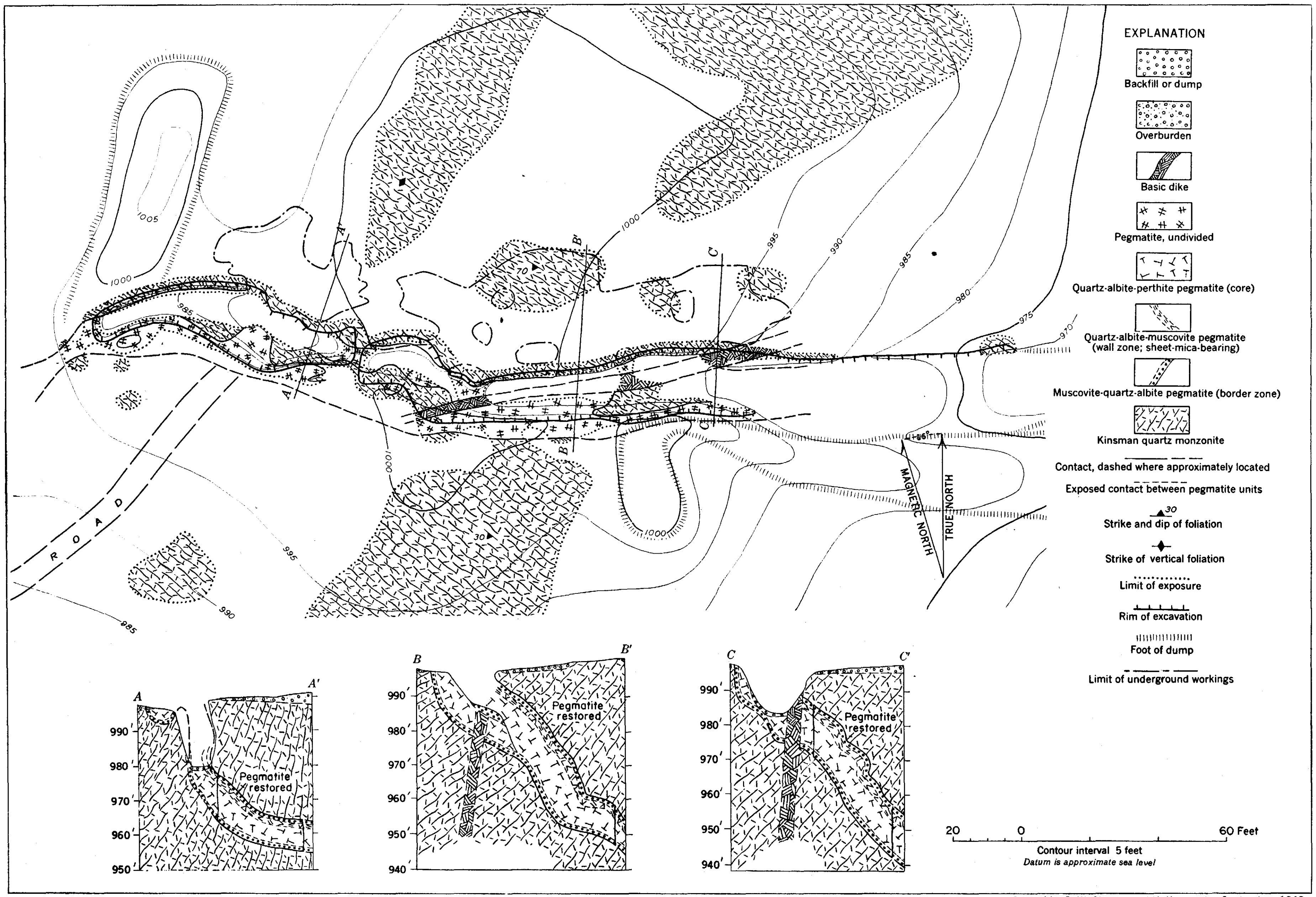
From a study of Sterrett's sketch map, it is inferred that the pegmatite has a quartz or quartz-perthite core, or quartz and quartz-perthite pods larger than any now exposed. These bodies have been bounded by segments of a discontinuous intermediate (core-margin) zone containing sheet-bearing muscovite. One large quartz body indicated by Sterrett's map appears to have been about 20 by 50 feet across. The core-margin zone around such pods may have yielded most of the early output of the mine.

After operations began in June 1942, muscovite was recovered from mica-bearing layers associated with the quartz pods and patches rich in quartz. Because the pods are sparsely distributed the yield of crude mica from rock mined during recent operations was low. The muscovite is light- to medium-rum, hard, and relatively free from mineral stains and inclusions. Many books are much ruled, and some are wavy. The books average 4 by 4 inches in size.

A veneer of border zone and wall-zone pegmatite, probably 10 to 30 feet thick, is all that remains along the walls and bottom of the pit, and it is clear from recent mining that the sheet-mica content of this material is low. The northeast corner of the pit, where the pegmatite plunges beneath the slumped rock was not explored during the war period, and the past yield of this part of the pegmatite is unknown. However, removal of the slumped rock would be expensive and, as there is no assurance that the yield of mica would be high, an operation in this part of the pegmatite would be a dubious enterprise under economic conditions comparable to those of 1943–44.

WADHAMS-TUCKER MICA MINE

The Wadhams-Tucker mine (pl. 1, no. 51) is in the town of Alexandria, 2.6 miles N. 45° W. of Alexandria village. To reach it from Alexandria follow a hard-surfaced road northwest for 0.2 mile to a fork; turn right and follow an improved gravel road 2.6 miles to a road on the right; turn right and proceed 0.3 mile to a farm house; turn left and follow a woods road north for 0.1 mile to the mine. The west workings (fig. 101) are owned by Erland O. Wadhams, Alexandria (R. F. D. Bristol), N. H. The mineral rights are leased by E. E. Smith of Canaan, N. H. The east workings are owned



Mapped by G. W. Stewart and H. Kamensky, September 1943

FIGURE 101.—Geologic map and sections of the Wadhams-Tucker mica mine, Alexandria, N. H.

by E. O. Lord, (R. F. D. Bristol). The mineral rights are leased by the Hill Mining Co. of Bristol, N. H. Prior to 1943–44 the west working was an opencut 75 feet long, 8 to 20 feet wide, and 10 to 15 feet deep. The east workings consisted of an opencut about 125 feet long, 10 to 20 feet wide, and 10 feet deep; and an inclined stope 10 to 20 feet deep, 40 to 45 feet long, and 7 to 12 feet high. A small prospect pit had also been made about 50 feet southwest of the west working. From December 1943 to May 1944 an irregular inclined stope was made in the west working by E. E. Smith. It extends 20 to 30 feet down dip from the floor of the old working and is 20 to 45 feet wide and 6 to 10 feet high. About 550 tons of rock was moved. From December 1943 to November 1944 the inclined stope in the east working was enlarged by the Hill Mining Company to a depth of 30 to 40 feet, a width of 80 to 115 feet, and a height of 6 to 12 feet. About 1,200 tons of rock was moved. Backfill, 2 to 4 feet deep, covers most of the bottom of the workings. The mine was mapped by G. W. Stewart and Harry Kamensky in September 1943. Periodic visits between December 1943 and November 1944 were made by E. N. Cameron, G. W. Stewart, N. K. Flint, and K. S. Adams.

The pegmatite is exposed for 290 feet along strike and is 8 to 12 feet thick. It strikes about east, and dips 20°–60° N. In the inclined stopes it dips 45°–50° N. About 10 feet west of the west working its dip is reversed. It is discordant to the foliation of the wall rock. Several broad folds and sharply defined rolls on the hanging wall plunge 20°–25° NE. The north flanks of the rolls are usually steeper than the south flanks and locally dip south. A small normal fault, which strikes N. 50°–60° E. and dips 40°–45° SE., is exposed in the middle pillar near the west end of the east working. The displacement along it is locally as much as 2½ feet. Minor shear surfaces cut the pegmatite between the two workings, but their relation to the fault is not clear. A basic dike, 2 to 5 feet thick, is exposed for about 100 feet in the east working. It strikes N. 70° E., dips 80° SE., and forms the southeast face of the inclined stope, cutting the pegmatite and gneiss. The wall rock (Kinsman quartz monzonite) has a well-developed foliation that strikes N. 50°–60° W. and dips 30°–90° SW.

The pegmatite is zoned. The border zone, 6 to 18 inches thick, consists of fine-grained muscovite, quartz, albite (An_6), and accessory garnet. Its contact with the wall rock is sharp. The sheet-bearing muscovite zone, 1 to 3½ feet thick, is present only along the hanging wall. It is composed of quartz, albite (An_2), and muscovite. The core, 6 to 10 feet thick, is composed of quartz, albite (An_2), perthite, and accessory beryl and tourmaline.

The muscovite is dark rum, fairly hard, flat, and badly ruled. It shows little mineral staining. The books average 4 by 4 inches, but books 12 by 12 inches are common. Some of the larger books are wavy and have a fish-scale structure.

Much mica remains unmined, but it is markedly ruled, especially that in the west face of the west stope and the east face of the east stope. Rock moved in the west stope yielded about 2.5 percent mine-run mica; in the east stope it was about 3.1 percent. It is believed that the mine-run mica from the east stope yielded more sheet than that from the west stope.

WHITE MOUNTAIN MICA COMPANY MINE

The White Mountain Mica Co. (Thornton Hill) mine lies in the town of Thornton, 1.8 miles N. 4° E. of Campton Upper Village. From Campton Upper Village follow a road north 0.8 mile to an intersection, take the right fork 1.0 mile to an obscure left fork, and follow the left fork northwest 0.9 mile to the mine.

Mineral rights are owned by the Walter I. Lee estate, Campton, N. H. The White Mountain Mica Mining Co. of Campton opened the mine in August under lease and operated it until December 1942. Two opencuts (fig. 102) were made: a west cut about 65 feet long, 5 to 50 feet wide, and 15 feet deep; and an east cut about 80 feet long, 20 feet wide and 10 feet deep. The deposit was mapped in 1942 by H. M. Bannerman and D. M. Larrabee, and the later mine development was mapped by A. H. McNair, G. B. Burnett, and J. B. Headley, Jr., in September 1942. It was restudied in April 1943 by D. M. Larrabee.

Three pegmatites outcrop on the property. The north pegmatite, in which the cuts were made, is exposed along strike for 180 feet, has a maximum width of 110 feet, and is lenticular in plan. Its north contact dips 60° S., but the south contact has a vertical or high northward dip, hence the body appears to be broadly lenticular in cross section. The south pegmatite, exposed along the north flank of the low hill, is approximately 120 feet long and 3 to 7 feet thick. It strikes east and dips 40° N., and probably is connected with the north body underground. The east pegmatite extends eastward 250 feet. It is 5 to 45 feet wide and ts walls have southward dips of 60°–75°.

The north pegmatite consists essentially of white oligoclase, blue-green oligoclase, perthite, and muscovite, with subordinate quartz. Pyrite and pyrrhotite are minor accessories and generally occur in blue-green oligoclase.

Mica is present in isolated books, in scattered "nests", and beneath several schist inclusions removed in mining, but in general the pegmatite is not appreciably richer in muscovite near its walls than elsewhere. Mica seem

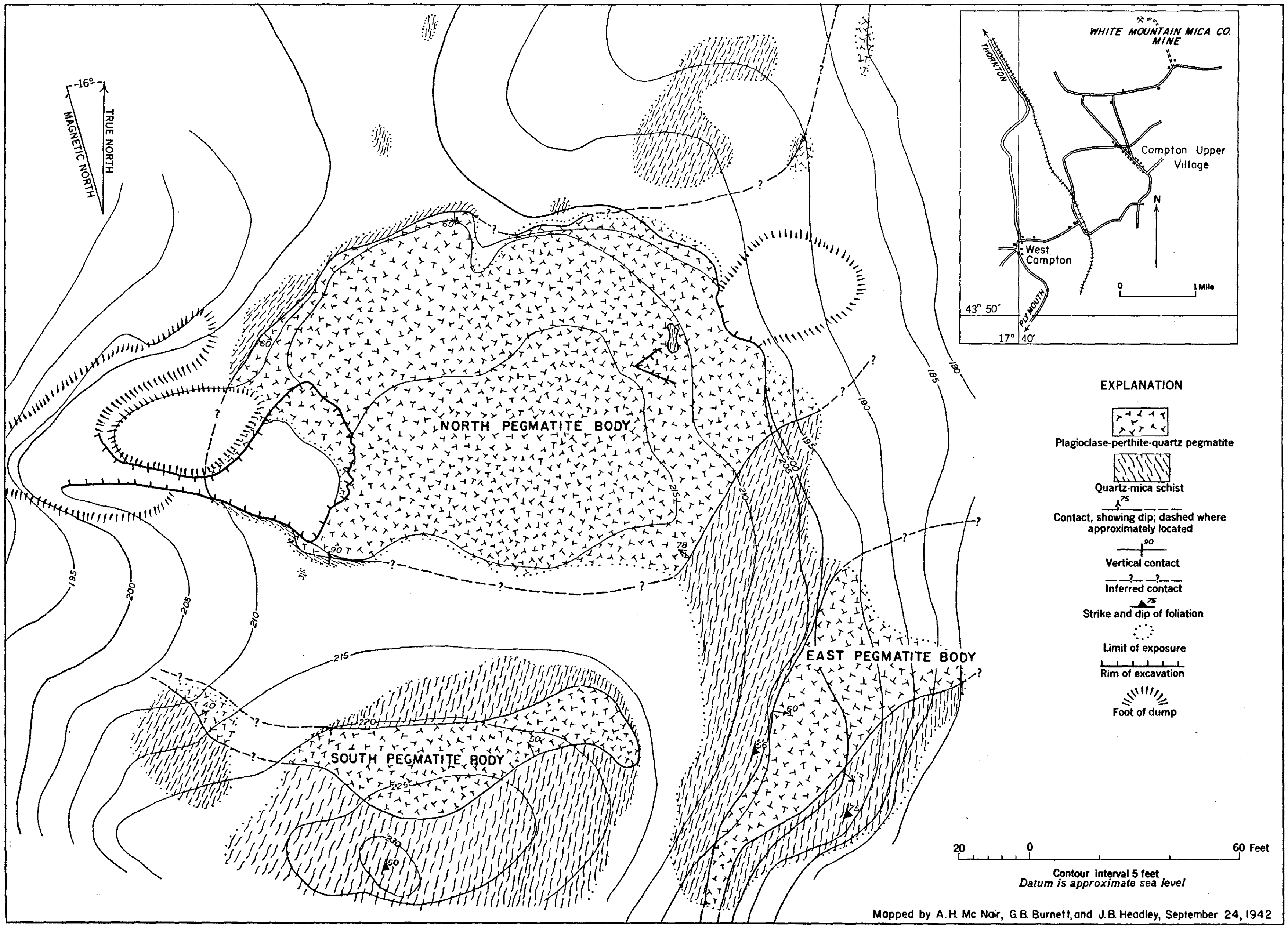


Figure 102.—Geologic map of the White Mountain Mica Company mine, Thornton, N. H.

to be somewhat more abundant in parts containing white oligoclase than in parts containing blue-green oligoclase. The mica was hard and rum and, though somewhat reeved, yielded a satisfactory quantity of sheet. About 1 percent of mine-run mica was recovered from rock mined in 1942. The pegmatite is best classified as a disseminated mica deposit.

The other pegmatites consist of white oligoclase, perthite, quartz, and muscovite. They have a higher quartz content than the north pegmatite and do not contain sheet-bearing muscovite.

Mica is not abundant in the deposit. Operations during 1942 indicate that the mine could not be operated profitably for muscovite under conditions similar to those of 1942–43.

WILLIAMS MICA PROSPECT

The Williams mica prospect (pl. 1, no. 45) is 1.4 miles S. 6½° E. of the school house in Orange village, on the east face of a spur of Tuttle Hill. A hard-surface road leads from Canaan village to the road junction in Orange village. Turn south and follow the road, part asphalt, part gravel, for 1.8 miles. At this point a logging trail turns off to the east. Follow the trail one-half mile to the prospect.

The property was operated by the owner, David S. Williams, of Orange, from July 21 to November 11, 1942. About 12 tons of crude mica and 70 pounds of beryl were produced from about 780 tons of rock mined. Shallow prospect pits were made in 1942. In 1943 the principal working was an opencut 40 feet long, 16 to 40 feet wide, and 3 to 13 feet deep.

The mine was studied by C. S. Maurice and J. B. Headley, Jr., in July 1942, and by E. N. Cameron and J. Chivers (fig. 103) in August 1943.

Two pegmatite lenses striking about N. 45° E. are exposed on the property. The larger ranges from 15 to perhaps 75 or 80 feet thick and is exposed along the strike for 220 feet. Its contacts with the wall rock dip 36°–68° SE. Probably, it pinches out a short distance beyond the southwesternmost exposures. The southeast and east sides of the knob formed by the thick part of the pegmatite bear erosional remnants of the border zone, and the entire slope up to the entrance of the main cut appears to be a stripped contact very little modified by erosion. The shape of this surface suggests that the pegmatite plunges northeast.

The smaller pegmatite is a flat lens about 15 feet thick. It dips 65°–70° SE.

The wall rock of the pegmatites is quartz-mica schist of the Littleton formation, in places containing sillimanite. Tourmaline is present in it near contacts with the pegmatites. The foliation of the schist in general strikes N. 16°–62° E., and dips 58°–80° E. Adjacent to the pegmatites, however, the foliation varies widely in attitude, as it is molded around undulations of the pegmatite surfaces. The pegmatites appear generally concordant with the wall-rock foliation.

The larger pegmatite contains medium- to coarse-grained plagioclase, quartz, and muscovite with accessory biotite, tourmaline, apatite, beryl, pyrrhotite, and chalcopyrite. It shows an indistinct zonal structure. The border zone consists of fine- to medium-grained quartz and muscovite with minor plagioclase. Most of the remainder of the pegmatite consists of medium- to coarse-grained plagioclase, quartz, and muscovite with accessory tourmaline, beryl, and sulfides. In the opencut in the central part of the pegmatite, however, an indistinct unit composed of these minerals and crisscrossed strips of intergrown biotite and muscovite is partly exposed. It appears to be the top of an intermediate zone flanked by a wall zone composed of the plagioclase-quartz-muscovite pegmatite.

Muscovite from the deposit occurs in hard, clear to fair-stained books that have light ruby centers and greenish edges. The books range from 1 to 12 inches in breadth and from ½ to 2½ inches in thickness, but a few of those observed would yield even small sheet. Ruling mars most of the books, and cross-fractures, reeving, and tanglesheet are also common. The mica occurs as scattered books in the wall zone, in part in small quartz-rich patches.

Scattered beryl crystals, 1 to 8 inches long and as much as 2 inches across, are present in all 3 zones, but most of the crystals seen were associated with a small body of quartz and coarse plagioclase in the southeast wall of the open cut. Part of the crystals appear pure; others are intergrown with feldspar or have been partly replaced by it. The average beryl content of the pegmatite is estimated as less than 0.01 percent.

The smaller pegmatite shows a thin border zone enclosing coarse plagioclase-quartz-muscovite pegmatite with accessory tourmaline and garnet. The muscovite books are mostly too small to yield sheet, although a few as large as 8 by 5 by 2 inches were seen. The larger books are associated with scattered small pods of quartz and quartz plagioclase. The mica is similar to that from the larger pegmatite and has the same defects. Prospecting in 1942 showed that the average content of crude mica in the pegmatite is very low.

The quantity and sheet-mica content of the crude mica in the Williams prospect did not warrant resumption of mining in 1943, though the topography favors cheap opencut mining of a considerable volume of pegmatite.

WOODWARD MICA MINE

The Woodward mica mine, in the town of Orford, is 300 yards east of U. S. Highway 10, ¾ mile S. 20° W. of

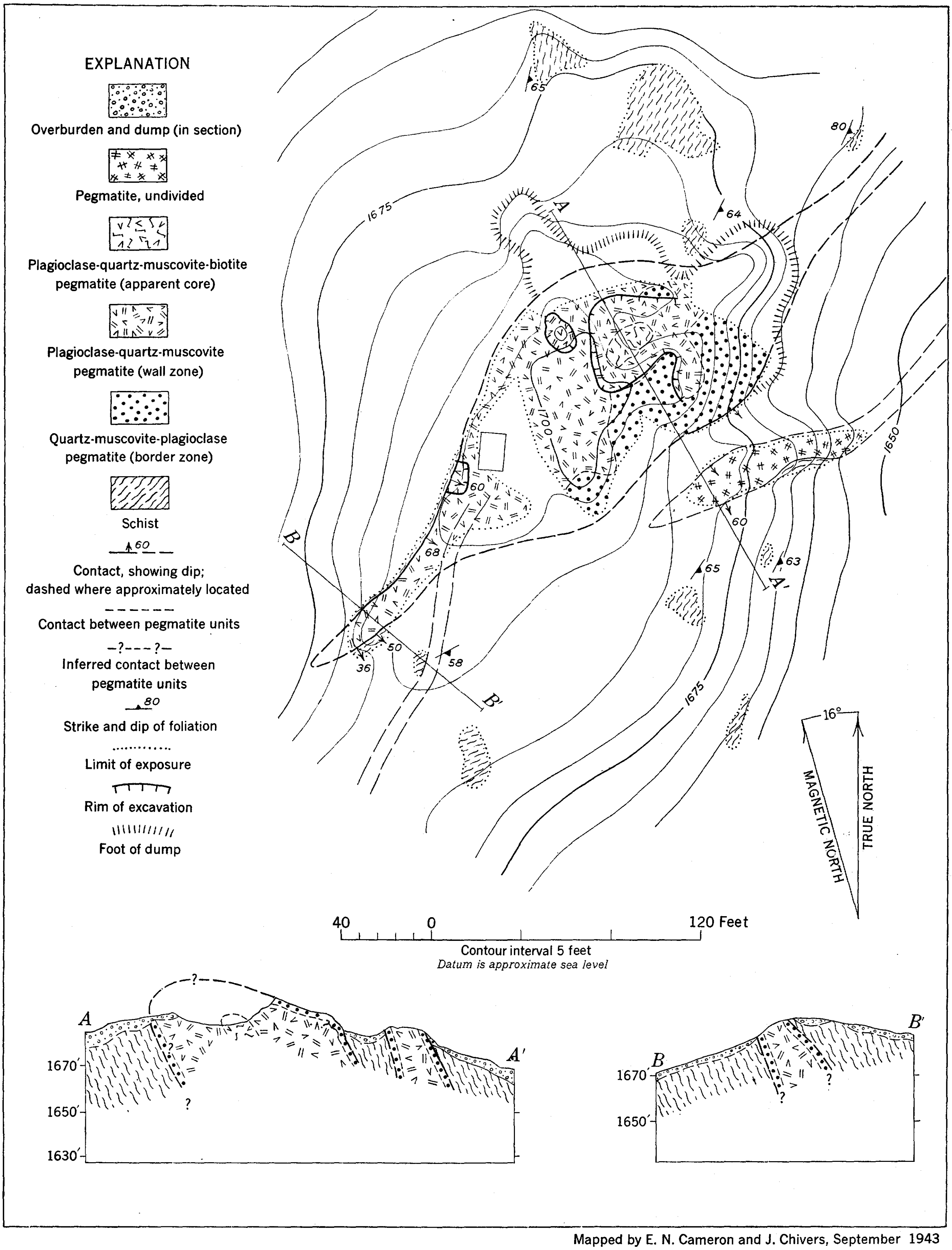


FIGURE 103.—Geologic map and sections of the Williams mica prospect, Orange, N. H.

Orford village. It is reached from the highway by a short farm and mine road. The property is owned by Alton Woodward of Orford, N. H., and was first opened by Percy Leggett, of Gorham, N. H., in October 1943. The Granite State Mica & Mining Corp. of Wentworth, N. H., purchased the mining rights in December 1943 and worked the property until October 1944. The pegmatite was examined in 1942 by H. M. Bannerman and D. M. Larrabee. The mine was studied by A. H. McNair and V. E. Shainin in November 1943, visited several times during 1943–44 by E. N. Cameron and G. W. Stewart and restudied by A. H. McNair and K. S. Adams in November 1944 (fig. 104).

An opencut approximately 140 feet long, 25 feet wide, and 5 to 40 feet deep has been made, and almost the entire pegmatite has been moved from the area of the cut. The west wall of the cut was in glacial till, and the east wall extended to and followed the footwall of the pegmatite. Derricks were used to remove broken rock from the quarry and a bulldozer and power shovel were used to remove overburden.

The Woodward pegmatite is lenticular in plan. Its length along strike is about 165 feet, and its thickness ranges from 6 to 15 feet. It strikes N. 45° E. and dips westward 40°–50°. The general westward dip of the body is interrupted in the central part of the opencut by a conspicuous roll which plunges approximately 36° NE. The northeast end of the body appears to plunge 40° N. Although its southwest end has not been seen (this part of the pegmatite was mined only to shallow depths), the miners reported that the pegmatite disappeared down dip. It would seem, therefore, that the southwest end of the body also plunges north.

The wall rock is fine grained quartz-mica and quartz-mica-garnet schist. Schist was stripped from the hanging wall by glacial erosion except for thin isolated patches and a small remnant preserved in the trough of the roll. The hanging wall was covered by compact glacial till, in places at least 40 feet deep, and open joints in the pegmatite were filled with till. For a few inches from the footwall, the schist contains numerous small black tourmaline crystals. The wall rock adjacent to the hanging wall, in the few places in which it was preserved, contains much quartz and feldspar. In general, the contact of the pegmatite conforms closely to the foliation of the schist, but small folds and irregular crenulations of the schist are truncated by the pegmatite.

Quartz, plagioclase, perthite, and muscovite are the essential minerals of the pegmatite, and garnet and black tourmaline are accessory minerals. Three zones can be distinguished. A poorly defined border zone, 1 to 4 inches thick and composed of fine-grained quartz, muscovite and plagioclase, is next to the contacts. Inside the border zone, a wall zone 1 to 4 feet thick and composed of muscovite, quartz, and plagioclase (An_{10}) lies along both walls of the pegmatite. The central part of the body is occupied by a core consisting of quartz and perthite, together with plagioclase that is coarser grained than the plagioclase in the wall zone.

All the zones contain much granular gray quartz and small green-brown muscovite crystals. These minerals seem to have been formed by replacement after the development of the zones. Plagioclase partly replaced by quartz occurs in many places, and streaks, "nests", and small veins of green-brown mica cut across the minerals of the zones. Several veinlike fracture-controlled bodies that extended across all three zones were removed during mining operations. They were 8 to 10 feet long and 4 to 6 inches thick, and consisted of quartz and green-brown scrap muscovite arranged in flakes normal to the fracture walls. Contorted sheared muscovite makes up about 85 percent of each fracture filling.

Mica occurred in minable concentration in the wall zone along both walls. Along the hanging wall the zone was 1 to 4 feet thick, and apparently was richest in mica in the vicinity of the roll. In the northeast part of the cut, the zone seems to have been leaner. Along the footwall the zone ranged from 5 inches to 4 feet in thickness. In the part of the pegmatite mined, the mica content of the zone was greater along the footwall than along the hanging wall, and most of the mica removed from the deposit was obtained from the footwall part of the zone. The highest concentration of mica books was found immediately above the narrow border zone. Along the footwall the zone apparently had a high content of mica throughout the opencut.

Mica from the wall zone was light rum to ruby muscovite of good quality, ruled or reeved but not excessively. The books averaged 5 by 8 by 1½ inches. Most of the books were free splitting and clear, and the content of strategic sheet was satisfactory.

As the body seems to plunge northeastward, it is probable that only a small quantity of unmined rock remains down dip from the cut. The principal reserves of mica-bearing pegmatite probably lie northeast of the cut in the direction of the plunge. If the pegmatite does extend northeastward down the plunge, future mining would require work extending to greater depths than in previous operations. Underground mining was not considered practicable during recent operations, because the rock roof has been stripped from this part of the pegmatite by erosion. The pegmatite may be covered with wall rock in the direction of its plunge, but there was no evidence of this when the mine was last operated.

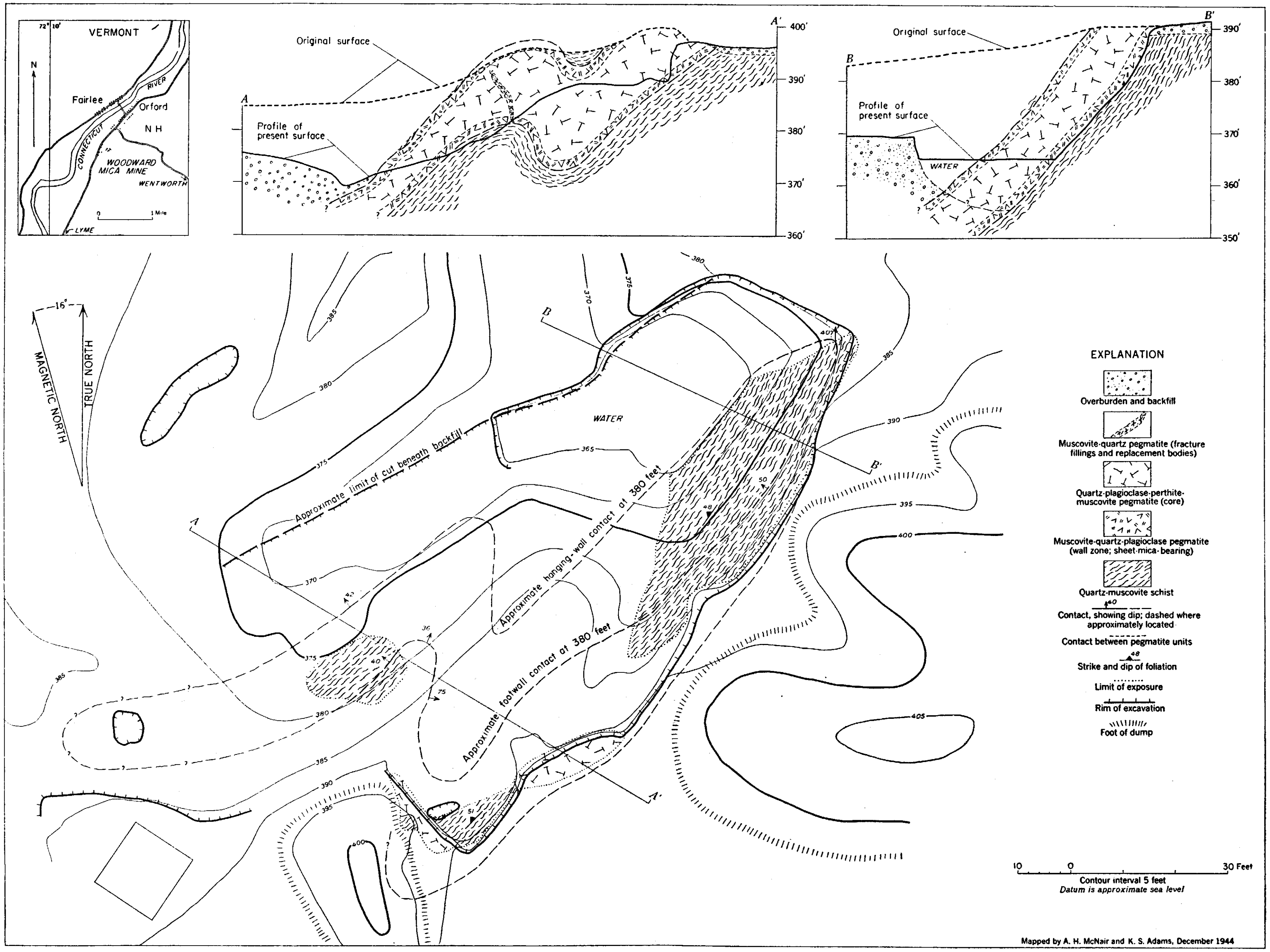


FIGURE 104.—Geologic map and sections of the Woodward mica mine, Orford, N. H.

The deposit is interesting geologically as the westernmost mica-bearing pegmatite in central New Hampshire.

MERRIMACK COUNTY

DANBURY MICA MINE

The Danbury mica mine (pl. 1, no. 57) is in the town of Danbury, 3.25 miles west-southwest of Alexandria village. To reach the mine, take the road (asphalt for 1.1 miles, gravel for 0.85 mile), that leads west-northwest from Alexandria village past Tenney School and then up Patten Brook valley; at 1.95 miles from Alexandria, just beyond the cemetery, a logging road turns south; follow this for about 2.4 miles to the mine. The road is steep and poor in places.

The mine is said to be owned by the General Electric Co., Schenectady, N. Y. According to Mr. William Patten, former superintendent of the company's rifting shop at Bristol, the mine was operated by the company for several years (1935–38?) and yielded mica of good quality. Colonial Mica Corp. pumped out the workings in September 1943 and mined about a ton of mine-run mica for testing.

The workings consist of two crosscuts (fig. 105) leading to an opencut 2 to 25 feet deep and 280 feet long. The cut has the shape of a broadly flaring V. In the north branch, an incline has been driven northward down the hanging wall of the deposit to a depth of 25 to 30 feet below the floor level. This section of the cut is nearly free of debris, but parts of the west section are filled to depths estimated at 5 to 20 feet.

A sketch map of the deposit is given by J. C. Olson (1942, p. 393). The mine was mapped in detail by E. N. Cameron, H. Kamensky, and J. Chivers in September 1943.

The mine is in a tabular pegmatite body ranging from 11 to about 35 feet in thickness. The pegmatite has a strike length of at least 500 feet, and according to Olson (1942, p. 393) extends more than 700 feet northward from the mine. In the west section of the cut the pegmatite strikes N. 50° E. and dips 35°–50° SE. At the head of the east crosscut trench its strike changes abruptly to N. 5°–10° E. and the dip becomes 22° W. Northwestward the dip steepens. The walls of the body are uneven, showing remarkable sharp, cross-cutting outward rolls into the gneiss which are accompanied by marked changes in thickness.

The wall rock is an easterly-dipping gneiss, Kinsman quartz monzonite, that ranges from prophyritic to even-grained and from nearly massive to markedly foliated. It contains schistose layers and others that appear quartzitic, and has many of the characteristics of a migmatite. It is locally enriched in muscovite adjacent to the pegmatite.

The pegmatite is poorly exposed, hence its structure is only partly determinable. It consists principally of the following units, which are described in order from the walls inward:

1. Border zone, 4 to 8 inches thick. Composed of fine-grained quartz, plagioclase, and scrap muscovite. A single small beryl crystal was found in the zone along the hanging wall.
2. Wall zone (plagioclase-quartz-muscovite pegmatite), 2 to perhaps 10 feet thick. Composed of medium to coarse-grained plagioclase, quartz, and muscovite, and accessory garnet. In the west section of the opencut, and in the north end, the zone contains scattered perthite crystals.
3. Perthite-quartz intermediate zone, probably between 5 to 15 feet thick. Coarse perthite with subordinate smoky quartz, accessory beryl associated with plagioclase, and traces of autunite.
4. Core, 2.5 feet thick. Coarse quartz, with minor plagioclase. The core is represented by a lens in the headwall of the north section of the quarry, and by scattered smaller lenses in the west section of the cut.

In the vicinity of the line of section AA′ (fig. 105) the perthite-quartz zone is underlain by strips of partly chloritized biotite intergrown with muscovite. This unit may be asymmetrically developed biotite-bearing zone of the type that partly envelopes perthite-quartz zones in pegmatites such as that of the Blister mine.

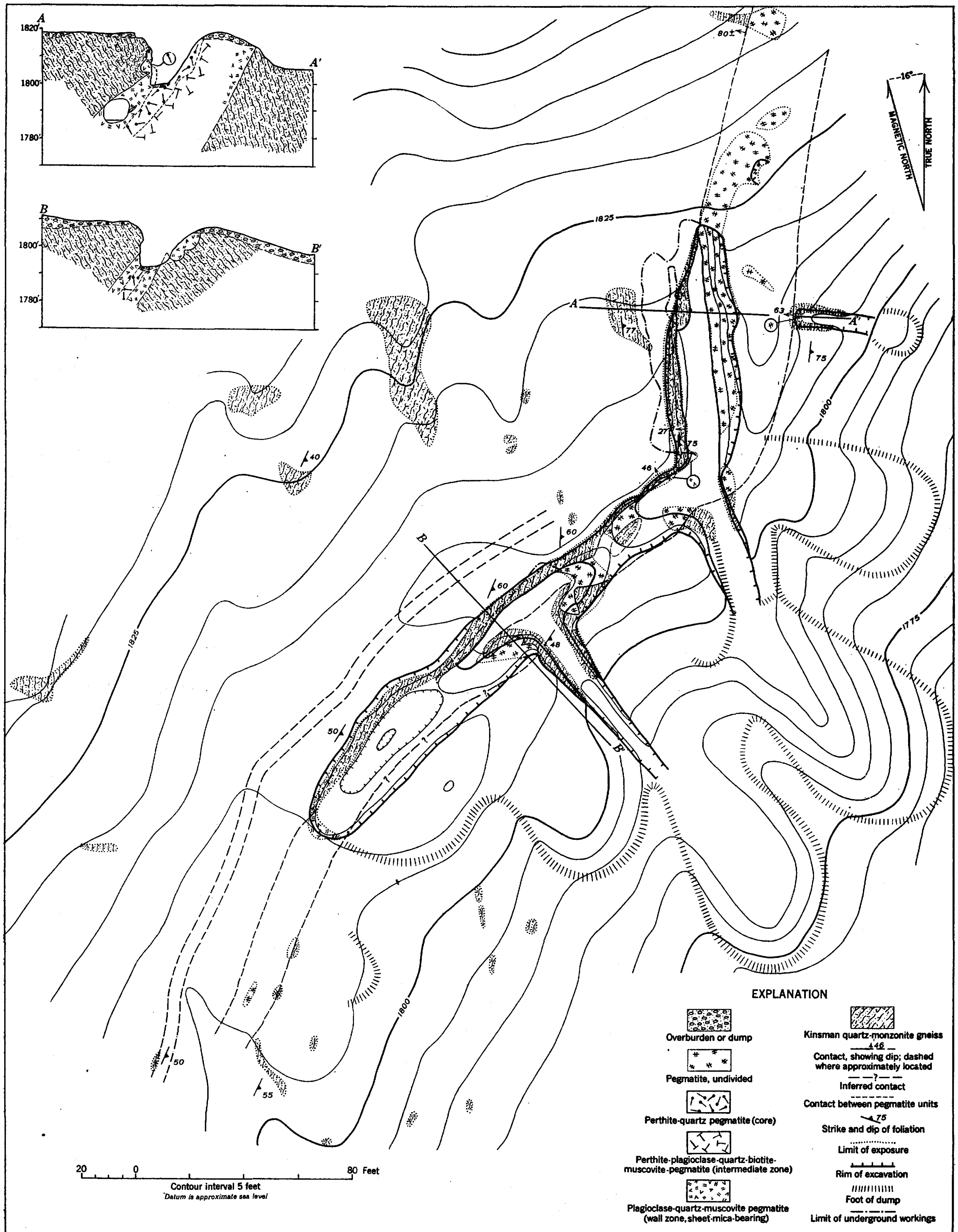
Mica from the mine is hard muscovite, clear or stained by magnetite(?). Some books show traces of limonitic stain. The books range from 3 to 18 inches broad and from one-half to 8 inches thick. Most of the larger books have ruby centers and green edges. Structural defects—reeving, ruling, "A" structure, tangle sheet, cross-fractures, herringbone structure—mar a large percentage of the books. The percentage of sheet obtainable appears low, and small sizes of sheet would be the principal product.

Book mica visible is confined almost entirely to the part of the wall zone along the hanging wall. Within this, however, mineral proportions vary, and the distribution of mica books exceeding 2 inches in breadth is spotty. Whether parts of the zone concealed beneath debris are richer in mica is unknown. A few books were found along the margins of the small quartz lenses in the west cut, but all are green and of scrap quality.

The beryl content of the pegmatite is very low. A small amount of potash feldspar of no. 1 grade is present in the perthite-quartz zone.

THE MICA QUEEN MINE

The Mica Queen (Powell) mine lies in the town of Wilmot, 3.2 miles N. 65° W. of Wilmot village. To reach it from Wilmot follow a hard-surfaced and graveled road northwest about 2.4 miles to a mine road on the left; turn left and follow the mine road 0.5



Mapped by E. N. Cameron, H. Kamensky, and J. Chivers, September 1943

FIGURE 105.—Geologic map and sections of the Danbury mica mine, Danbury, N. H.

mile to a fork; turn right and proceed 0.4 mile to the mine. The mineral rights are owned by the Warren Soap Co., 51 Waverly Street, Cambridge, Mass. The mine was operated for feldspar by the Warren Soap Co. about 1936. It was reopened by the same company in February 1943 and was operated intermittently until July 1944. The mine (pl. 38) consists of workings in two pegmatite bodies, here designated the eastern and western pegmatites.

The mine was mapped by C. S. Maurice, G. B. Burnett, and J. B. Headley, Jr., in August 1942. A new map was made in November 1943 by Glenn W. Stewart and Norman K. Flint, and the map was revised in July 1944. During later operations progress maps of the workings were made by E. N. Cameron and Stewart.

EASTERN PEGMATITE

The working in the eastern pegmatite is an opencut 222 feet long, 15 to 25 feet wide, and 5 to 65 feet deep. The deepest part, an open stope near the center, is partly filled with waste rock and water. During 1943–44 the open stope was deepened about 15 feet down dip and extended 40 feet eastward along the strike of the pegmatite. Waste rock was removed by derrick and carried to the dump by truck.

The pegmatite is 150 to 220 feet long and 2 to 15 feet thick. Its strike is generally east. The hanging wall dips 40°–75° N.; the dip of the footwall ranges from 15° N. to vertical. Near the eastern end of the cut the dip of the footwall is reversed to 40° S. Its average dip in the main working is 55°–60° N. The keel of the pegmatite probably plunges 30°–40° NE. The pegmatite transects the foliation of the wall rock, Kinsman quartz monzonite, and pinches and swells along strike and down dip. The wall rock has a well developed foliation that strikes N. 40°–65° E. and dips 55°–65° SE.

The border zone, 3 to 12 inches thick, is composed of fine-grained quartz, muscovite, albite (An_9), and accessory black tourmaline, red garnet, nad green apatite. The wall zone, 1 to 3 feet thick, is composed of medium-grained albite (An_2), quartz, sheet-bearing muscovite, and accessory tourmaline and apatite. Most of the albite is white, but some is salmon-colored or blue-green. Tourmaline commonly occurs in small subhedral crystals. A lens-shaped body of anhedral and subhedral tourmaline crystals with interstitial quartz and albite occurs in the east face of the main working. The lens is 4 feet long and 4 to 6 inches thick. The sheet-bearing muscovite books are unevenly distributed in the upper half of the wall zone. The intermediate zone, 1 to 8 feet thick, consists of medium to coarse-grained quartz, albite (An_2), perthite, small quantities of disseminated muscovite books and accessory tourmaline, beryl, and apatite. The core is discontinuous and consists of pods composed of extremely coarse-grained quartz with or without perthite. Several quartz pods have been mined out. The largest pod was 25 to 30 feet long and 1 to 5 feet thick. Sheet-bearing muscovite was unevenly distributed along the hanging wall side of this large quartz pod. Part of a quartz-perthite pod, with anhedral and subhedral crystals of perthite as large as 2 by 3 feet, remains along the footwall side of the pegmatite at the east end of the cut. Most of the large quartz pods are composed of white or smoky quartz, but some contain patches of rose-colored quartz.

Most of the muscovite is medium to dark rum, hard, and free from mineral stains and inclusions. The books average 3 by 3 inches. Ruling, reeving, cross fracturing, and tanglesheet mar most of the books. Muscovite was obtained from the hanging wall zone and from the margins of the quartz pods. The average yield of crude mica from rock moved was low. Operations ended because the pegmatite pinches to less than 2 feet at the bottom of the main working, and the yield of the pegmatite elsewhere was too small to justify operations.

WESTERN PEGMATITE

The working in the western pegmatite is an opencut approximately 135 feet long, 7 to 25 feet wide, and 5 to 25 feet deep. During 1943–44 this cut was extended about 35 feet westward and the southeastern corner was enlarged about 15 feet southeast.

The pegmatite is exposed for about 200 feet along strike and is 2 to 10 feet thick. It strikes east and dips 45°–65° N. along the hanging wall and 20°–65° N. along the footwall. It is discordant with the foliation of the wall rock, Kinsman quartz monzonite.

The zonal structure and mineral components of the western pegmatite are similar to those of the eastern pegmatite. The border zone, 2 to 8 inches thick, is composed of fine-grained quartz, muscovite, albite, and accessory tourmaline and garnet. The wall zone, 1 to 2 feet thick, is composed of medium-grained quartz, albite, sheet-bearing muscovite, and accessory tourmaline. The sheet-bearing muscovite is unevenly distributed in the upper half of the wall zone. The intermediate zone, 1 to 6 feet thick, is composed of medium-grained albite, quartz, perthite, sparsely disseminated muscovite, and accessory tourmaline. The discontinuous core consists of several quartz pods 1 by 4 feet, or smaller, that occur near the center of the pegmatite.

The muscovite is similar to that of the eastern pegmatite. The quantity in the hanging wall zone is less than in the eastern pegmatite and only scattered books were found along the margins of the quartz pods.

Operations ended because insufficient mica was recovered to repay operating costs under 1944 conditions.

JAKE PATTEN MICA PROSPECT

The Jake Patten mica prospect (pl. 1, no. 56) is in the town of Danbury, 3.2 miles S. 73° W. of Alexandria village. To reach it from Alexandria follow a hard surfaced road 0.3 mile northwest to a fork. Take the left fork and continue 0.8 mile southwest to Tenney School, then continue on a gravel road 1.0 mile to a logging road; follow for 1.3 miles to the second fork on the left; then turn left and follow a logging road to a bridge. Follow Patten brook upstream about 0.5 mile to the prospect, 45 feet south of the brook.

The property is owned by Ervin Perkins of Danbury, N. H. A cut 40 feet long, 10 to 15 feet wide, and 5 to 10 feet deep was excavated into the hillside in the early 1900's. In August 1943 the prospect was mapped by tape and compass by Glenn W. Stewart and Harry Kamensky (fig. 106).

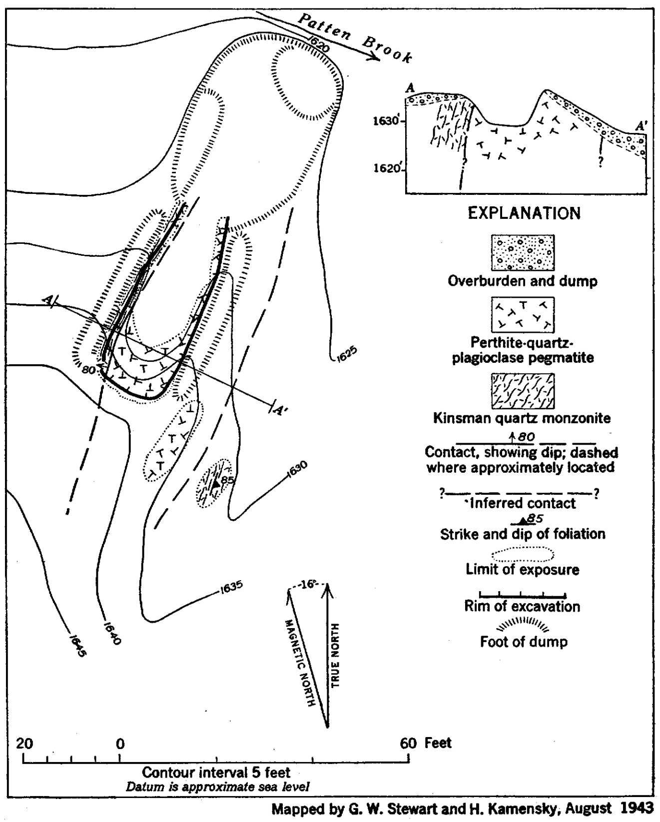


FIGURE 106.—Sketch map and section of the Jake Patten mica prospect, Danbury, N. H.

The pegmatite, poorly exposed, can be traced along strike for 58 feet. It has a width of at least 20 feet, strikes about N. 35° E., and dips 80° NW. It cuts across the foliation of the wall rock, Kinsman quartz monzonite. The foliation of the gneiss strikes N. 15° E. and dips 85° SE.

The pegmatite is composed of perthite, quartz, plagioclase, muscovite, and garnet. It has a narrow border zone, 2 to 4 inches thick, consisting of fine-grained quartz, muscovite, and minor plagioclase. The pegmatite inside the border zone is composed of perthite, quartz, plagioclase and subordinate muscovite. Quartz occurs in part as small pods scattered through the pegmatite. Some of the muscovite occurs as disseminated books, but most of it is found near the small quartz pods. The disseminated books measure 1½ by 1½ inches, but some of the books near the quartz pods are 3 by 3 inches. The mica is light rum, heavily stained, and slightly ruled. The occurrence of mica in this pegmatite is characteristic of the pod type of mica deposit.

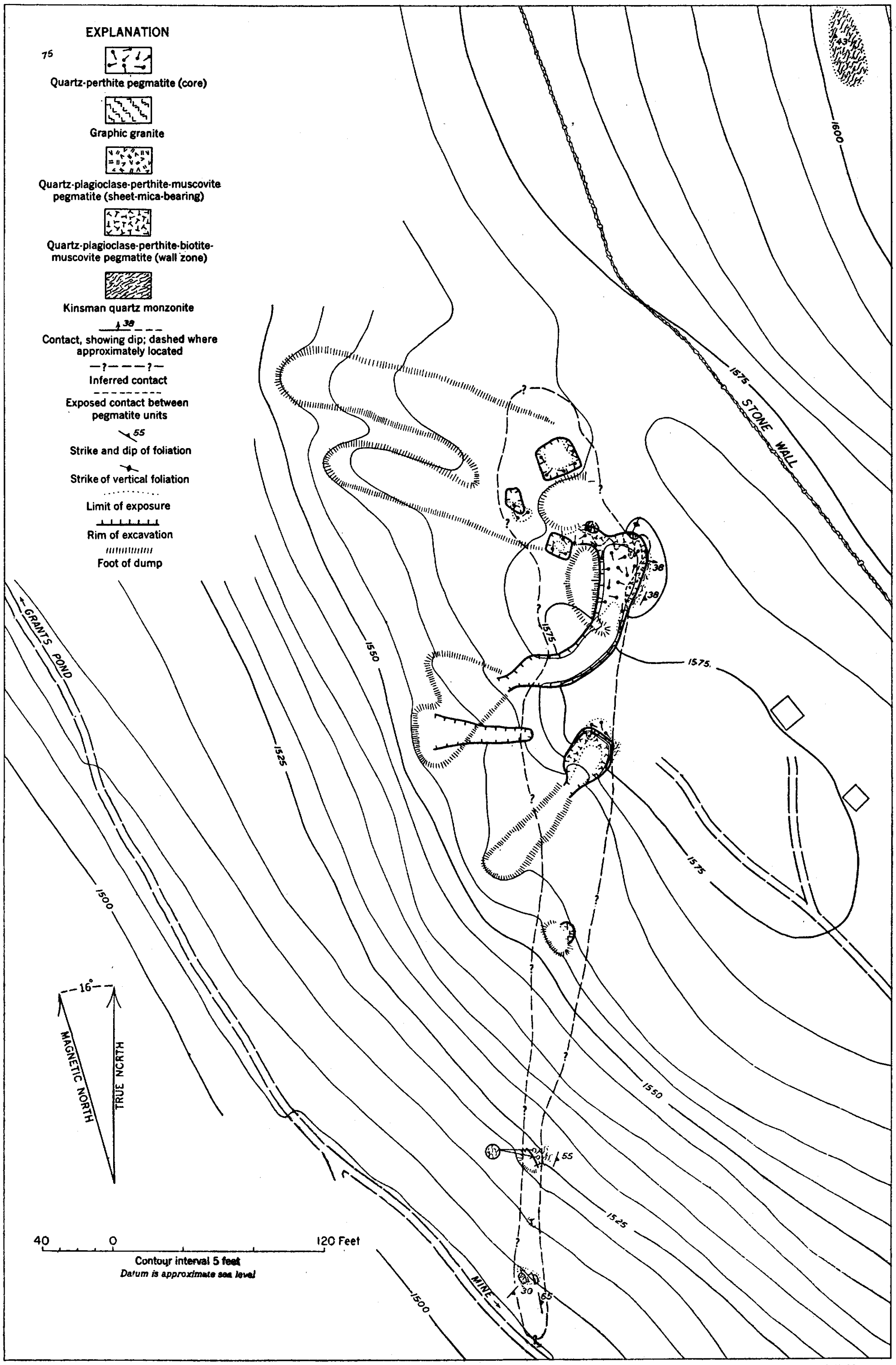
The small size and the distribution of the mica books indicate that the deposit would yield only a small quantity of sheet mica per unit of rock mined.

PICKWICK MICA MINE

The Pickwick (Tenney) mine (pl. 1, no. 58) is in the town of Danbury, 3.6 miles N. 11° W. of Danbury village. To reach it from this village, drive 2 miles north from the junction of Routes 4 and 104, to the North Road school; go northwest 0.6 mile to a fork; follow the northwest branch 3.7 miles, passing Grants Pond, to a road turning southeast; follow this 0.6 mile, passing some old farm buildings, to a sharp turn to the southwest; follow a logging road 0.5 mile southeast from this turn to the mine, which is 0.4 mile northwest of the summit of Pillsbury Mountain. The mine is owned by a Mrs. Solloway, Grafton, from whom the mineral rights were leased in 1942 by William Lislie, Boston. A base map was prepared in December 1942 by D. M. Larrabee and J. B. Headley, Jr. (fig. 107). The mine was visited several times during the winter, and in May 1943 the map was completed by Larrabee and W. M. Hoag.

Several small pits were made prior to 1942 during a search for feldspar, and three opencuts were made in 1942–43 by Lislie. Outcrops are not abundant, and much work was done in overburden in an effort to expose the rock further and to provide suitable grades for the hauling of waste rock from the main quarry face.

The pegmatite probably trends N. 5° E. and its east contact dips 38° E. The west contact is not exposed. The wall rock is porphyritic biotite gneiss of the Kinsman quartz monzonite, the foliation of which strikes northeast and in general dips southeast. The pegmatite at the east or hanging wall contact has a narrow aplitic border zone. The wall zone, 7 feet thick, is composed of medium-grained quartz, plagioclase, perthite, biotite, and muscovite, with accessory tourmaline, garnet, and a few beryl crystals. Part of this zone



Mapped by D. M. Larrabee, J. B. Headley, Jr., and W. M. Hoag, December 9, 1942-May 31, 1943

FIGURE 107.—Geologic map of the Pickwick mica mine, Danbury, N. H.

(quartz-plagioclase-perthite-muscovite pegmatite of figure 107) contains sheet-bearing book muscovite. Underneath this unit is a core of quartz and perthite containing mica books and a few small beryl crystals. The west margin of the wall zone dips 15° E., indicating that the zone pinches at a shallow depth between the hanging wall and the underlying body of quartz and perthite, unless the dip of the lower contact steepens and becomes parallel to that of the hanging wall. An inclusion of gneiss at the west margin of the main cut is surrounded by medium-grained pegmatite containing muscovite. Graphic granite occurs as irregular bodies in the quartz-perthite pegmatite exposed in old workings.

The rum or ruby mica books associated with the quartz-perthite core contain some flat sheet of good quality, but most is "A" and wedge mica. The mica obtained from the wall zone is generally of better quality, although it is warped, reeved, and ruled in three directions, and brown-stained around minute pinholes. Some books contain much magnetite, in needles and partly developed crystals that are arranged in lines parallel to the directions of reeving and ruling, and are concentrated most heavily in the reeved parts. A few books are green but have hexagonal margins outlined by narrow ruby bands. Much of the mica is color-banded or crosshatched by alternating ruby and colorless bands; the principal bands are parallel to the reeves, and are crossed at right angles by other less prominent color bands. The magnetite inclusions or "stains," reeve lines, ruling, and color banding are all arranged according to crystallographic directions and appear to be primary. Green "iron stains" are scattered through many books; the ruby color in others is mottled with minute clear spots of irregular shape.

Some of the production during 1942 was derived from large glacial boulders of pegmatite encountered in the main opencut; some was from books lying in the bedded glacial gravels surrounding the boulders. Most, however, was from the disseminated deposits in coarse-grained quartz-perthite pegmatite exposed in the two opencuts nearest to the end of the road. The wall zone, mined chiefly during 1943, contains about 3 percent muscovite in recoverable books. The quality and quantity of sheet mica recovered did not justify operation throughout 1943.

STRAFFORD COUNTY

JOHN FELKER MICA PROSPECT

The John Felker mica prospect is in the town of Strafford, 3.2 miles N. 20° E. of the village of Center Strafford. To reach it from Center Strafford follow U. S. Highway 202A for 0.3 mile southeast to a fork; continue eastward on 202A for 3.6 miles to the third crossroad; turn left and follow a gravel road 1.3 miles to an intersection with a hard-surfaced road; turn left and go 1.2 miles to a crossroad; continue northwestward on same road, now gravel, for 0.9 mile to a farm lane on the right; follow the farm lane northeast for 0.1 mile to the prospect. The property and mineral rights are owned by the John Felker Estate, Rochester (Crown Point R. F. D. 1), N. H.

A small pit (fig. 108) was made sometime prior to 1940. It was enlarged by A. E. Buzzo of Center Strafford in 1943. The present cut is 30 feet long, 20 feet wide, and 5 to 10 feet deep. Waste rock was removed by a mine car on an inclined track. In December 1943 the prospect was mapped by tape and compass by Glenn W. Stewart and Norman K. Flint.

The pegmatite is exposed along strike for 30 feet. It is 4 to 12 feet wide and is essentially parallel to the foliation of the wall rock. The pegmatite strikes N. 50° E. The keel of the pegmatite probably is not far below the bottom of the cut, because the walls converge. The hanging wall is nearly vertical and the footwall dips 50° SE. Minor rolls occur along both walls. The wall rock is quartz-mica schist, probably part of the Littleton formation. Its foliation strikes N. 50°–65° E. and is nearly vertical.

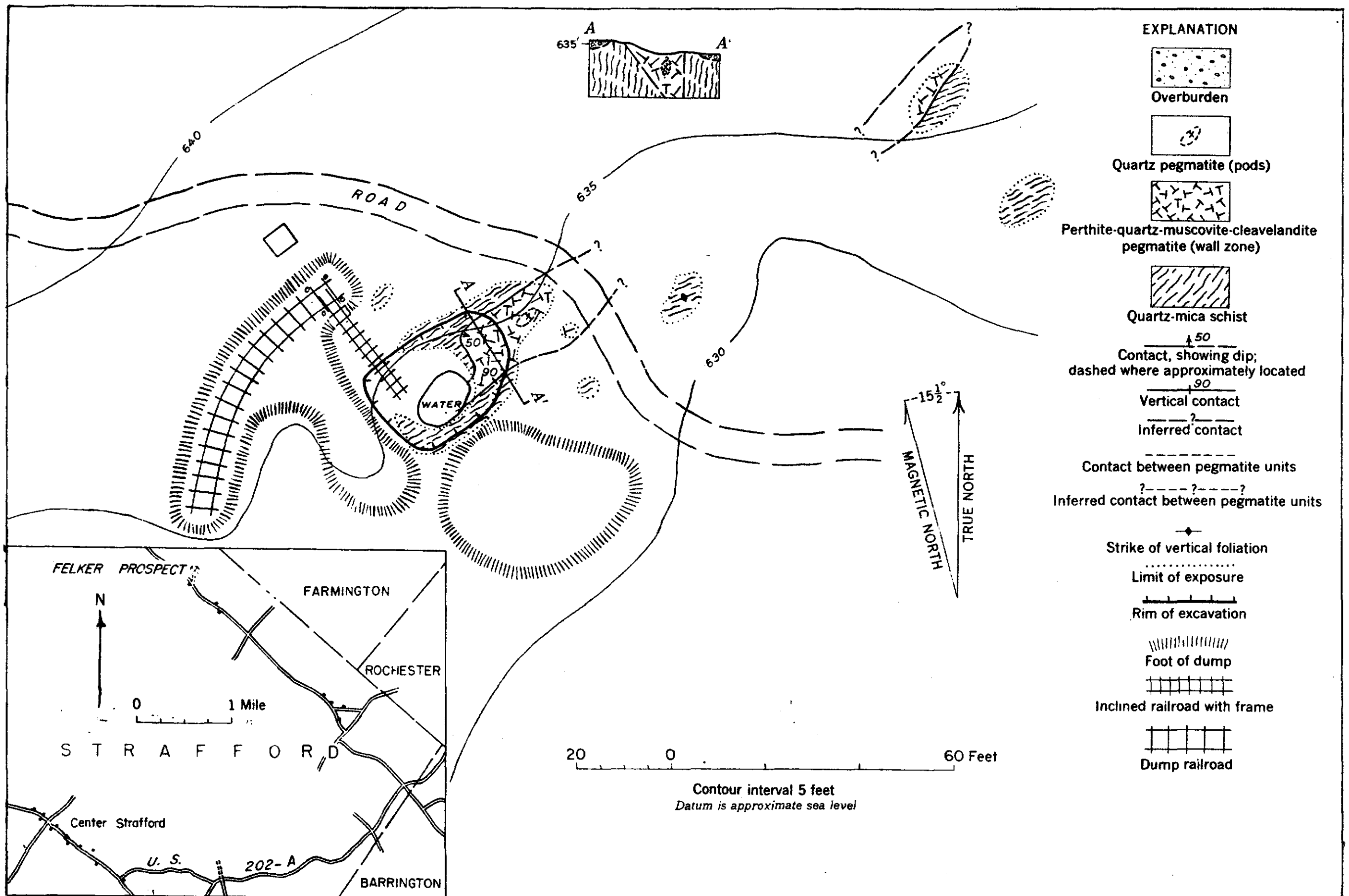
The pegmatite is poorly exposed. The border zone, 1 to 3 inches thick, is composed of fine-grained quartz and muscovite. The wall zone, 3 to 11 feet thick, is composed of medium-grained perthite, quartz, muscovite, and cleavelandite. Accessory minerals are small crystals of tourmaline, garnet, and beryl. Small scattered quartz pods occur near the center of the pegmatite.

Some muscovite books are disseminated in the wall zone, but most are associated with the small quartz bodies. The muscovite books are very hard and compact, average 2 by 2 inches, and are nearly free from mineral stains or inclusion. Reeves and ruling, however, are common.

Prospecting in 1943 did not yield sufficient muscovite to encourage operations. It is unlikely that the pegmatite would yield more or better muscovite if it were mined further along strike or down dip.

PARKER MOUNTAIN MICA MINE

The Parker Mountain mica mine, formerly known as the Foss or Foss Ledge mine, is on the eastern slope of Parker Mountain, in the town of Strafford, and 2.3 miles N. 46° W. of the village of Center Strafford. To reach it from Center Strafford follow the old Rochester-Dover road, which forks northwest from U. S. Highway 202A at the post office, about 2.5 miles to an abandoned road on the right; turn right and proceed 0.1 mile to the mine. The property and mineral rights are owned by Mrs. M. E. Lithner, 149 Broadway, New



Mapped by G. W. Stewart and N. K. Flint, December 4, 1943

FIGURE 108.—Geologic sketch map and section of the John Felker mica prospect, Strafford, N. H.

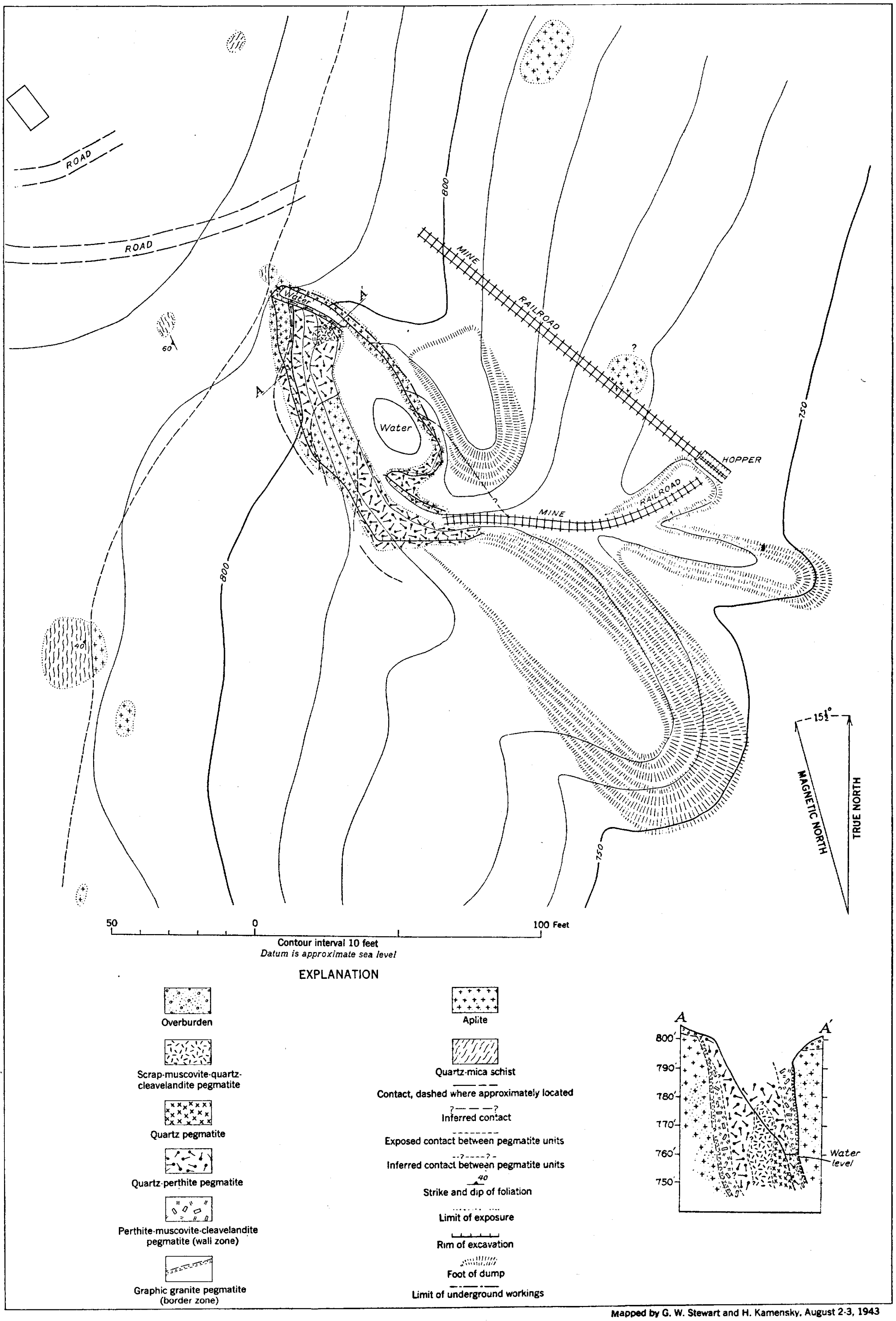
York City. The mineral rights are leased by the Whitehall Co., Inc., of New York City.

According to Sterret (1923, p. 156–158), the mine was worked in 1913 by James Davis for the Keene Mica Products Co., The working at that time consisted of an irregular opencut about 100 feet long, 10 to 30 feet wide, and 10 to 40 feet deep. Two inclined stopes, filled with water 30 to 40 feet deep, extended from the bottom of the cut. The deposit has been mined subsequently for feldspar, with mica as a by-product. During the summers of 1936, 1937, and 1938 the mineral rights were leased by A. E. Buzzo of Center Strafford, who obtained about 300 tons of feldspar. The southern stope described by Sterrett was completely filled with waste rock. The northern stope and floor of the opencut have been partly backfilled. The mine was mapped in August 1943 by Glenn W. Stewart and Harry Kamensky (fig. 109).

The pegmatite is poorly exposed but is at least 110 feet long and 5 to 40 feet wide. It strikes about N. 45° W., dips 70°–80° NE., and is discordant to the foliation of the wall rock. At the northwest end of the cut the pegmatite seems to lens out and its crest to have a very steep northward plunge.

The wall rock, a relatively fine-grained, massive aplitic rock, is composed of quartz, microcline, albite (An_6), muscovite, and accessory tourmaline, biotite, and apatite. The aplite body is at least 350 feet long and 80 to 120 feet wide. Along the northeast wall of the cut, the aplitic rock is gneissic in some places. Its foliation strikes about north and dips 40°–50° W., essentially parallel to the strike and dip of the foliation of the country rock. The aplite contains small thin lens-shaped bodies of coarser pegmatitic material whose longer axes are parallel in general to the foliation of the aplite. The contact between the pegmatite and aplite is fairly sharp along the hanging wall but indistinct along the footwall. Indistinct and discontinuous bands containing abundant tourmaline crystals occur in the aplitic rock close to the pegmatite contact. Away from the contact the tourmaline crystals are scattered through the aplite.

The country rock, probably part of the Littleton formation, is a quartz-mica schist containing muscovite,



Mapped by G. W. Stewart and H. Kamensky, August 2-3, 1943

FIGURE 109.—Geologic map and section of the Parker Mountain mica mine, Strafford, N. H.

biotite, and scattered garnet and sillimanite crystals. The contact between the schist and aplite is exposed in one of the three outcrops of country rock near the mine. It strikes north, parallel to the foliation of the schist.

Statements by Sterrett (1923), Switzer (1938, p. 811–820), and Buzzo, the former operator of the mine, have assisted in the recognition of a possible zonal structure in the pegmatite. Most of the central part of the pegmatite has been removed from the cut. Only patches of its margins remain on the northeast and southwest walls. Inward from the aplite the pegmatite apparently consists of a discontinuous graphic granite zone, a discontinuous wall zone, and a core.

The graphic granite zone, 1 to 12 inches thick, is composed of fine-grained quartz and perthite in graphic intergrowth. This zone corresponds in position to the border zone of fine-grained quartz and muscovite that is found in many other New England pegmatites. The wall zone, 2 to 10 feet thick, is composed of perthite, muscovite, and cleavelandite (An_2), with accessory beryl, black tourmaline, and dark green apatite. Remnants of this zone occur near the southeast corner of the cut on the hanging wall and in the central part of the cut along the footwall. Muscovite along the hanging wall appears to be associated with the perthite. On the footwall side the muscovite is less abundant, unevenly distributed, and commonly associated with the other minerals of the zone as well as with perthite. Sterrett mentioned two pegmatite "veins" or shoots that were almost completely mined out. These shoots must have been the richest parts of the wall zone and seem to have lain on opposite sides of the core. One was at the northern end of the pegmatite on the hanging wall, the other on the footwall in the old completely backfilled stope near the center of the cut. Beryl crystals, 2 to 12 inches in diameter, seem to have their long axes perpendicular to the footwall of the core. The crystals have been partly replaced by apatite and cleavelandite. Numerous small tourmaline crystals occur in the muscovite books, and these crystals are arranged with long axes parallel to the muscovite cleavage. Some of the muscovite books appear to have been replaced along their cleavage planes by cleavelandite.

The core, 10 to 20 feet thick, is composed essentially of quartz and perthite. Large amounts of quartz and perthite appear to have been replaced by cleavelandite, muscovite, apatite, and triphylite. According to Switzer, quartz and perthite have also been replaced by garnet, löllingite, graftonite, amblygonite, rhodochrosite, fairfieldite, columbite, and cassiterite. Autunite has been replaced by vivianite, eosphorite, and heterosite. Spodumene and cymatolite that formed by replacement of spodumene were found in the dump and may have occurred in the core. Colorless and smoky quartz occurs in individual bodies and as large interstitial masses in the perthite. One quartz body is at least 3 to 5 feet wide and 25 feet long. Perthite occurs in white to grayish-white anhedral and subhedral crystals. Most subhedral crystals are 2 by 4 feet or less, but some anhedral crystals are larger. Near the northwest end of the cut is an irregular, pipelike body of muscovite, at least 3 by 10 by 20 feet, adjacent to a large quartz body, itself near the margin of the core. Minor quantities of perthite, quartz, and cleavelandite are associated with the muscovite, which seemingly was formed by the partial replacement of these minerals. The muscovite occurs in 2 by 2 inch tangled greenish books. Triphylite generally occurs in bodies 1 to 2 feet in greatest dimension, but one body at least 10 feet across was reported to have been uncovered during the last period of mining. Löllingite occurs in small anhedral and very small subhedral crystals, commonly associated with the cleavelandite.

Most of the muscovite in the wall zone is green to light rum, fairly hard, and ruled. Many books are wedge-shaped and have "A" structure. They average 3 by 4 inches. Some of the muscovite contains specks of magnetite or pyrite, and tourmaline inclusions. Many large crystals are reported to have been recovered during the early period of mining when the richer mica-bearing parts of the pegmatite were removed.

The muscovite books in scattered remnants of the hanging wall mica zone would yield only small sheet mica of low quality. Further mining of the hanging wall mica zone down dip would probably yield a similar product. Considerable amounts of potash feldspar could be mined from the core.

ASHTON ROLLINS PROPERTY

The Ashton Rollins property, including Parker Mountain, the eastern half of Evans Mountain, an unnamed hill south-southwest of Saunders Ledge, and territory north and south of the Blue Hills Range, is in the town of Strafford. From Center Strafford village follow the old Rochester-Dover road, which forks northwest from U. S. Highway 202A at the post office, 3.0 miles to a house occupied by the caretaker of the Rollins property. A small prospect pit, about ½ mile east of the caretaker's house, was excavated in the early 1900's. None of the other pegmatites has been prospected.

Several traverses were made by G. W. Stewart across the north slopes of Parker Mountain between Wiley Ponds and the Old Rochester-Dover road, the north slopes of Parker Mountain between the Old Rochester-Dover road and an unnamed pond 1 mile north of the caretaker's house, and the western slopes of an unnamed hill south-southwest of Saunders Ledge. Twenty to 25 pegmatites were examined. All were composed of perthite and quartz, with minor plagioclase, muscovite and biotite, and accessory tourmaline and garnet. They are enclosed in a schistose rock, probably the Littleton formation, that has been impregnated locally with granitic material.

None of the pegmatites seen is sufficiently rich in muscovite to warrant prospecting. Nearly all the muscovite books are either small (3 by 3 inches or less) or poor in quality, because of cracks, ruling, fishtail structure, and intergrowth with biotite. Profitable mining for sheet mica under the economic conditions of 1943–44 did not seem likely.

SULLIVAN COUNTY

AARON LEDGE MICA PROSPECTS

The Aaron Ledge prospects (pl. 1, no. 74) are in the town of Springfield 4.1 miles S. 68° W. of Grafton village. To reach them from Grafton follow a graded gravel road southwestward 0.3 mile to a fork; turn right and continue for 2.0 miles to Robinson Corner. Take the right fork northwestward, passing two left forks, 2.0 miles to a crossroad. Take a left fork over the newly constructed mine-access road for 0.9 mile to a left fork; proceed along the left fork for 0.3 mile to the Saunders mica mine; travel about 0.4 mile cross country, S. 25° W., to the top of Aaron Ledge. The property and mineral rights are owned by Charles C. Morrison of Danbury, N. H.

The five opencuts in the pegmatite (fig. 110) were probably made between 1918 and 1920. Cut 1 is 20 feet long, 5 feet wide, and 3 to 5 feet deep. Cut 2 is 20 feet long, 20 to 25 feet wide, and the north face is 30 feet high. A short drift, 7 by 8 feet, extends northward into this high face from the floor level. Cut 3 is about 60 feet long, 15 feet wide, and has an average depth of 10 feet. Cut 4 is 30 feet long, 36 feet wide, and 5 feet deep. Cut 5 is 20 feet long, 10 feet wide, and has an average depth of 5 feet. The pegmatite was mapped in September 1943 by G. W. Stewart and Harry Kamensky.

The pegmatite is well exposed for 790 feet and probably extends northeast for several hundred feet farther. At the northeast end, where both contacts are exposed, the pegmatite has an average width of 5 feet, but in its southern and central parts it ranges from 100 to 220 feet in exposed width. The southern half strikes about north. The northern half has a more easterly strike, and at its northeast end the pegmatite strikes N. 45° E. Only the west contact is exposed. Its dip varies from 40°-90° E., along the southern half of the pegmatite, but the dip along the northern half is probably gentler. The contacts of the pegmatite are concordant with the wall-rock foliation in some places, discordant in others. Several apophyses of pegmatite project into the wall rock, and numerous fingers of schist, some too small to map, project into the pegmatite.

The wall rock is quartz-mica schist of the Littleton formation that strikes northeast in general and dips 35° SE. to vertical. Several small bodies of aplite, consisiting of quartz, perthite, oligoclase (An_{18}) and muscovite, occur scattered through the southern half of the pegmatite. Contacts between the aplite and pegmatite are gradational.

The pegmatite is poorly zoned. The border zone, 2 to 4 inches thick, is composed of fine-grained quartz and muscovite. The wall zone, 100 to 220 feet wide, forms the bulk of the pegmatite. It is composed of medium- to coarse-grained quartz, perthite, graphic granite, oligoclase (An_{18}), muscovite, biotite, and accessory tourmaline and garnet. Aplitic bodies are also present in this zone. The core consists of quartz pods that range from 10 to 20 feet in thickness and from 5 to 25 feet in length.

Most of the muscovite books are near the margins of quartz pods or embedded in them. Some books occur in areas rich in quartz and oligoclase. The muscovite books are light rum and average 2 by 2 inches. Many have organic and mineral stains and are cracked and ruled, and some have conspicuous herringbone structure. Most of the muscovite is intergrown with partly chloritized biotite. Some of the muscovite occurs in lath-shaped books along the cleavages of perthite or between perthite crystals.

Several quartz bodies that are not related to the quartz pods project inward and northeastward from the west contact, but terminate abruptly at the contact. They are 2 to 3 feet thick and range from 10 to 25 feet in length. Their approximate parallelism together with the absence of muscovite and feldspar suggests that they were formed in tension cracks developed after solidification of the pegmatite.

Owing to the characteristic intergrowth of muscovite and biotite and the many structural defects in the muscovite, this prospect could not be operated under economic conditions of 1943-44.

BERYL MOUNTAIN PEGMATITES

Beryl Mountain (pl. 2, no. 1) is a prominent hill in the town of Acworth, about 0.8 mile S. 32° W. of South Acworth Village. To reach the mountain from the village, cross Cold River and drive southwest about 0.9 mile, passing a left fork at 0.2 mile, from this point an old road leads southeastward about 0.2 mile to Beryl Mountain quarry. The quarry and surrounding property are reported to be owned by Miss Sadie A. Cohen, 285 Washington Street, Providence, R. I.

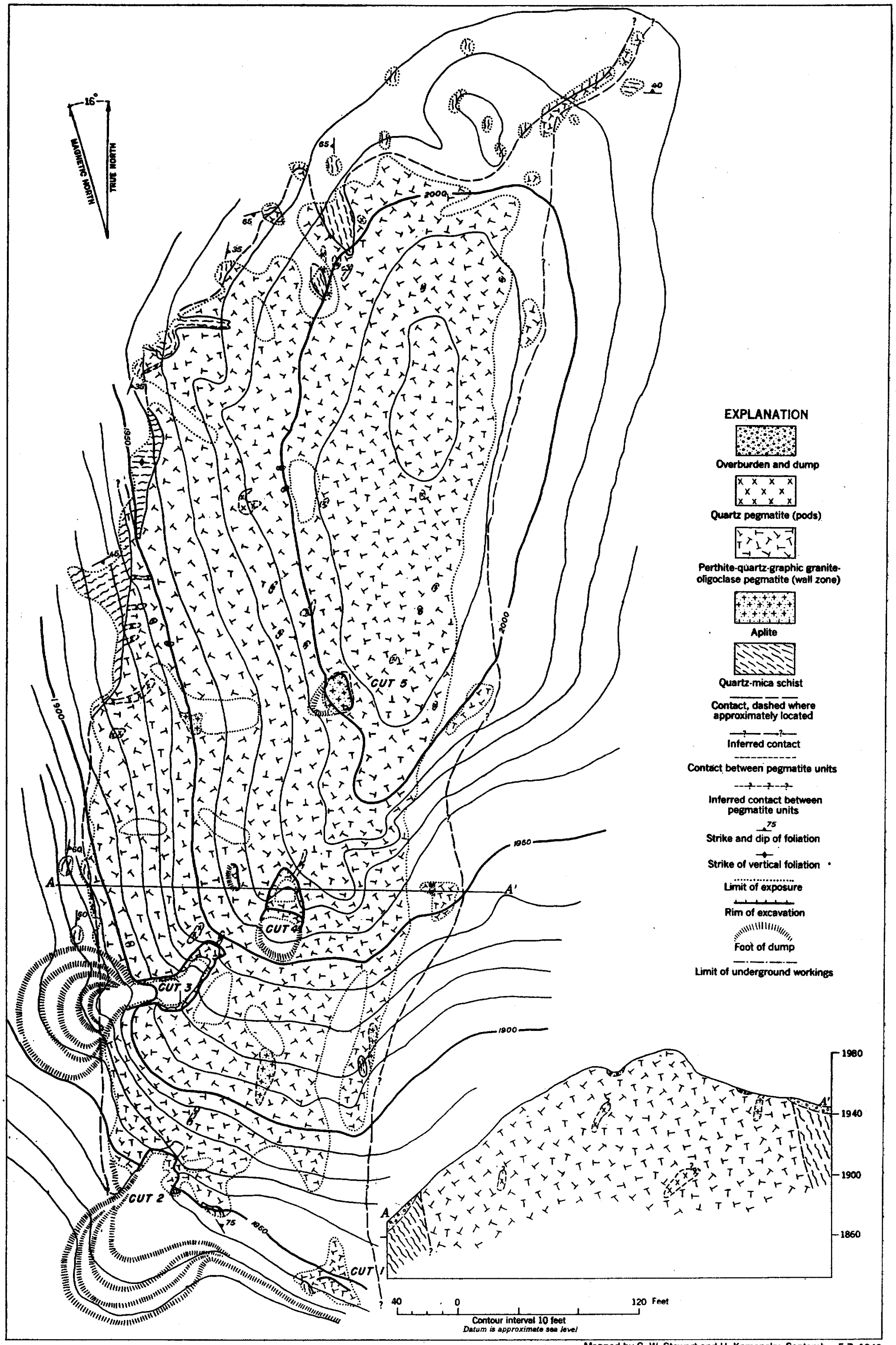


FIGURE 110.—Geologic map and section of the Aaron Ledge mica prospects, Springfield, N. H.

Beryl Mountain is a well-known mineral locality, and many descriptions of the minerals of the pegmatites mined have been published (Shepard, 1830, p. 353–360; Teschemacher, 1844, p. 191–192; 1845, p. 87–89; and Holden, 1918, p. 199–200). The mine was opened by a Mr. Bowers prior to 1844 (Jackson, 1844, p. 59, 182) and was operated intermittently on a small scale for 30 years. The workings on the property are in three essentially parallel pegmatites that trend northeasterly across the mountain. Two pits in the middle pegmatite probably were opened in the course of a search for feldspar. The principal workings are a small quarry and several small pits excavated in the beryl-bearing eastern pegmatite on the north slope of the hill.

The pegmatites of Beryl Mountain were examined by H. M. Bannerman in 1942, and a large part of the beryl-bearing pegmatite was mapped by him and J. B. Headley, Jr. In 1943, the Bureau of Mines cleaned the floor of the largest cut and made a 50 foot exploratory tunnel, and S. B. Levin, engineer in charge of the project, mapped and studied the beryl-bearing pegmatite in great detail. The general description of the locality given below is taken from the report by Bannerman. The detailed description of the beryl-bearing pegmatite is based largely on information which Mr. Levin has kindly furnished to the authors.

Beryl Mountain is underlain chiefly by schistose amphibolites and interbedded metasediments comprising quartz-biotite schists and quartz-muscovite schists. These rocks dip gently eastward on the east flank of the mountain, westward on the west flank. The foliation and bedding of the metasediments are parallel, and the major structure appears to be an anticline plunging gently south.

Two large bodies of pegmatite extend across the higher part of the mountain, and a third is exposed on the west flank near the highway. The pegmatites appear to be essentially parallel. They cut sharply across the foliation of the schists, trend northeasterly, and appear to dip 75° to 85° E. The pegmatite nearest the road is poorly exposed. It seems to be thin and composed largely of graphic granite. The middle body forms a steep escarpment on the west shoulder two-thirds of the way up the mountain. It is agout 50 feet wide and consists largely of coarse graphic granite enclosing bodies of perthite of suitable size and quality for the feldspar trade. Black tourmaline and scattered clusters of biotite, however, are fairly abundant in this body particularly along the boundaries and toward the the southern end of the exposed part. No beryl was observed in this pegmatite. The two pits opened in it evidently yielded little feldspar.

The beryl-bearing pegmatite that spans the summit of the mountain is the largest of the three. It is 1,000 feet long and 50 to 190 feet thick, and follows a thrust-fault surface that strikes N. 55° E. and dips steeply southeastward. The pegmatite has a core of massive white and rose quartz flanked on each side by a unit 25 to 50 feet wide, consisting of feldspar and quartz with some muscovite, biotite, and black tourmaline, the last two minerals being most abundant at or near the walls. The contact between the core and the outer pegmatite is sharp, and locally books of wedge muscovite, 5 to 15 inches long, occur in the quartz along the contact.

The blue-green and brown beryl is near the margins of the quartz core. The bottom of the core is saddle-shaped, and beryl seems to be most abundant along the crest of the saddle. This crest probably plunges gently northeastward. The main exposure of beryl in the largest cut is a saddle-shaped zone about 20 feet long and 5 to 7 feet thick, in which beryl crystals from 4 inches to 5 feet long, associated with wedge-muscovite, are embedded in a matrix of albite. The floor of the beryl-bearing zone is sharp and distinct, but the upper part is gradational; the beryl content decreases upward. This beryl-bearing zone probably crops out also at the southwest end of the quartz core, where a radiating group of crystals averaging 3 feet in length is exposed. Whether these two exposures are parts of a single beryl-bearing unit, continuous along the crest of the saddle, or are separate bodies is not known. A third, smaller concentration of large beryl crystals is present along the hanging wall margin of the quartz core in a small cut southwest of the larger cut. Here 6 large crystals ranging up to 2 feet in length are associated with albite and muscovite.

The beryl crystals in the deposit range from 4 inches to 5 feet long, and have diameters ¼ to ⅛ the length. Analyses of some of the blue-green beryl indicates a beryllium oxide content of 14 percent, whereas that of the golden-brown crystals is 13.8 percent. In the largest cut, 188 square feet of measured beryl surface is exposed in 400 square feet of pegmatite, and 25 square feet of the beryl measured is in the lower part of the walls of the cut. Measurements made in 1944 indicated ore reserves of 35 to 45 tons of beryl. Subsequent production is said to have exceeded this figure.

There is a large quantity of quartz in the core, and some of it would have to be mined if the beryl is to be recovered. The average depth of the quartz is not known, but is not less than 10 feet. On this basis, at least 50,000 tons of quartz is available in the core and easily recoverable by opencut mining. An analysis published by the State Planning and Development

Commission (Myers, 1941) shows that the white part of the core contains 99.38 percent of SiO_2, 0.30 percent of Al_2O_3, and 0.016 percent of Fe_2O_3. Not all parts of the core can be expected to yield quartz of such purity, but it seems safe to conclude that the core contains large quantities of quartz of the purity required by the glass industry.

COLBY MICA MINE

The Colby mica mine (pl. 1, no. 77) is in the town of Springfield, 2.2 miles N. 31° E. of Springfield village and may be reached by following a graded gravel road northward 1.0 miles to a road junction, turn left and proceed 0.3 mile to a fork; follow the right fork to the next right fork, and follow this 1.1 miles to the mine.

The mineral rights are owned by W. A. Shepard of Canaan, N. H. An opencut 65 feet long, 10 to 25 feet wide, and 5 to 30 feet deep was made about 1920. The cut and dumps are now largely overgrown with brush and trees. The mine was mapped by A. H. McNair, G. W. Stewart, and R. P. Brundage in June 1943 (fig. 111).

The Colby pegmatite is irregular and outcrops in two areas. In the southern outcrop it strikes, in general, N. 15° W., and dips about 40° E. It is at least 110 feet long, and has an outcrop width of about 15 feet; it is separated on the surface from the northern outcrop by a thin veneer of schist. The northern part, exposed only in the vicinity of the opencut, probably N. 10° E. and dips about 35° E.

The wall rock is fine-grained, markedly foliated quartz-mica schist of the Littleton formation, the foliation of which strikes in general N. 15° E. and dips 40°–75° E. The contacts of the southern part of the pegmatite are about parallel to the foliation of the schist; those of the northern part are discordant. A keel-like projection of schist extends eastward along the southern face of the opencut almost to the head of the cut, where it terminates against a mass of gray quartz. Probably the schist along the northern face of the cut is also part of this keel. If it is, the northern part of the pegmatite consists of two forks separated by a keel of schist whose bottom has a moderate northward plunge.

The pegmatite contains perthite, quartz, plagioclase, and some muscovite, black tourmaline and garnet. Mica books are most abundant just below irregularly spaced quartz pods and schist inclusions. A few scattered muscovite crystals occur in the northern part of the pegmatite. Most of the books in the sides of the cut are small and rum, and somewhat ruled and reeved. In the lower part of the south face of the cut the pegmatite contains a narrow interrupted layer of scrap mica where it is in contact with the overlying schist. Several "nests" of scrap mica project upward from the scrap-mica layer into the schist for a foot or so. Only scattered small crystals of mica are exposed in the southern part of the pegmatite.

The mine was not operated during 1942–44 and information concerning the quality and concentration of muscovite is therefore not available. Mica does not appear to be abundant in the pegmatite, and it is unlikely that the mine could be operated successfully for muscovite under conditions similar to those of 1942–44.

COLUMBIAN GEM MINE

The Columbian Gem mine (pl. 1, no. 75) is in the town of Springfield, 2.75 miles S. 37° W. of Grafton village. From Grafton follow a graded gravel road southwestward 2.3 miles to Robinson Corner, follow the right fork 0.2 mile to an obscure left fork, and then proceed along the left fork, a poorly graded overgrown woods road, 0.9 mile to the mine.

The property is owned by Norman Davenport of Danbury, N. H. It was worked for gem beryl and mica for several years prior to 1914, and four small opencuts were made (Sterrett, 1923). The Hill Mining Corp. of Newport, N. H., leased the property in 1943 and did prospecting work in May and June. The deposit was mapped by G. W. Stewart, J. Chivers, and R. P. Brundage in June 1943 (fig. 112).

The mine is in an extremely irregular pegmatite about 8 to 55 feet wide and exposed for a distance of about 460 feet. Its area of outcrop forms an irregular T. The general strike of the stem is northeast, and the bar strikes roughly east. The present outcrop seems to be the upper surface of a partly unroofed pegmatite body, for gneiss "patches" are scattered over the pegmatite outcrops, and in the larger gneiss outcrops are isolated patches of pegmatite that may be related to the main pegmatite body. The pegmatite walls in most places are discordant to the foliation of the gneiss and contain many inclusions of wall rock.

The wall rock is massive poorly foliated gneiss that is quartzitic in places. Where its attitude is determinable, the foliation strikes about N. 10° W. and has an average westerly dip of 70°, but in places the dip is vertical or steeply east.

Quartz, perthite, and plagioclase are essential minerals, and garnet, black tourmaline, muscovite and beryl are minor accessory minerals in the pegmatite. Most of the body now exposed seems to be perthite-quartz-plagioclase pegmatite containing small scattered, lenticular quartz pods. Some pods have a marginal zone of scattered muscovite books or scattered beryl crystals. Sparsely scattered small isolated muscovite crystals occur throughout the body. The muscovite is rum, free splitting, and relatively free from ruling or

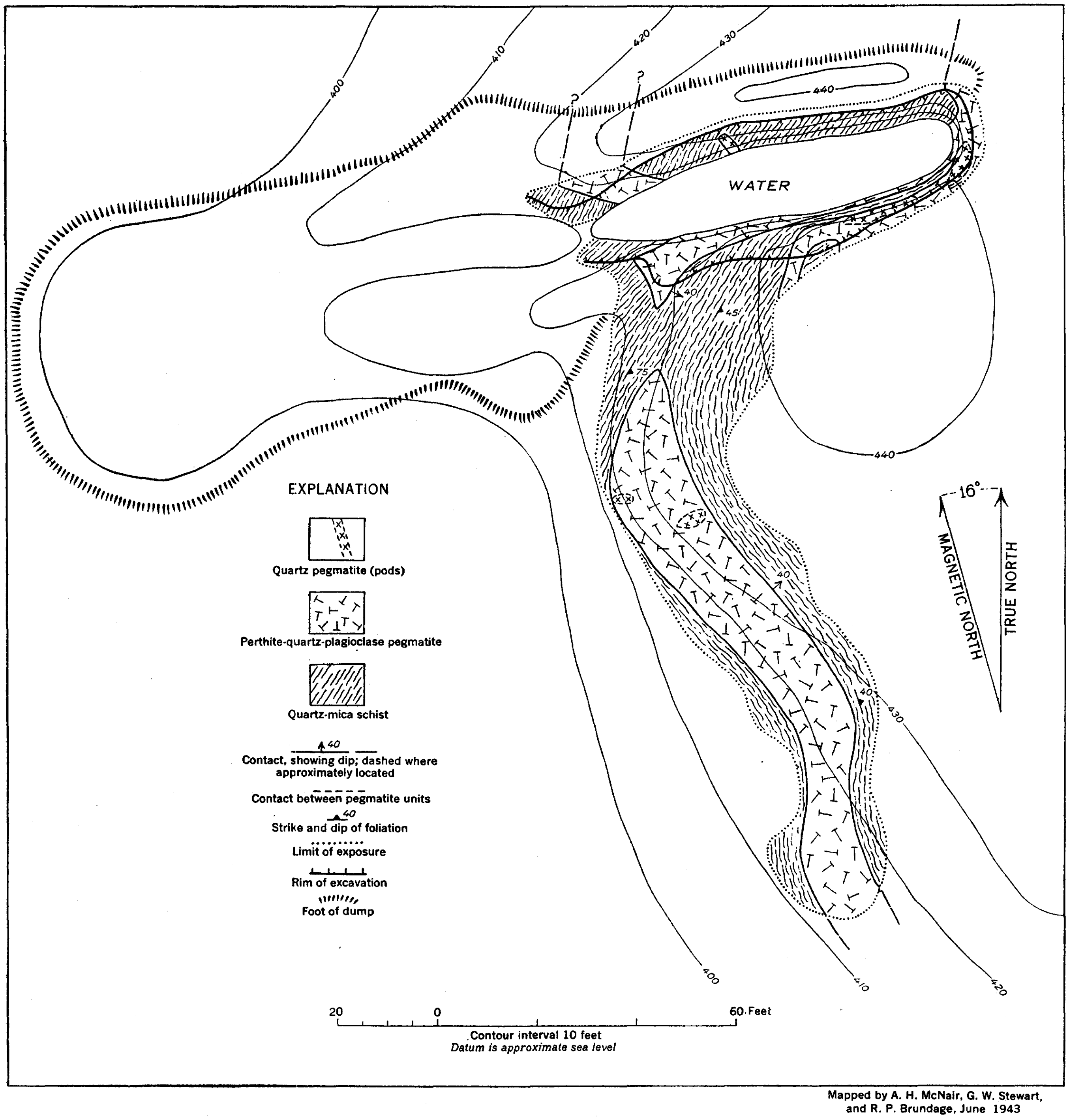


FIGURE 111.—Geologic map of the Colby mica mine, Springfield, N. H.

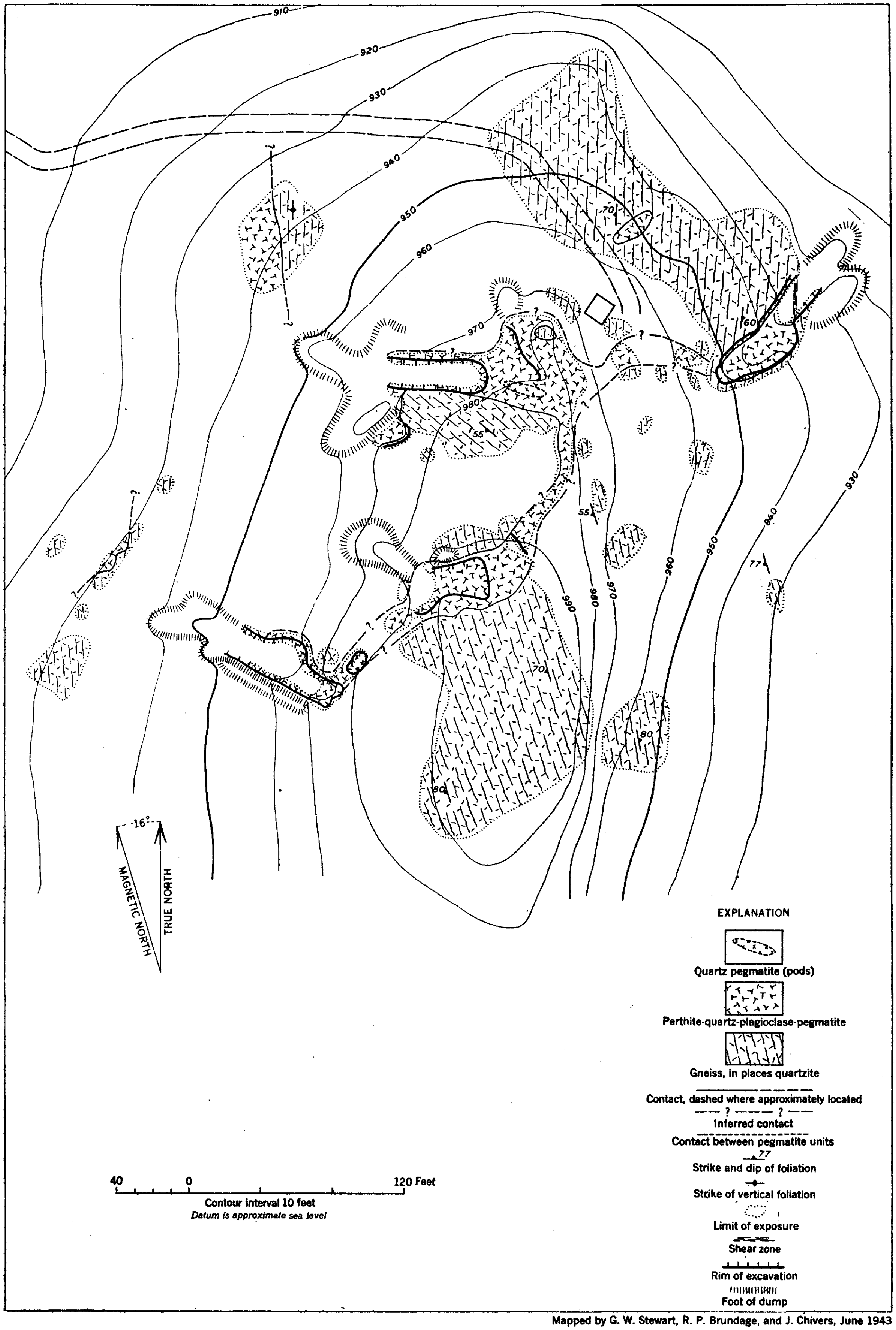


FIGURE 112.—Geologic map of the Columbian Gem mica mine, Springfield, N. H.

other structural defects. All beryl crystals seen in the deposit were small (largest about ¾ by 2 inches), and none was of gem quality.

Both muscovite and beryl seem to occur chiefly around small scattered quartz pods. Prospecting in 1943 did not yield sufficient muscovite to encourage further operations, and probably the mine could not be operated profitably under 1942–44 conditions.

GLOBE MICA MINE

The Globe mine (pl. 1, no. 79) is in the town of Springfield 1.5 miles N. 66° E. of Springfield village. It can be reached from Springfield traveling north 0.9 mile to the old Enfield turnpike. Proceed southeast on the turnpike for 1.6 miles to a poorly graded logging road which runs 0.5 mile north to the mine.

The property is owned by the Whitehall Co., Inc., of New York City. The workings consist of two open-cuts and two small prospect pits. According to Sterrett (1923, p. 156), the mine was opened before 1880 but had been idle for many years prior to 1914. Subsequent to 1914 the no. 2 quarry (fig. 113) was opened to a length of 80 feet, and a width of 45 feet. Late in June, 1944, the Warren Soap Manufacturing Co., 51 Waverly Street, Cambridge, Mass., leased the property and began mining mica at the northeastern end of the no. 1 quarry. Operations were halted in December 1944, at which time the quarry was 200 feet long, 30 to 50 feet wide, and 25 feet in maximum depth. About 1,400 tons of rock was removed during 1944.

V. E. Shainin and K. S. Adams mapped the property in June 1944, and A. H. McNair and G. W. Stewart made progress maps during the period July to December 1944 (fig. 113).

The exact form and attitude of the pegmatite are unknown. It is at least 750 feet long, and between 300 to 400 feet thick. It strikes northeast and seems to be almost vertical. It is enclosed in medium-grained quartz-mica schist having a well-developed foliation which is parallel, in general, to the contacts of the pegmatite.

The body exhibits a zonal structure, and the following zones appear successively inward from the walls:

1. Border zone, 1 to 4 inches thick. Consists of fine-grained quartz, plagioclase, and muscovite.
2. Quartz-perthite-plagioclase wall zone, 160 to 200 feet thick. Composed of medium- to coarse-grained quartz and perthite with subordinate muscovite and plagioclase, and accessory biotite, garnet, tourmaline, apatite, and löllingite.
3. Albite-muscovite intermediate zone, 2 to 8 feet thick. Composed of coarse blocky white albite (An_{5-6}), with subordinate muscovite in coarse books, minor quartz, and black tourmaline.
4. Quartz pegmatite core, as much as 60 feet thick. Consists of coarsely crystalline milky quartz with minor green beryl and autunite. The core is discontinuous along strike and down dip. It consists of several large, apparently separate, ellipsoidal bodies of quartz lying near the center of the pegmatite. The long axis of each body is parallel to the inferred strike of the dike. The largest quartz body is poorly exposed, but seems to have an outcrop length of at least 120 feet and a width of 60 feet. An irregular southward-pitching quartz lens, largely mined out from the northern corner of the no. 1 quarry, was at least 50 feet long and 10 feet wide. It seems to narrow considerably down dip and probably terminates a short distance below the floor of the quarry. A third quartz body, in the flooded part of the no. 2 quarry, is at least 50 feet long and 40 feet wide. Smaller, widely-scattered quartz bodies ranging from a few inches to 18 feet in length are visible near the center of the pegmatite. One lens, exposed in cross section on the eastern face of the no. 2 quarry, is 18 feet long and 5 feet thick (fig. 113, sec. A–A′).

The albite-muscovite zone has been identified only in the no. 1 quarry, where it forms a shell completely enveloping the segment of the core mentioned. Mica recovered in 1944 came from this core-margin zone. Although some books were recovered in the zone 6 to 8 feet from the quartz core, most occurred nearer the core, and were associated with a persistent layer containing large, scattered euhedral crystals of tourmaline. Pegmatite removed from the cut yielded about 4 percent of mica. The hanging-wall part of the zone contained considerably more muscovite than the footwall part.

Lack of good exposures has prevented recognition of the zone adjacent to other segments of the core, but in each quarry the zone is absent adjacent to bodies less than 20 feet long. In the no. 2 quarry a few scattered books, 4 inches in average diameter and ½ to 1 inch thick, occur adjacent to the smaller quartz body, partly in the quartz-perthite zone and partly in the quartz body.

The muscovite obtained in 1944 was in books 4 by 5 inches in average diameter and 1 inch thick. The muscovite was rum, hard, and free-splitting, and was not excessively ruled or reeved. A satisfactory quantity of sheet mica was recovered from it.

Sparsely scattered subhedral grayish-green beryl prisms, 1 inch to 1½ feet long, occur in the large segment of the core that is now under water in the no. 2 quarry. Most of the crystals occur close to the margins of the body.

The margins of the large quartz body that is northwest of the no. 1 quarry are exposed in only two places. The rock bordering the quartz seems to be more typical of the quartz-perthite zone than of the albite-muscovite zone, but neither exposure is large enough for positive identification. If further mining for mica were contemplated, it would be desirable to expose the margins of this body more completely to determine the presence of the albite-muscovite zone.

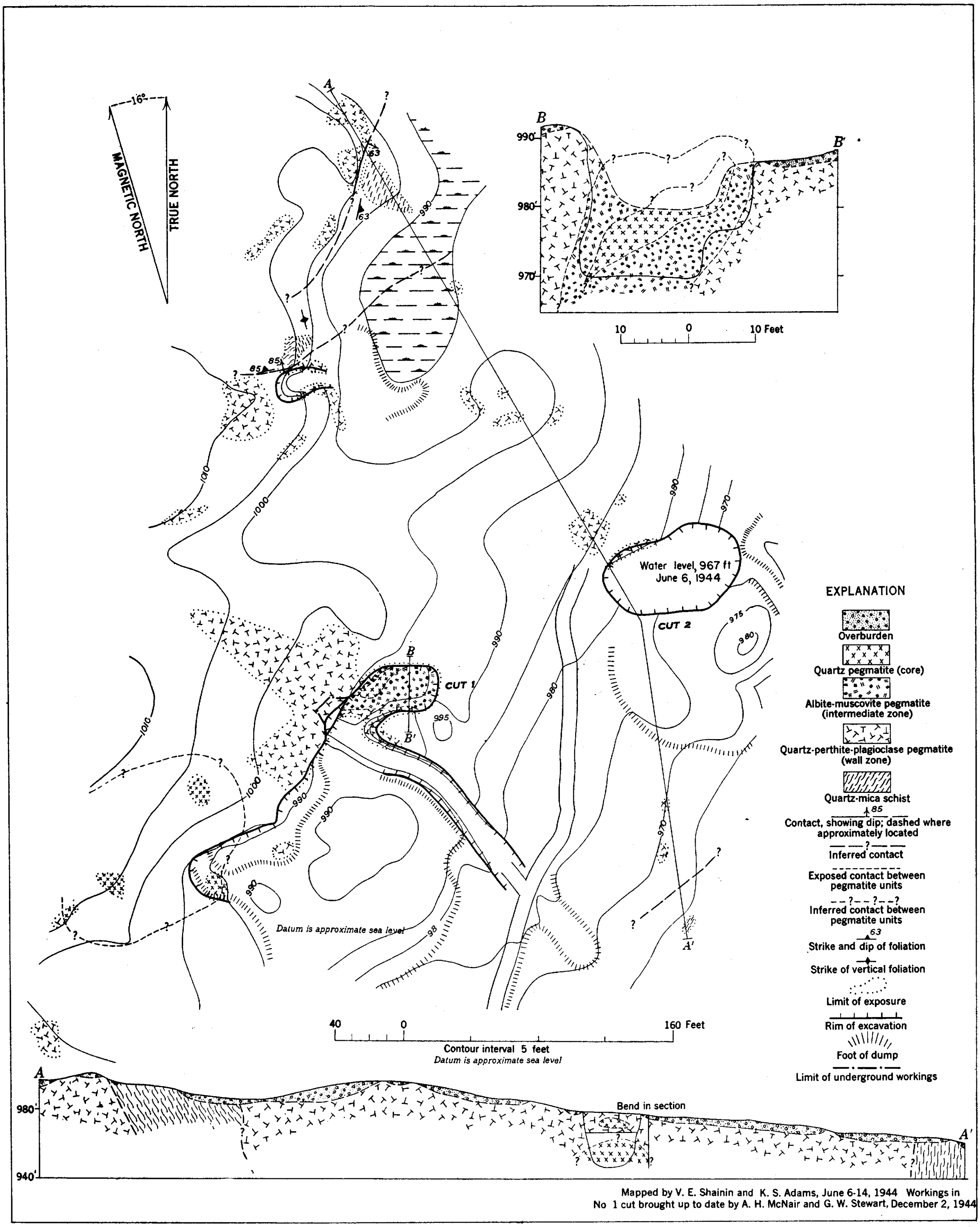


FIGURE 113.—Geologic map and sections of the Globe mica mine, Springfield, N. H.

Mica seems to occur in quantity only along the margins of certain segments of the core. Although these deposits may be fairly rich, most of them are probably of small size.

LEDGE POND MICA MINE

The Ledge Pond (Trow Hill) mica mine is in the town of Sunapee, 1.5 miles S. 70° W. of the village of Georges Mills and 0.5 mile northwest of Trow Hill. To reach it from Georges Mills follow U. S. Highway 11 southwest for 1.3 miles to a road on the right; turn right and proceed 0.8 mile along a graded gravel road to a mine road on the right; turn right and follow the mine road 0.3 mile to the mine.

The property is owned by Philip Farwell, Sunapee, N. H. Mineral rights are leased by E. A. McWilliams, Newport, N. H. An opencut about 65 feet long, 8 to 30 feet wide, and 4 to 20 feet deep, was made about 1894 by the New England Mining Co. During May–August 1944 the mine was operated by E. A. McWilliams, and about 1,700 tons of rock was moved. The old cut was extended about 30 feet northeast, and several prospect pits were dug northeast of the main cut. The mine was mapped in September 1943 by G. W. Stewart and Harry Kamensky (fig. 114). Subsequent visits were made by E. N. Cameron and Stewart.

The pegmatite is exposed for 480 feet along strike and is 10 to 48 feet wide. It strikes N. 60°–70° E., and dips irregularly northwest. The hanging wall dips 75°–90° NW., the footwall 50°–60° NW. Owing to a local flattening of dip, about 50 feet east of the cut the footwall contact strikes N. 40° W., and dips 20°–30° NW. Except at a few places the pegmatite is discordant to the strike of the foliation of the wall rock, and it is everywhere discordant to the dip of the foliation. The foliation of the wall rock, which is probably the Bethlehem gneiss, strikes N. 35°–55° E. and dips 30°–58° SE.

The pegmatite is zoned. The border zone, 2 to 4 inches thick, is indistinct. It is composed of fine-grained quartz and oligoclase (An_{18}), minor amounts of perthite and muscovite and accessory apatite. The wall zone, 1 to 5 feet thick, is composed of oligoclase (An_{18}), quartz, perthite, disseminated muscovite intergrown with partly chloritized biotite, and accessory apatite and tourmaline. The intermediate zone, 1 to 15 feet thick, contains coarse-grained perthite and quartz, graphic granite, subordinate plagioclase and disseminated muscovite intergrown with partly chloritized biotite, and accessory tourmaline and beryl. Perthite crystals ranging from 1 to 3 to 4 by 5 feet occur in this zone. The discontinuous core is 1 to 10 feet thick. It consists of isolated pods of white quartz 5 to 85 feet long. Small patches of rose quartz, and perthite crystals measuring 1 by 3 feet occur in the pods.

Muscovite occurs as disseminated books in the wall zone, near the margins of the core, and within the segments of the core. The muscovite is light- to medium-rum, hard, flat, ruled, and slightly cracked. Most of the books average 3 by 4 inches and are intergrown with biotite, and many contain "specks" of magnetite. Lath-shaped books of biotite, 1 to 1½ feet long and 1 to 3 inches wide, occur in the wall zone and the core.

Muscovite is not abundant in the pegmatite. The mica recovered during 1944 was about 1 percent of the rock moved. The mica was of poor quality and only a small percentage of sheet was obtained from it. The work done in 1944 indicated that the mine is a marginal operation under economic conditions comparable to those of 1943–44.

MELVIN HILL MICA PROSPECTS

The Melvin Hill prospects (pl. 1, no. 78) are in the town of Springfield, 6.7 miles S. 47° E. of the village of Enfield Center. To reach them from Enfield Center follow a hard-surfaced road 2.0 miles southeastward; continue on a gravel road for about 5.3 miles to the fourth fork on the left; turn left and continue for 0.6 mile to another fork. Take the left fork for 0.1 mile, and turn right on a logging road for 0.3 mile to prospect no. 1; take the right fork for 0.2 mile to prospect no. 2.

During June–September 1943 the former owner, the Melvin Hill Syndicate, Georges Mills, N. H., made several small cuts at prospects no. 1 and no. 2 (pl. 39). At present the property and mineral rights are owned by the New England Mineral Co., Newport, N. H., which purchased the prospects and worked them between March and June 1944. The cut at the no. 2 prospect was extended about 20 feet eastward and deepened 5 to 10 feet. Cut A at the no. 1 prospect was extended across the pegmatite to the footwall. The prospects were mapped by G. W. Stewart, John Chivers, and Harry Kamensky in July 1943, and were revisited by Stewart in 1944.

The northwestern pegmatite at prospect no. 1 is exposed along strike for about 460 feet. A northward-trending branch at least 50 feet long leaves the main pegmatite about 315 feet from its southwestern end. The pegmatite ranges from 5 to 25 feet in width, has a general strike of N. 30° E. and dips steeply southeast. It has an indistinct zonal structure. The border zone, 1 to 3 inches thick, consists of fine-grained quartz and muscovite. The inner part of the pegmatite is composed of perthite, quartz, plagioclase, muscovite, and accessory tourmaline and garnet.

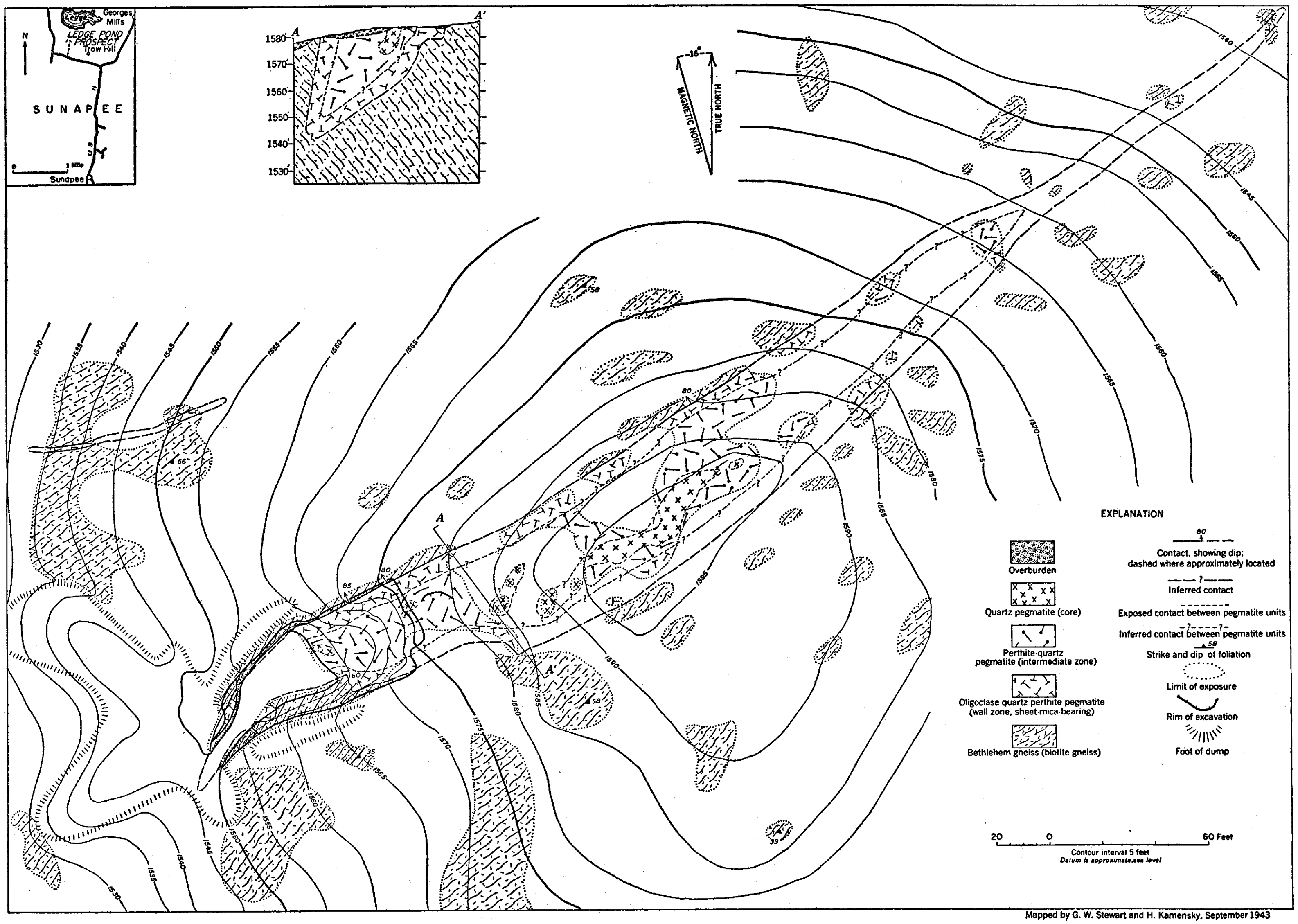


FIGURE 114.—Geologic map and section of the Ledge Pond (Trow Hill) mica prospect, Sunapee, N. H.

The central pegmatite at prospect no. 1 is exposed for about 660 feet along strike. An eastward-trending branch, about 250 feet long, leaves the pegmatite about 175 feet from its northeast end. The pegmatite ranges from 25 to 75 feet in width, strikes approximately N. 60° E. and dips steeply southeast. It has an indistinct border zone 1 to 3 inches thick consisting of fine-grained quartz and muscovite; and a core composed of perthite, quartz, graphic granite, and lesser quantities of plagioclase, muscovite, and biotite. Accessory minerals are tourmaline and garnet. A few small beryl crystals were seen. Most of the muscovite books are light- to medium-rum, hard, and compact, and they average 2 by 3 inches. Much of the muscovite is stained and badly ruled, has "A" structure, and is intergrown with biotite. In most of the pegmatite the books are evenly but sparsely distributed. Locally, there is a slight increase in the number of books near the walls.

The southeastern pegmatite at prospect no. 1 is exposed for 465 feet along strike and ranges from 20 to 55 feet in width. It strikes N. 45° E. and dips steeply southeast. The pegmatite has a border zone, 1 to 3 inches thick, composed of fine-grained quartz and muscovite; and a core composed of perthite, quartz, graphic granite, and small quantities of plagioclase, muscovite, and biotite.

The pegmatite at prospect no. 2 is poorly zoned. It is exposed for about 100 feet along strike and ranges from 7 to at least 20 feet in width. It strikes N. 80° E. and dips steeply northwest. The pegmatite has a narrow border zone 2 to 3 inches thick consisting of fine-grained quartz and muscovite. The wall zone is composed of coarse perthite, quartz, small quantities of fine- to medium-grained graphic granite, oligoclase (An_{17}), muscovite, biotite, and accessory tourmaline apatite, and beryl. Some muscovite was recovered adjacent to the hanging wall, but most of the books were associated with a quartz-perthite pod near the center of the pegmatite. The pod probably is the core of the pegmatite or a segment of the core. The muscovite books average 3 by 3 inches. Many are intergrown with biotite.

The pegmatites at prospect no. 1 are disseminated deposits, but locally there is a slight increase in the number of books near the wall. In prospect no. 2, most of the muscovite was recovered from the margin of a quartz-perthite pod. The muscovite was unsatisfactory owing to its structural defects and small size, and the percentage of mica recovered from rock moved was very low. It seems unlikely that further prospecting would disclose richer deposits of muscovite.

JUSTIN NICHOLS MICA PROSPECT

The Justin Nichols prospect (pl. 1, no. 17) is in the town of Springfield, 1.6 miles S. 48° W. of Springfield village. To reach it from Springfield follow a graded gravel road west-southwest for 0.7 mile to an intersection; turn right and follow a hard-surfaced road 0.2 mile to a road on the left; proceed on the left fork, a graded gravel road, southward 1.6 mile to a farm house on the left; continue southward on an abandoned road for 0.2 mile; turn left and follow a trail 0.1 mile to the prospect. The property and mineral rights are owned by Justin Nichols of Springfield, N. H., and are leased by the New England Mineral Co., Newport, N. H.

The pegmatite was first prospected by Colonial Mica Corp., of Newport, N. H., shortly before September 1943. Between May and August 1944, the New England Mineral Co. enlarged the cuts made in 1943 by moving about 600 tons of rock. The southwest cut (fig. 115) is about 50 feet long, 15 feet wide, and 5 to 12 feet deep. The northeast cut is about 20 feet long, 10 to 20 feet wide, and 5 to 10 feet deep. The prospect was mapped by G. W. Stewart and Harry Kamensky in September 1943 and remapped in July 1944 by Stewart and N. K. Flint.

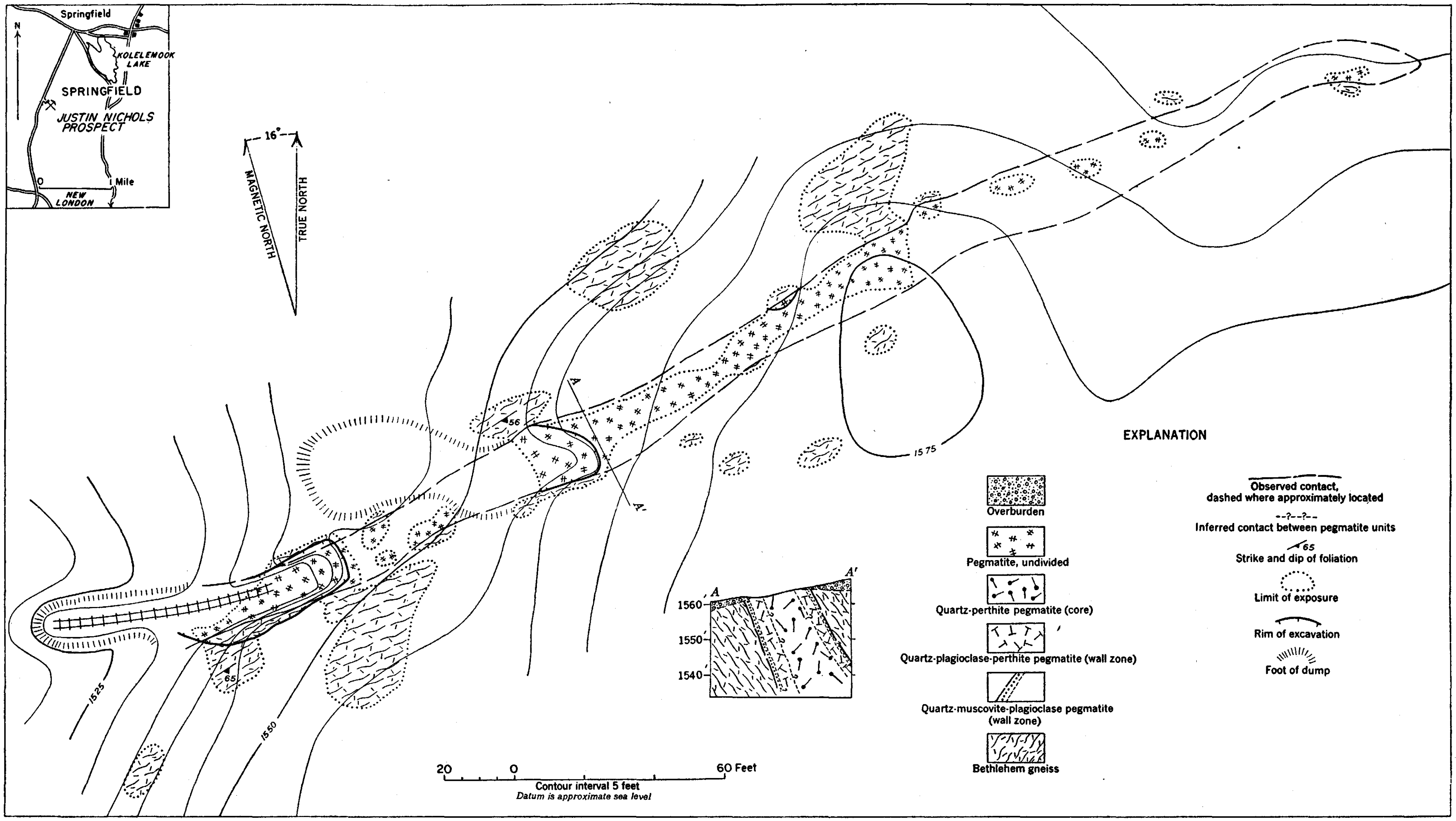
The pegmatite is exposed for about 365 feet along strike, and is 10 to 15 feet wide. It strikes N. 60°–70° E., and dips 70°–85° SE. The contact and the strike of the foliation of the wall rock are essentially parallel, but the pegmatite appears everywhere to transect the dip of the foliation.

The foliation of the wall rock, the Bethlehem gneiss, strikes about N. 60°–70° E. and dips 40°–65° SE. In one exposure near the northeast end of the pegmatite the foliation strikes N. 25° E. and dips 40° SE.

The pegmatite has an indistinct zonal structure. The border zone, 6 to 12 inches thick, is composed of fine-grained quartz, muscovite, plagioclase, and accessory garnet and apatite. The wall zone, 1 to 3 feet thick, is composed of quartz, plagioclase, small amounts of perthite, small muscovite books, and accessory garnet and tourmaline. The core, 8 to 12 feet thick, contains quartz and perthite, subordinate plagioclase, muscovite, and biotite, and accessory garnet, tourmaline, and beryl.

Most of the muscovite occurs as small books sparsely disseminated in the core. It is dark rum to ruby, hard, flat, and nearly free from mineral stains or inclusions. The books average 2 by 2 inches. Some are slightly ruled and intergrown with partly chloritized biotite.

The work done indicated that although the muscovite is of good quality, it occurs in books that are too small and too sparsely distributed to support mining operations under conditions similar to those of 1943–44.



Mapped by G. W. Stewart and H. Kamensky, September 1943
Revised by G. W. Stewart and N. K. Flint, July 1944

FIGURE 115.—Geologic map and section of the Justin Nichols mica prospect, Springfield, N. H.

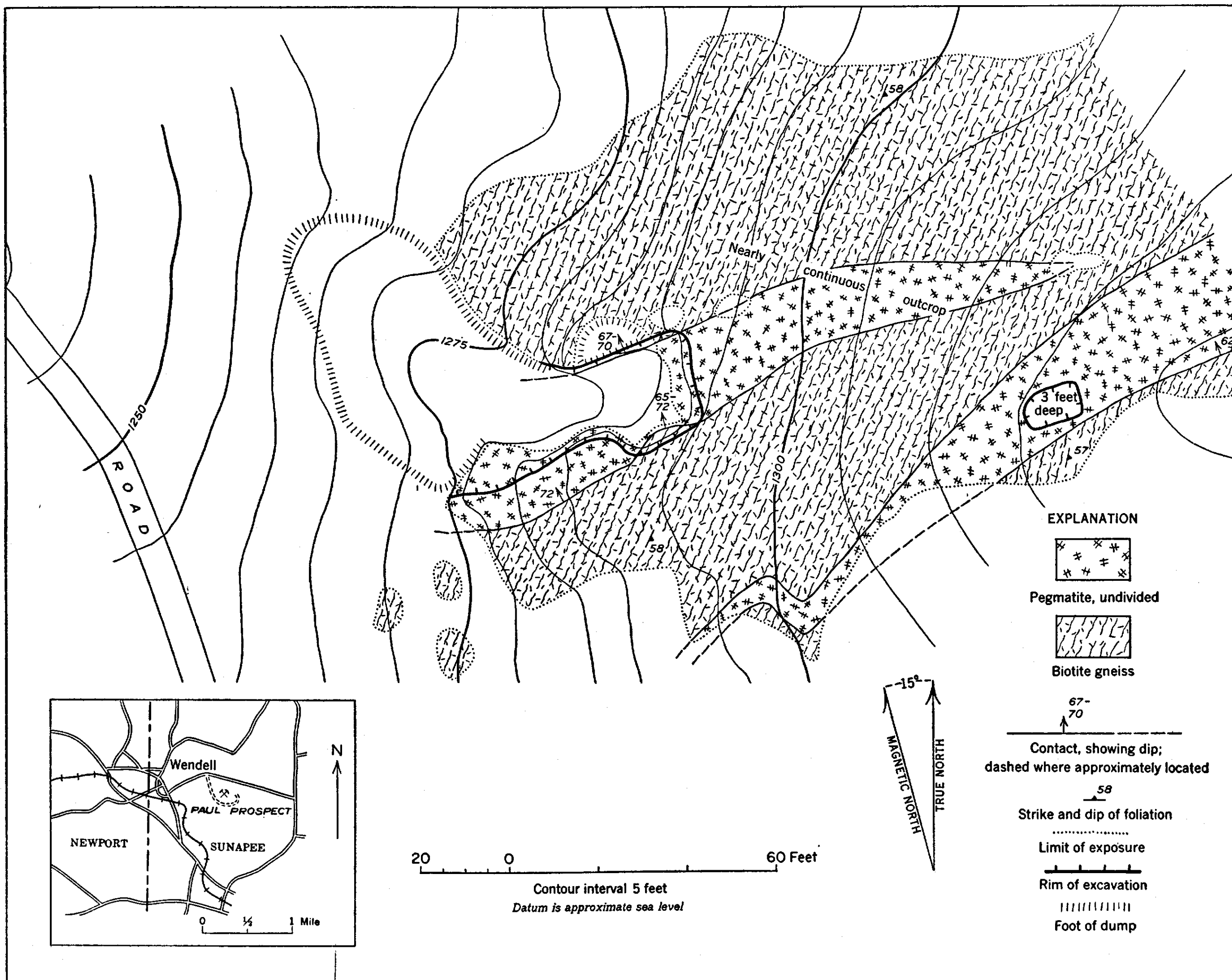
PAUL MICA PROSPECT

The Paul mica prospect is 6.0 miles N. 88° E. of Sunapee Station, on the south side of Young's Hill near its summit. To reach it follow Routes 11 and 103 east 2.9 miles from Newport to the point at which the routes divide. Take route 103 southeast for 0.3 mile, then turn left on a gravel road. At 0.5 mile a dirt road turns south through a pasture. Follow this for 0.2 mile to the prospect.

The property is owned by George M. Paul and Sidney E. Paul, of Wendell, N. H., and is leased and operated by Mr. and Mrs. G. Stanley Paul, of Wendell, N. H. A number of small pits on the property are the record of unsuccessful efforts, over a period of many years, to mine feldspar. In July 1944, G. S. Paul began mining a pegmatite shown on the accompanying map. The yield of mica was small, and mining was discontinued in September. The prospect was mapped by E. N. Cameron and P. W. Gates on August 22, 1944 (fig. 116). The opencut at the west end of the pegmatite was then being enlarged.

The deposit is a lens exposed for nearly 150 feet along strike. It trends N. 70°–85° E., and dips 65°–72° to the north. It has a maximum thickness of about 20 feet in the cut. The wall rock is thinly foliated quartz-biotite-muscovite-feldspar gneiss. Its foliation strikes N. 10°–24° E. and dips about 58° E., so that the pegmatite transects it. The wall rock adjacent to the contact appears unaffected by the pegmatite, but upward flexure of the foliation adjacent to the hanging wall was shown at one point in the opencut.

The pegmatite is a mixture of quartz, plagioclase, and perthite (in part graphically intergrown with quartz), with subordinate muscovite and biotite, and accessory garnet and schorlite. The pegmatite within the border zone shows vaguely defined units differing in propor-



Mapped by E. N. Cameron and P. W. Gates, August 22, 1943

FIGURE 116.—Geologic map and section of the Paul mica prospect, Sunapee, N. H.

tions of quartz, plagioclase, perthite, graphic granite, biotite, and muscovite, but apparently none is persistent. Along part of the hanging wall, however, an indistinct zone, 2.5 to 3 feet thick was exposed containing scattered books of biotite and muscovite, in part intergrown. The books ranged from 6 by 1 by 1.5 inches to 2.5 by 6 by 1 inch. Most of the mica recovered came from this part of the pegmatite, although some was reported taken from the central part.

Mica from the deposit is hard ruby muscovite ranging from clear to mineral-stained and rust-stained. The books are cracked, ruled and reeved, and some are "tanglesheet," or intergrown with biotite. The percentage of sheet mica in the crude product is evidently low. The low yield of crude mica together with its low sheet content led to abandonment of the prospect.

REYNOLDS MICA PROSPECT

The Reynolds mica prospect (pl. 1, no. 76) is in the town of Springfield, 2.8 miles S. 31° W. of Grafton village. To reach it from Grafton follow a graded gravel road southwestward 2.3 miles to Robinson corner; proceed on the right fork 0.2 mile to an obscure left fork; follow the left fork, a poorly graded overgrown woods road, 0.9 mile to the Columbia Gem mine. Walk southeast 300 feet to the prospect.

Five small cuts were made at the prospect prior to 1914. The northern cut, in which most of the work was done, had a short incline that extended south from the south face of the cut. The floor of this cut and the incline contain backfill, and all the cuts are overgrown with vegetation. The prospect was mapped by G. W. Stewart and R. P. Brundage (fig. 117) in June 1943 and was revisited by F. H. Main in May 1945.

Three irregular pegmatites crop out at the prospect. The northern cuts were made in the largest pegmatite. This can be traced for 100 feet along strike, and it ranges from 4 to 50 feet thick. It strikes, in general, N. 60° W. and seems to be almost vertical. The southern cuts were made in two parallel pegmatites. These strike N. 70° E. and have steep dips. Each is exposed for 35 feet along strike and is 5 to 10 feet wide.

The wall rock consists of muscovite-biotite granite Concord granite and quartz-mica schist of the Littleton formation. The schist strikes N. 20° W., has a high westward dip in general and contains small irregular stock-like masses of the granite. The pegmatites seem to be enclosed largely in the granite, but are in contact with schist in a few places.

The pegmatites contain thin, fine-grained, discontinuous border zones, and inner wall zones consisting of medium-grained quartz, perthite, plagioclase, muscovite and biotite. The northern pegmatite has, in addition, a small discontinuous quartz core. Scattered muscovite books occur throughout the pegmatites and a few wedge-shaped books are present near the margins of the quartz core in the northern pegmatite. The muscovite books are hard, rum-colored, small (rarely exceeding 3 by 5 inches in area), and are usually marred by "A" structure and ruling.

It is unlikely that this prospect could support a profitable mining operation for mica under 1942–45 conditions.

SARGEANT MICA MINE

The Sargeant mine is in the town of Claremont, 2.8 miles N. 10° W. of Unity village. To reach it from Unity follow a hard-surfaced road 0.25 mile northwestward; turn right on a newly constructed mine-access road and proceed 1.4 miles to a fork; follow the left branch 1.5 miles to the mine.

Three small prospect cuts were made prior to 1900. The mine (pl. 40) was opened in August 1942 by its owners, the Sargeant Mining Co., Newport, N. H., and was worked continuously until July 1944. An opencut 110 feet long, 25 to 45 feet wide and 15 to 37 feet deep was made in 1942–43. In 1944, a chamber 60 feet long, 30 feet wide, and 6 to 8 feet high was driven northward from the northern wall of the opencut.

The mine was mapped in October 1942 by A. H. McNair and J. B. Headley, Jr. The map was revised in August 1943 by McNair and J. H. Chivers and J. J. Page and P. W. Gates revised the map of the cut and underground working in June 1944.

The mine is in the central of three closely spaced lenticular pegmatites that outcrop along a northeast-trending ridge. The three pegmatites have similar attitudes and are arranged en echelon. They are separated by narrow partitions of wall rock, though they appear at first study to be parts of the same body. They strike north to N. 45° E., and dip 15°–35° E. The wall rock is quartz-mica schist and quartz-mica staurolite schist of the Littleton formation, whose foliation generally strikes north-northwest to northeast and dips 15°–36° E. It is concordant with the pegmatites, and contains abundant black tourmaline at most places near the contacts.

The southernmost pegmatite (pl. 40), exposed for 500 feet along strike, has a maximum width of 250 feet. It has a border zone 2 to 4 inches thick and a core of quartz, perthite, plagioclase, biotite, and muscovite. None of the outcrops contain abundant muscovite books.

The northernmost pegmatite, exposed along strike for 550 feet, is 50 feet wide at its southern end. It tapers abruptly and is only 15 feet wide over most of its length. It has a narrow border zone and a core of quartz, perthite, plagioclase, biotite and muscovite.

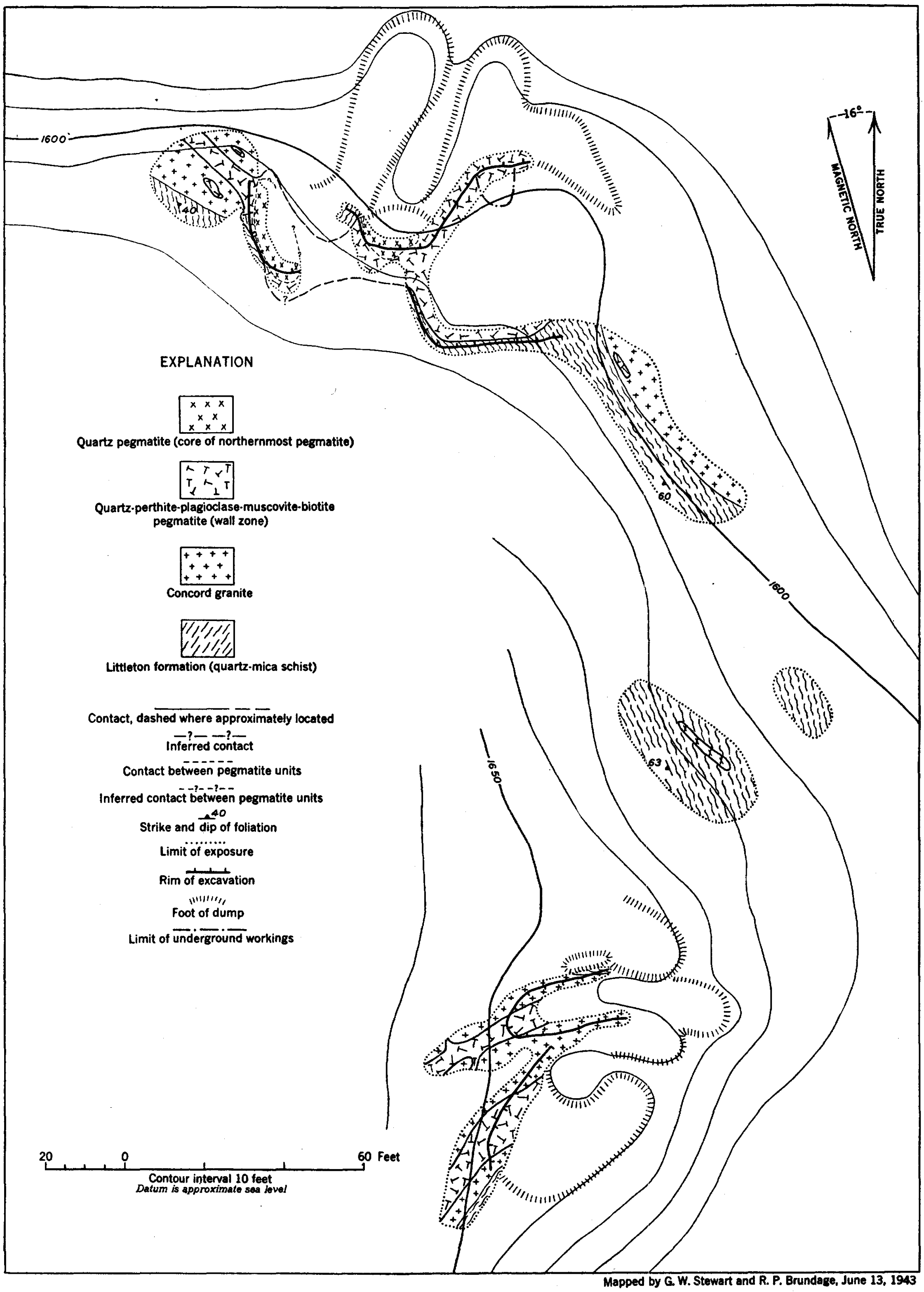


FIGURE 117.—Geologic map of the Reynolds mica prospect, Springfield, N. H.

No sheet-bearing mica books are exposed in its outcrops.

The middle pegmatite (pl. 40) is 950 feet long, 150 feet wide and appears to be approximately 60 feet thick in the vicinity of the cut. Only the lower part of the pegmatite is preserved; the upper part of the body has been removed by erosion. Along the east wall of the opencut the pegmatite is separated from the southern pegmatite by a partition of schist 11 feet thick. The partition is minutely drag folded, and dips in general 65°–70° E. The middle pegmatite is separated from the northern pegmatite by a wall rock layer about 20 feet thick. The footwall schist in the opencut and underground working contains minor folds. The largest folds, exposed in the floor of the opencut, plunge northeast at an angle of 35°. The keel or bottom of the pegmatite, in the vicinity of the cut, plunges northeast at angles ranging from 15° to 30°.

The pegmatite has three zones. The border zone, 2 to 6 inches thick, consists of fine-grained albite (An_{4-5}), quartz, muscovite, pink, garnet, green apatite, and black tourmaline. The border zone is in sharp contact with the wall rock, but is gradational into the wall zone.

The wall zone has a maximum thickness of 5 feet and averages 3 feet in thickness in the workings. It consists of medium-grained albite (An_{4-5}), quartz, apatite, garnet, black tourmaline, and large muscovite books that generally lie normal to the contact. The books range from 2 by 3 by ½ inches to 2 by 3 feet by 6 inches. Few of the muscovite books from the wall zone extend through the border zone to the wall rock contact. Granular albite extends into some of the books between the cleavage laminae. That some books may have been partly replaced by albite is indicated by relict muscovite structure in albite surrounding the books. The wall zone is almost completely restricted to the footwall part of the pegmatite, and only patches of this rock are present along the hanging wall contact in the cut. The zone is best exposed in the northern wall of the opencut and in the face of the chamber. It is also present in the small cut 110 feet north of the opencut and at the south end of an outcrop 70 feet northeast of the small cut.

The core makes up the major part of the pegmatite exposed. It consists of graphic intergrowths of perthite and quartz, irregular patches of albite, small blocky crystals of perthite, biotite flakes, and small bodies of milky and gray quartz. Quartz bodies in the core in places are smoky and contain nests of wedge muscovite surrounding small bodies of graftonite and triphylite partly altered to purpurite and vivianite.

The core in the vicinity of the opencut contains two tabular replacement bodies. The largest body is exposed in places for 80 feet in the south, east and north ends of the cut. It ranges from 2 to 5 feet in thickness, and is parallel to the footwall. It did not extend completely across the width of the cut. The smaller replacement body, exposed only in the northeast corner of the cut, is parallel to the larger body and about 15 feet above it. The bodies consist of albite (An_{4-5}), quartz, sheet-bearing muscovite, garnet in anhedral crystals as much as 3 inches in diameter, green apatite (in places graphically intergrown with albite), and conspicuous black tourmaline. The bodies are similar in mineral content to the footwall zone, but they contain less muscovite and more tourmaline, garnet and apatite. The muscovite books range from 2 by 2 to 8 by 10 inches. Some of the books are greenish but most are rum.

Thin quartz veins bearing scattered muscovite flakes cut the core. One vertical vein, ¾ inch thick, can be traced for 30 feet along the northwest wall of the cut.

Most of the muscovite obtained in 1942–43 came from the wall zone along the footwall of the middle pegmatite, but small quantities were recovered from the tabular replacement bodies. The muscovite occurs in large books, most of which is rum to ruby; a few are greenish. It is hard, flat and free-splitting. Although most of the books are ruled and reeved, a satisfactory percentage of sheet was obtained from them. The average recovery of mine-run mica per ton of rock moved from the opencut in 1942-44 was 2.9 percent. Recovery during underground work in 1944 was about 7.4 percent.

The sheet-bearing muscovite zone outcrops discontinuously along the footwall. It is probable, therefore, that the zone is not everywhere present down dip from the footwall exposures. The quantity of muscovite remaining in the deposit depends on the extent and mica content of the footwall zone north of the underground working, and down the plunge of the keel of the pegmatite. It seems likely that in this part of the body there is a considerable tonnage of mine-run mica that could be mined profitably under 1942–44 conditions.

G. F. SMITH AND CHANDLER MILLS MICA MINES

The G. F. Smith and Chandler Mills mica mines are on the south side of the Sugar River at Chandler Station, about 4 miles west of Newport. Asphalt and gravel roads lead to the property, which is crossed by the road from Newport and by the Claremont-Sunapee branch of the Boston & Maine Railroad.

The mines (pl. 41) are on a farm owned by G. G. Smith. The G. F. Smith mine, north of the road, was worked intermittently by Smith from May to September 1943, when he formed a partnership with Lawrence E. Sargeant and William A. Hoy, of Newport. The

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partners worked the mine steadily until July 1944, after which Smith mined it intermittently until November 1944. From December 1944 to February 1945, the Newport Mica Co., of Newport, leased and operated the property. The principal working is a shallow pit about 130 feet long and 75 feet wide. On the northwest side, the pit was carried about 12 feet downward along the dip of the pegmatite. This part is now flooded and much of the remainder of the working is covered by debris. Broken rock was transferred to the dumps by wheelbarrow during most of the operations.

The Chandler Mills mine lies south of the railroad, on the site of a former feldspar quarry. No records of the earlier operation are available, but the original pit was apparently the one described by Chapman in 1941 (p. 377–379) and again in 1943 (p. 90–98). The mine was leased in 1942 by the New Hampshire Mica and Mining Co., of Keene. Operations began in May 1943 and continued until December 1944. The principal working is a pit 180 feet long, 20 to 50 feet wide and 5 to about 30 feet deep. The pit is deepest in the two ends. The east end, excavated in 1943, is now completely backfilled; the west end is partly flooded. Waste rock was moved by derrick.

The mines were studied by H. M. Bannerman, A. H. McNair, and J. B. Headley, Jr., in July 1942 and by E. N. Cameron and V. E. Shainin in October 1943. Periodic visits were made by E. N. Cameron and J. J. Page from November 1943 to December 1944. The Chandler Mills mine was further studied by Page in September 1944. In April 1945, the maps of the mines were revised by Cameron, F. H. Main, and K. S. Adams.

The G. F. Smith mine is in a tabular pegmatite, 6 to about 14 feet thick, that generally strikes N. 30° W. and dips 5°–30° NE. At an early stage of operations it was almost completely exposed for 250 feet along strike. Over most of the area of the main pit, the dip of the pegmatite was low, overlying wall rock had been almost entirely removed by erosion, and mining was simply a matter of stripping away the upper, productive, part of the pegmatite. On the northeast side, the dip is steeper, and if this attitude is maintained down dip, further mining will require underground work. The hanging wall of the deposit is characterized by shallow undulations. The footwall, exposed at the base of the ledge southwest of the pit, is more even.

The pegmatite at the Chandler Mills mine is likewise a tabular body, but it is irregular. The hanging wall is sharply rolling in places, angular in other places. The footwall was exposed in 1943 at the north base of the dumps and was reached in both the east and west ends of the main pit. As indicated in section CC′ (pl. 41), it is likewise sharply rolling. The general dip of the pegmatite is southeast. The pegmatite is propably the southward extension of the pegmatite of the Smith mine, which it resembles closely in mineralogy.

The wall rock is quartz-mica schist of the Littleton formation containing beds rich in sillimanite or staurolite, or both. Bedding and foliation are essentially parallel. Large lenses of quartz are present in places in the schist. The pegmatite body in general is parallel to the foliation, although in places the contacts transect sharply. The schists for a few inches to a few feet from the contacts show various degrees of enrichment in tourmaline, muscovite, and albite. Where enrichment is greatest, the product is a tourmaline-bearing albite-quartz granulite containing only vestiges of the original schistosity. The pegmatite likewise contains many xenoliths of wall rock in various stages of replacement and digestion as noted by Chapman.

The structure of the pegmatite is extraordinarily complex and, despite repeated visits by the writers, has not been fully determined. Over most of the area of the main pit at the G. F. Smith mine, the structure is as shown in section AA′ (pl. 41), and the pegmatite consists of the following units in order from the walls inward:

1. Border zone, 1 to 6 inches thick, composed of fine-grained quartz and muscovite with small quantities of albite.
2. Sheet mica-bearing zone, 1 to 2 feet thick, composed of medium- to coarse-grained plagioclase-muscovite-quartz pegmatite with accessory large schorl crystals. Rum mica books up to 18 by 18 by 8 inches. This zone was continuous over the area of the main pit and was rich in muscovite, but it is lean and apparently discontinuous along the footwall.
3. First intermediate zone, 6 inches to 18 inches thick, composed of medium-grained plagioclase and quartz with subordinate scrap muscovite and accessory tourmaline.
4. Second intermediate zone, 1 to 2 feet thick, similar in composition to the wall zone. This zone, so far as known, was found only along the hanging wall side of the pegmatite.
5. Probable core, consisting of medium- to coarse-grained pegmatite similar to the first intermediate zone but richer in quartz and containing scattered masses, up to 10 inches in maximum diameter, of triphylite intergrown with pyrrhotite and chalcopyrite, and scattered crystals of beryl up to 8 inches long and 4 inches in diameter. Where the mica-bearing second intermediate zone is absent, the apparent core is virtually indistinguishable from the first intermediate zone and could not be mapped separately. Both zones contain numerous zenoliths in various stages of conversion to albite-quartz granulite.

The most recent mining has disclosed a body of quartz, 2 to 6 feet thick and 18 feet long in the center of the pegmatite, in the position normally occupied by unit 5 described above. The first and second intermediate zones appear to extend completely around this quartz body, which therefore has the normal relationships of a core. By analogy to other pegmatites having discontinuous cores, it seems probable that the apparent incongruity is caused by asymmetric zone development plus lateral variations in core composition. The structure is further complicated by variations in lithology due to assimilation of xenoliths.

In December 1943, mining disclosed a quartz body cutting obliquely across the center and upper zones of the pegmatite. Where the margin transected books of rum muscovite, selvages of light green wedge mica were developed on the books.

At the Chandler Mills mine, the pegmatite shows a structural complexity which is unrivalled in any other mine studied in New Hampshire. The units present are the same as those at the G. F. Smith mine, but none is persistent. The wall mica zone is present along both walls, but it is discontinuous and shows a wide range in book-mica content. Inside this zone the pegmatite consists largely of quartz and plagioclase (cleavelandite in part), with scattered books of muscovite, and areas rich in triphylite crystals, tourmaline, or beryl. The core of the pegmatite consists of coarse quartz and perthite. Part of the largest segment is shown on the map, but it extends eastward into the filled pit and appears likewise to have been represented by small pods scattered along the center of the pegmatite down dip.

Between the core and the plagioclase-quartz unit, which seems to correspond to the first intermediate zone at the G. F. Smith mine, other units composed of plagioclase and quartz in various proportions have been exposed from time to time. The most important of these were incomplete sheet-mica bearing zones, apparently related (pl. 41, sec. BB′) to the core. None of these units were persistent, however, and their interrelations are far from clear. Pods of quartz, plagioclase, and sheet-bearing rum muscovite were encountered in places. In July 1943, a vein of quartz, plagioclase, and book muscovite was exposed cutting the pegmatite in the eastern part of the pit.

In October 1943, small bodies of quartz, with margins rich in light green wedge muscovite, were exposed. The bodies transected the upper part of the pegmatite obliquely. In part this green wedge mica occurred as selvages on books of flat rum transected by the quartz bodies.

Rosettes of cleavelandite and associated fine-grained green mica appear to be minerals formed by replacement of quartz in the core. Locally, pseudomorphs of albite and green muscovite have formed after perthite.

Mica from the mine is of two kinds—flat, rum, sheet-bearing books, and light green wedge mica. The latter is suitable only for scrap. The books of rum mica show ruling along one to three directions, and in most books sheet was confined to parts lying between widely spaced rulings. Reeves, tanglesheet, warping, and cross-fractures are other defects. Magnetite inclusions are present in some books, and rust stain is prominent at the G. F. Smith mine. Despite these defects, however, about 2 percent of sheet of high quality was obtained from crude mica at both mines. Cobbing was practiced at both mines, and obvious mine scrap was shipped separately. The recovery of crude mica from rock moved was about 4.5 percent at the Chandler Mills mine, 5.5 percent at the G. F. Smith mine.

Beryl from the mines is light yellow or golden, opaque, and massive or intergrown with albite and quartz. The crystals range from 1 by 1 by 1 inch to 12 by 8 by 8 inches. The surface of the southeast dump at the Chandler Mills mine showed about 0.12 percent beryl in October 1943, but examination of the cuts indicated that a beryl-rich pod had recently been mined and that the average for the entire pegmatite would be far below this figure.

The G. F. Smith mine has yielded mica from two zones near the hanging wall. The zones extend beyond the present workings. The wall zone apparently is continuous along the hanging wall, but the intermediate book-mica bearing zone has been found to be discontinuous, and during the latest operations the average yield of crude mica from rock mined was declining. Further operations probably would be confined to the part of the pegmatite lying down dip from the northeast, flooded part of the cut. As far as known there has been no inflow of water from the river, although the bottom is below river level. Operations along the strike of the pegmatite north of the main pit, however, would be hazardous. The content of the mica zones southward and southeastward from the main opencut does not appear high enough to repay mining. It is doubtful, in view of the low percentage of sheet recovered, whether underground mining could profitably be undertaken, even under conditions similar to those of 1943–44.

The Chandler Mills mine is difficult to appraise. Mining has disclosed no persistent concentration of mica, but the average yield from the numerous small concentrations found has been satisfactory. Under conditions comparable to those of 1943–44, the mine might well be operated profitably as long as opencut mining is feasible. It is doubtful, however, whether it would repay the underground mining which will ultimately be necessary because of the gentle dip of the pegmatite.

YUHAS NO. 1 FELDSPAR MINE

The Yuhas No. 1 mine (pl. 2, no. 2) is in the town of Acworth, 2.2 miles N. 56° E. of Alstead village. To reach it from Alstead follow Highways 123 and

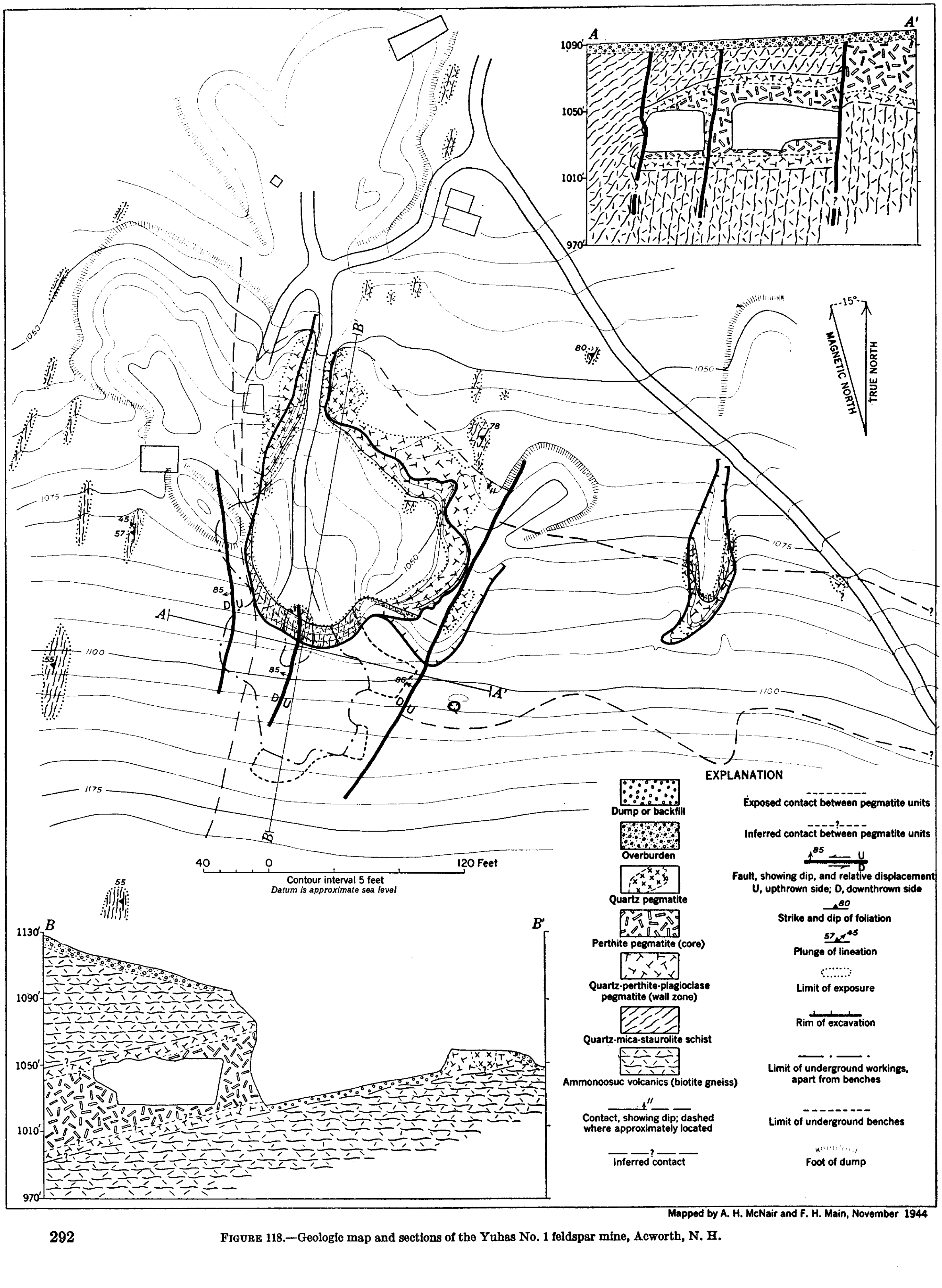


FIGURE 118.—Geologic map and sections of the Yuhas No. 1 feldspar mine, Acworth, N. H.

123A northward 3.1 miles to the Yuhas farm; turn right before crossing the Cold River Bridge; proceed 1.1 miles over a steep, graded woods road to the mine.

Mineral rights are owned by Mrs. Elizabeth Yuhas, Acworth, N. H. and are leased by Cold River Minerals, Inc., of Bellows Falls, Vt. The mine was opened in 1927 by the American Mineral Products Co. of Hartford, Conn., who shipped feldspar to the Eureka Flint & Spar Co., Trenton, N. J. It was subsequently worked by the American Minerals Co. and the Seaboard Minerals Co., both of New York City, who ceased operations in 1942. Cold River Minerals, Inc., began work in August 1944.

An opencut (fig. 118) 140 feet long, 115 feet wide, and 12 to 65 feet deep, and underground workings that were 100 feet long, 85 feet wide, and 20 to 30 feet high, and extended southward from the floor of the cut, had been made prior to November 1944. Another cut 110 feet long, 32 feet wide and 2 to 17 feet deep lies 135 feet east of the larger cut.

During early operations a derrick, loading bin, a track, and cars were used for the removal of broken rock. The present operators constructed a truck road into the opencut and underground chambers, by way of an old crosscut trench. Underground mining is done by raises and benches. The feldspar is trucked to a grinding mill at Cold River, N. H. The mine was mapped by A. H. McNair and F. H. Main in November 1944.

The pegmatite is poorly exposed except in the walls of the cuts and workings. It has an inferred length of 530 feet, an outcrop width of about 100 feet, and a maximum thickness of 50 to 70 feet. The body is lenticular, strikes east, and dips 11° to 21° S. It is nearly uniform in thickness throughout its length, and ends west of the cut in a rounded termination that apparently extends S. 20° E. beyond the underground workings. The distribution of pegmatite boulders on the surface suggests a similar, but more abruptly rounded termination at the east end of the body. The pegmatite is discordant to the foliation of the wall rock.

The wall rock consists of quartz-mica staurolite schist and feldspathic biotite gneiss of the Ammonoosuc volcanics. The schists cropping out west of the cut contains minute crumples together with an obscure lineation that plunges 45° NW. The biotite-gneiss is light to dark gray and is laminated. It is silicified and pyritized near the contact and is darker, especially on weathered surfaces, than at a distance from the contact. Its foliation, in general, strikes N. 5° to 30° E. and dips 65 to 85° NW. An abrupt change in dip near the pegmatite contacts suggests that the pegmatite was emplaced along a shear zone.

The pegmatite is complexly faulted and sheared. The most pronounced set of shear surfaces in general strikes N. 30° E. and dips 80 to 85° W. Three conspicuous faults belonging to this set of shears are exposed in the underground workings. The western fault, exposed at two places along the west face of the workings, has an irregular westward dip. It cuts across the rounded western termination of the dike. Displacement along it is sufficient to bring wall rock on its western side down so that it can be observed in two "windows" broken through the shear zone. The pegmatite within 1 to 2 feet of the zone is finely brecciated and discolored red and green. A second fault passes through the western part of the pillar at the entrance of the underground workings, and through the west wall of the working south of the pillar. Movement along this fault was not more than a few inches. The third fault is exposed at the face of the northeast bench and in the upper corner of the southeast bench. It strikes N. 30° E. and dips 86° W., and has a minimum throw of 18 feet. All of the faults of the set of shears are normal faults.

A second set of shears, less conspicuous and showing less displacement than the first, strikes N. 78° W. and has an almost vertical dip. This set has been utilized in past operations to form the faces of the walls in the eastern drifts and to aid in breaking rock. Smaller shears and fractures having various strikes and dips occur between the master sets.

The pegmatite consists of perthite, quartz, plagioclase, scrap muscovite, and garnet. Two zones can be recognized in the cut and underground workings. The wall zone contains quartz, perthite, and plagioclase. It is 5 to 15 feet thick and lies adjacent to the wall rock. The zone contains masses of white and gray quartz, the largest of which is shown on the map, and scattered "nests" of scrap muscovite. It has a sharp contact with the wall rock and gradational contact with the inner zone. The inner zone, or core, is about 30 feet thick in the vicinity of the workings. It contains brecciated masses of perthite, with minor gray quartz and scrap mica. Feldspar obtained from the mine is taken from the core. Mining in the past has been limited to the core, as the marginal zone contains a higher percentage of quartz. A chemical analysis of the feldspar from the core, furnished by Mr. Paul H. Spiers, president of Cold River Minerals, is as follows:

Silica	68. 1
Alumina	18. 7
Iron	. 05
Calcium	. 2
Potash	7. 3
Soda	5. 4
	99. 75

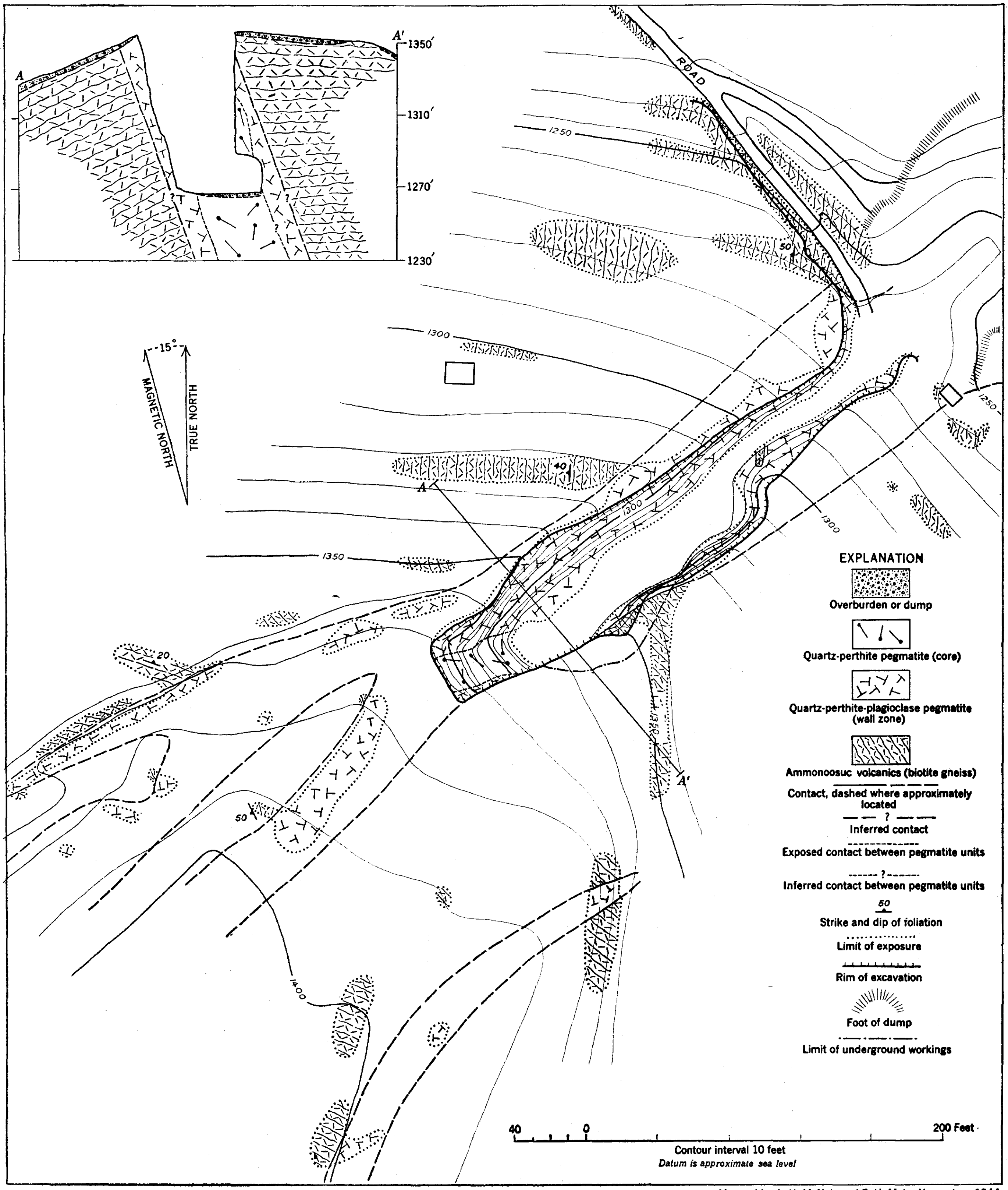


FIGURE 119.—Geologic map and section of the Yuhas No. 2 feldspar mine, Acworth, N. H.

The feldspar in the pegmatite is complexly fractured, brecciated, and somewhat altered as a result of shearing. Specimens showing fresh cleavage faces, even from areas between shears and joints, are rare.

The pegmatite in the smaller opencut and the boulders on the surface east of the large cut are composed of quartz-perthite pegmatite. The feldspar does not appear to be of high quality. A large tonnage of feldspar (of the grade recovered in past operations) probably can be removed from the mine, however, if the core persists down dip and eastward from the present workings.

YUHAS NO. 2 FELDSPAR MINE

The Yuhas No. 2 mine is 2.2 miles N. 62° E. of Alstead village. To reach it from Alstead, follow Routes 123 and 123A northeastward 3.1 miles to the Yuhas farm, turn right and proceed 1.3 miles over a steep graded road to the mine.

Mineral rights are owned by Mrs. Elizabeth Yuhas, Acworth, N. H., and are leased by Cold River Minerals, Inc., of Bellows Falls, Vt. The mine was opened in 1927 by the American Mineral Products Co. of Hartford, Conn., and was worked subsequently by Seaboard Minerals Co. of New York. An opencut (fig. 119) 310 feet long, 20 to 50 feet wide and 10 to 90 feet deep was made prior to 1944. Operations by Cold River Minerals began in August 1944, when a truck road was built to the floor of the cut. The mine was mapped by A. H. McNair and F. H. Main in November 1944.

The Yuhas No. 2 pegmatite is at least 550 feet long and is 30 to at least 80 feet wide. It strikes N. 55° E. and dips 60° to 80° SE. The pegmatite bifurcates 40 feet west of the rim of the opencut. Each fork extends westward at least 180 feet. The northern fork bifurcates in turn 150 feet west of the opencut, and a narrow offshoot extends westward, nearly parallel to the cut for approximately 100 feet. The pegmatite is discordant to the foliation of the wall rock.

The wall rock is biotite gneiss of the Ammonoosuc volcanics having a prominent layering. It strikes in general, N. 10° E. and dips 40° to 50° NW. West of the opencut scattered outcrops show strikes ranging from N. 28° to 80° W. and dips that range from 50° W. to 20° NE. Adjacent to the contact the gneiss is crumpled and has a zone 4 inches thick or less that is partly replaced by pegmatite.

The border zone of the pegmatite is commonly 4 inches or less thich and grades into partly replaced wall rock. It contains fine-grained plagioclase, quartz, tourmaline and iron sulfides. The wall zone consists of quartz, perthite, plagioclase, and scrap muscovite and is much coarser grained than the border zone. It is 5 to 25 feet thick and seems to be thicker near the footwall than near the hanging wall. The zone grades into the innermost zone or core.

The core consists of large blocky masses of salmon-colored perthite as much as 4 by 4 by 6 feet, gray quartz, much of it in masses between perthite blocks, irregular areas of graphic granite, and small irregular aggregates of white platy albite. The zone ranges from 10 to 40 feet in thickness and seems to be thickest and most sharply defined in the lower two thirds of the opencut. The commercial feldspar is obtained from the core. The narrow opencut in the pegmatites is restricted to the central part of the body, and the walls of the cut are made up of the wall zone.

A chemical analysis of feldspar from the core, furnished by Mr. Paul Spiers of the Cold River Co., is as follows:

Silica	66.6
Alumina	18.2
Iron	.03
Calcium	.11
Potash	12.2
Soda	2.6
	99.74

A second, smaller pegmatite outcrops 120 feet southeast of the face of the cut, and is approximately parallel to the main pegmatite. It is 35 feet wide and can be traced by scattered outcrops for several hundred feet. It contains quartz, perthite, and plagioclase. Its composition and internal structure cannot be determined from the few outcrops available for study.

In the main pegmatite, no relatively rich perthite core can be identified in exposures west of the opencut. The core is not sharply defined in the upper part of the opencut, hence it is possible that perthite-rich material underlies the exposures west of the cut. The pegmatite bifurcates 40 feet west of the rim of the opencut, and each branch is considerably thinner than the pegmatite in the cut. If a core is present in one or both branches, it would probably occupy a narrow space between the wall zones. It seems, therefore, that the largest reserves of feldspar are below the floor of the present cut.

VERMONT

RUTLAND COUNTY

ALLEN MICA PROSPECT

The Allen prospect lies in the town of Sherburne 3.8 miles N. 40° W. of Sherburne village. From Sherburne follow U. S. Route 4 west for 2.0 miles to a junction with Vermont Route 100; follow Route 100 north 2.5 miles to an obscure road leading northeast to an abandoned barn; walk 300 yards northwest to the prospect.

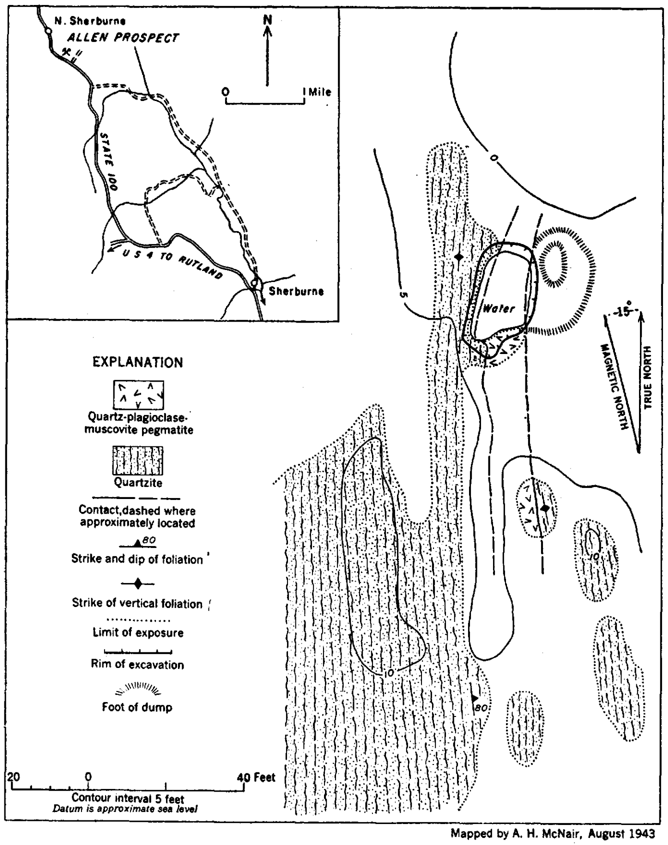


FIGURE 120.—Geologic map of the Allen mica prospect, Sherburne, Vt.

Mineral rights are owned by Charles Allen of Sherburne. A small opencut about 27 feet long, 16 feet wide, and 5 feet deep was made before 1942. During the summer of 1943 the property was leased to John B. Davenport, 825 Emerson Avenue, Elizabeth, N. J. The cut was pumped and a small amount of prospecting work was done. A tape and compass survey of the vicinity of the cut was made by A. H. McNair in August 1943 (fig. 120).

The Allen pegmatite can be traced for 75 feet. It is about 10 feet wide, strikes roughly north and has an almost vertical dip. It is parallel to the foliation of the wall rock, a micaceous quartzite. The pegmatite consists of granular gray quartz, albite, silver-white muscovite, black tourmaline, and minute flakes of chlorite and graphite. In the two places in which it is exposed it is intensely brecciated. The northern outcrop at the south end of the cut is similar but contains larger mica books than those in the southern outcrop. Some are 6 by 8 by 2 inches, but they are crumpled and ruled. None of the books seen would yield sheet mica.

The deposit is interesting geologically owing to its remoteness from other known pegmatites. Prospecting in 1942 did not reveal muscovite of good quality. The low sheet content and poor quality of the mica appear to be due to deformation after development of the pegmatite.

CONNECTICUT

FAIRFIELD COUNTY

BRANCHVILLE MICA MINE

The Branchville mica mine lies in the town of Redding, 550 feet N. 48° E. of the railroad station in Branchville village. To reach the village from White Plains, N. Y., travel 22 miles eastward on the Merritt Parkway to Route U. S. 7, then 9 miles northward on Route 7 to Branchville. The railroad station lies on the eastern side of the highway on the Housatonic Branch of the New York, New Haven & Hartford Railroad.

The locality is famous for its rare minerals, particularly manganese phosphates. Nine minerals were first described from Branchville. Detailed studies of some of the minerals in the pegmatite have been made by Boltwood (1907, p. 78–88), Brush and Dana (1878, p. 33–46; 1879a, p. 359–368; 1879b, p. 45–50; 1880, p. 257–285; 1890, p. 201–216), Comstock (1880, p. 220–222), Hawes (1881, p. 203–209), Hillebrand (1890, p. 384–394; 1891, p. 64); Osborne (1885, p. 336), Penfield (1883, p. 176), and Penfield and Pratt (p. 387–390). An account of its internal structure and paragenesis has been published by Shainin (1946, p. 329–345, 598–599).

The property is owned by David Schornick of Branchville. The first excavation was made in 1876 by A. N. Fillow of Branchville, who quarried the pegmatite for mica, abandoning it before 1878. G. B. Brush and E. S. Dana, of Yale University, mined the pegmatite in 1878 and 1879 with funds furnished by Yale. The Union Porcelain Works of Greenpoint, N. Y., bought the property in 1880 and operated it for feldspar and quartz until at least 1890. The Bridgeport Wood Finishing Co. is reported to have operated it for quartz and feldspar prior to 1920. Fred and Josephh Burrone and Carlo Rusconi, all of North Branford, operated the mine for mica from September 1943 to November 1944. The Sandy Ridge Mica & Mining Co., Inc., 927 15th Street NW., Washington, D. C., worked the mine in November and December 1944.

The main working (pl. 42) is an opencut 240 feet long, 50 to 85 feet wide and 60 feet in maximum depth. A crosscut 20 feet long has been driven into the north wall of the cut, and from this one drift extends 75 feet northwest and another 57 feet southeast. Both opencut and drifts are partly backfilled. About 2,300 tons of rock was moved between September 1943 and December 1944.

The mine was studied in November 1943 by E. N. Cameron and V. E. Shainin, and detailed studies were made at monthly intervals by Shainin during 1944. It was restudied in September 1944 by Shainin, K. S. Adams, and F. H. Main. George Switzer and Harry Mikami, of the Connecticut Natural History and Geological Survey, generously assisted in the laboratory determination of rocks and minerals from the locality.

Geologic relationships.—The pegmatite is probably a tabular body, but only its hanging wall is exposed. It is at least 200 feet long and at least 40 feet thick. The hanging wall strikes N. 60° W. and has an average dip of 45° NE. The strike length of the body is uncertain, but the internal structure of the pegmatite, the presence of country rock outcrops to the southeast on strike with the body, and the lack of outcrops of the pegmatite outside of the workings all suggest that it either terminates or plunges beneath country rock in both directions from the quarry. The pegmatite probably terminated up dip a short distance above the quarry.

The country rock is a medium-grained (2 to 4 mm) dark brownish-green amphibolite composed of hornblende, biotite, and plagioclase, with accessory sphene and ilmenite. The rock was mapped by Gregory and Robinson (1906, p. 84) as part of the Danbury granodiorite. The amphibolite contains a few small, angular inclusions of fine-grained (0.2 to 0.3 mm) gneiss composed of plagioclase, biotite and quartz. In the northwestern corner of the quarry a granite dike, 10 feet thick, cuts the amphibolite and in turn is cut by the pegmatite. The granite is a gray, medium-grained, gneissoid biotite-muscovite granite, containing accessory apatite, magnetite and zircon. Numerous small angular zenoliths of amphibolite occur in the dike. According to Agar (1934, p. 373) this and other granite dikes in the vicinity are part of the Thomaston granite, which is probably Late Ordovician in age. The western margin of a stock of Thomaston granite lies 500 feet northeast of the mine. The stock outcrops over an area 3½ miles long and 1½ miles wide and probably is the intrusive from which the Branchville pegmatite was derived. Shaub (1938, p. 339) averaged 5 analyses of uraninite from the pegmatite and concluded that the age of the mineral is 368 million years, or probably Late Ordovician.

Composition and internal structure.—The pegmatite is composed chiefly of quartz and cleavelandite with subordinate muscovite. It has a striking internal structure. The following units are found successively inward from the wall: quartz-oligoclase zone, muscovite-quartz zone, cleavelandite-quartz unit, cleavelandite unit, cleavelandite-spodumene unit and quartz core.

The quartz-oligoclase zone, the border zone of the pegmatite, is 2 to 6 inches thick and is composed of grains of quartz and oligoclase (An_{14}) ¼ inch across with subordinate muscovite and accessory green apatite, green tourmaline, hornblende and biotite. Calcite is a minor constituent. In some places the zone consists largely of quartz, and oligoclase is lacking; in others, oligoclase is the predominant mineral. Hornblende and biotite occur in the upper part of the zone but are visible only in thin section. They were probably derived from the amphibolite. Calcite occurs in narrow veins, mostly along the contact with amphibolite.

The sheet-mica bearing wall zone is 1 to 2½ feet thick, and averages 1½ feet thick. It is composed of muscovite, quartz, and cleavelandite (An_{5-6}), with minor apatite, pyrite, tourmaline and fluorite. Muscovite constitutes 30 to 60 percent of the zone and occurs in deep rum books oriented with cleavages roughly perpendicular to the hanging wall. The books, easily broken from their matrix, range from 1 to 24 inches in diameter and ⅛ to 12 inches in thickness. Most of the books are about 5 inches in diameter and 1 inch thick. Ruling is a common defect. Cross fracturing, "A" structure and reeves are present in some books. Most of the mica is hard and free-splitting.

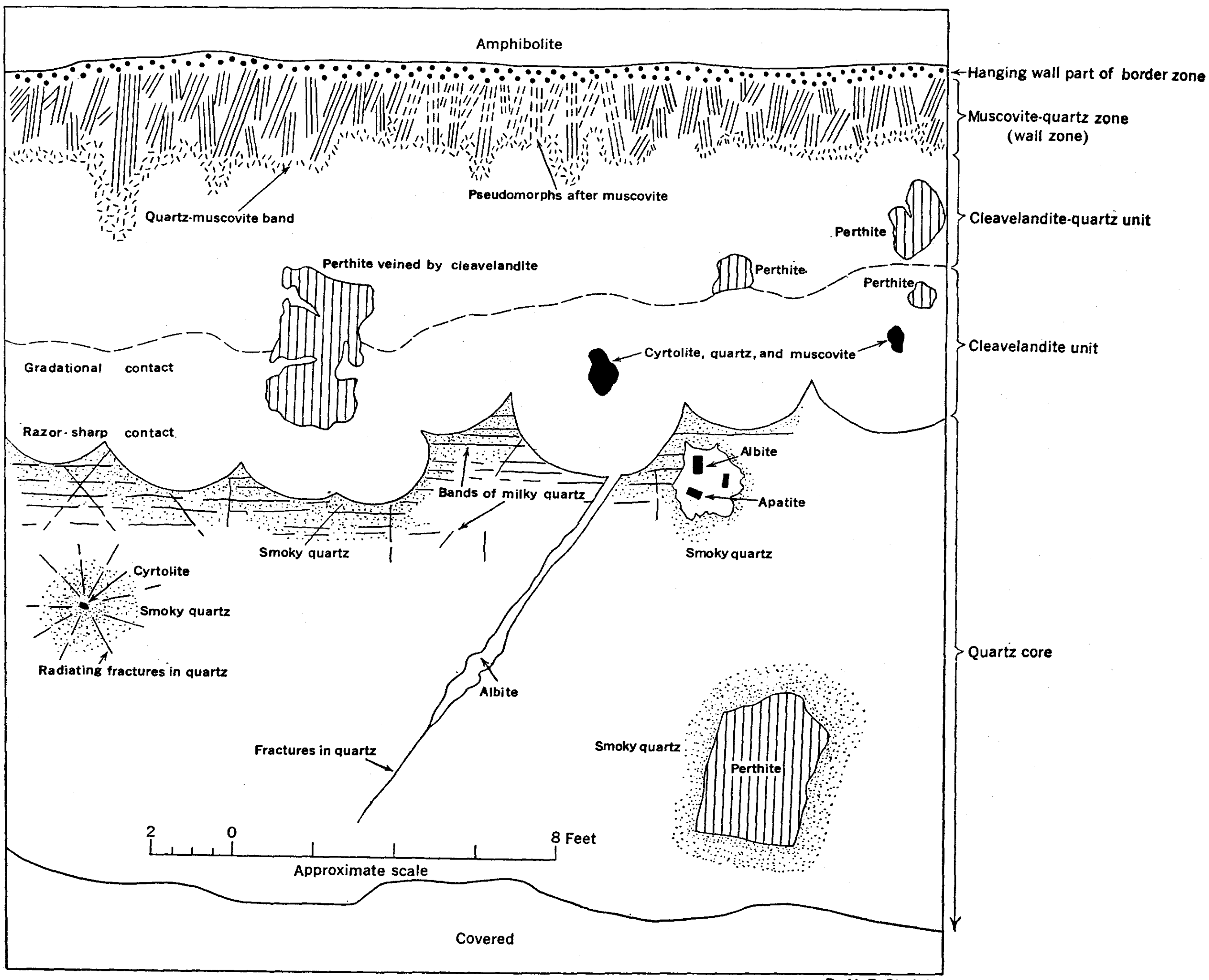
About 15 percent of the muscovite visible in the wall zone in December 1944 had been metasomatically replaced by material too fine grained to identify in thin section, but which appears to be albite (An_5) and quartz. Perfect pseudomorphs after muscovite have been formed. The replacement was limited to certain parts of the zone; these are irregular in outline and appear distributed without relation to the original structural or mineralogical features of the zone. Within these parts practically all the muscovite adjacent to the wall rock contact, including that in the border zone, has been replaced, but mica in the inner one-third or one-fourth of the wall zone is mostly unaffected. Large books that extend across the full thickness of the zone grade from unaltered muscovite in the inner part to pseudomorphs in the outer part.

Although the footwall of the pegmatite is not visible the wall-zone may be present along it. The evidence for this is found around two large bodies of amphibolite that are probably xenoliths in the pegmatite (pl. 42 sec. B–B′). Studies of other pegmatites in Connecticut have suggested that a xenolith bounded on its lower surface by a mica-bearing zone indicates the presence of a similar zone on the hanging wall of the pegmatite. Likewise, a xenolith bounded on both surfaces by a mica-bearing zone may indicate the presence of a similar zone along both walls of the pegmatite. At Branchville, a mica-bearing zone is present on both upper and lower surfaces of the amphibolite bodies; hence it seems likely that a mica-bearing wall zone is present along the footwall.

The cleavelandite-quartz unit has an average thickness of 3 feet. Its essential minerals are cleavelandite and quartz with subordinate muscovite. Accessories are perthite and garnet. The cleavelandite is mostly white, fine-grained, dense and lamellar, and occur in laths ⅛ to ¼ inch long. Muscovite occurs in pale books ½ to 1 inch in diameter, a very few of which are concentrically curved. Perthite occurs in scattered anhedral crystals 1 to 5 feet long that range from grayish white to light buff-brown. A crystal 3 feet long lies partly in the cleavelandite unit. The crystal is veined throughout its length by minerals of both units (cleavelandite, quartz, garnet and muscovite). This crystal, and other crystals of microcline-perthite in the cleavelandite-quartz and cleavelandite units, appear to be unreplaced parts of a pre-existing perthite zone.

Cavities ½ to 4 inches in diameter occur in the cleavelandite-quartz unit. Superposition of one mineral on the crystal faces of another is a common feature in these cavities. Albite (An_3) is found in most of the cavities and usually forms the lining on which the following minerals have grown: perthite, quartz, muscovite, apatite, calcite, and pyrite.

The cleavelandite unit is discontinuous. It has an average thickness of 2 to 2½ feet. It is composed of cleavelandite, with subordinate muscovite, cyrtolite, quartz, and biotite. Apatite, garnet, perthite, columbite-tantalite, autunite, and torbernite are accessory minerals. The unit has an unusual structure, for it consists of laterally coelescing hemispheres that have an average radius of 1 to 1½ feet (fig. 121). The outer



By V. E. Shainin

FIGURE 121.—Diagram illustrating relationships of zones at the Branchville mica mine, Redding, Conn. Scale of small features is slightly exaggerated.

margin of the unit grades indistinctly into the cleavelandite-quartz unit, whereas the inner margin has a very sharp contact with the quartz core. Each hemisphere in the cleavelandite zone may be considered a structural unit. In each hemisphere four minerals commonly occur in succession from the center outward: cyrtolite, quartz, biotite, and muscovite.

The cleavelandite-spodumene unit is exposed only in the southwestern corner of the opencut, where it is probably 2 to 6 feet thick. Because exposures are lacking, much of its structure must be inferred. It seems to lie adjacent to the core and to be limited in general to the crest of the core. Nowhere is it exposed in contact with the cleavelandite unit. The cleavelandite-spodumene unit is composed of cleavelandite with subordinate spodumene muscovite and quartz. Accessories are eucryptite, garnet, perthite, columbite-tantalite, lithiophilite, manganapatite, uraninite, autunite, and torbernite.

Beryl was not observed in the pegmatite, although it occurs on the dump and as specimens in many museums. Most of the specimens are aggregates of columnar green prisms, and some are 2 feet long. One specimen of beryl (Peabody Museum, No. 8261) is associated with cleavelandite sheaves growing outward from a spodumene crystal, and this feature suggests that it occurs in the cleavelandite-spodumene unit.

Spodumene occurs in scattered crystals in a matrix of cleavelandite. About 40 percent is unaltered; the remainder is altered in various degrees. The alteration products have been described in detail by Brush and Dana (1880, p. 257–285). Those least altered have been metasomatically replaced, in part, by very fine-grained albite and eucryptite. Further alteration has led to formation of "cymatolite", a mixture of fine-grained albite and muscovite.

The manganese phosphates, of which lithiophilite is the most common, occur in rare, scattered concentrations within the cleavelandite-spodumene unit. There are two kinds of concentrations: (1) those in which lithiophilite and manganapatite are the sole manganese phosphates, and (2) those in which three or more phosphate minerals are present. Yellowish-brown lithiophilite occurs in isolated ellipsoidal nodules ranging from ¼ inch to more than 1 foot in length. The nodules are invariably coated with bluish-black manganese oxide.

The core of the pegmatite is poorly exposed but probably ranges from 20 to 35 feet thick. Only its irregular but sharp upper contact is exposed. Coarsely crystalline quartz comprises more than 95 percent of the visible parts of the core. Other minerals are, in order of abundance, spodumene, albite, perthite, apatite, cyrtolite, muscovite and garnet. The quartz is predominately milky, but smoky quartz occurs in places in a 6-inch to 1-foot band adjacent to the cleavelandite unit. The band grades imperceptibly into milky quartz. Smoky quartz also occurs in halos, 8 to 12 inches wide, surrounding crystals of perthite and cyrtolite and masses of albite.

Spodumene occurs in diversely oriented isolated crystals similar in habit and size to those of the cleavelandite-spodumene unit. Many crystals have one or both sides covered by a 1-inch layer of white cleavelandite plates arranged in sheaves radiating from the spodumene.

Cleavelandite occurs in the core as irregular aggregates of small subhedral crystals and as veins ⅛ to ¼ inch wide and as much as 6 feet long. The veins are composed of very fine grained dense cleavelandite that fills fractures and locally has replaced the walls of the fractures. One vein was observed to blend into the cleavelandite unit. A very few subhedral crystals of perthite, 3 to 4 feet long, occur within 10 feet of the margins of the core.

Crystalline cyrtolite aggregates, similar to those in the cleavelandite unit, occur close to the margins of the core. The aggregates are completely surrounded by halos of smoky quartz about 2 feet in diameter. Conspicuous fractures in the quartz radiate outward in all directions from the cyrtolite nuclei. The zone of fracturing coincides roughly with the extent of the halo. A similar occurrence has been described from the Baringer Hill, Tex., pegmatite (Landes, 1932, p. 381–390), where rare-earth minerals occur in massive quartz which is radially shattered, forming "stars" 8 to 10 feet in diameter. Hidden (1905, p. 427) found that the "stars" at Baringer Hill served as guides to thorium, uranium, or zirconium minerals at their centers. Hess and Wells (1930, p. 21) believed that the growth of the mineral at the center "took place faster than the older mineral is replaced, breaking the rock radially", and Landes (p. 390) has concurred in this opinion.

Origin.—The origin of the Branchville pegmatite is discussed fully in a paper by Shainin (1946, p. 329–345), and only a brief summary is given in the present report. Three stages in the formation of the pegmatite are postulated: a first stage during which the zones developed, a second stage characterized by partial replacement of the zones, and a third stage of supergene alteration. There is no evidence at Branchville to indicate the order in which the zones were formed. However, their relationships to the cleavelandite-quartz, cleavelandite, and cleavelandite-spodumene units indicate that the zones developed at an earlier stage, and as there is no evidence that the zones were developed at the expense of pre-existing massive pegmatite, zone development appears to represent the first stage in the development of the pegmatite as a whole. During the first stage there may have been some replacement of earlier-formed minerals by those later in the sequence. The evidence suggests that near the end of, or after, the first stage, hydrothermal solutions altered the zones, particularly those with abundant minerals, such as perthite, that were susceptible to replacement. The cleavelandite-quartz, cleavelandite, and cleavelandite-spodumene units are believed to have formed during this stage. The units developed along interzonal contacts because these places provided favorable conditions. Some solutions followed the contact of the pegmatite with wall rock, hence parts of the border and wall zones were replaced. The third stage consisted of supergene alteration of primary minerals. Manganese oxide and, possibly, purpurite were formed from lithiophilite, and pyrite was altered to limonite.

In both the first and second stages, plagioclase grew progressively more sodic. Indices of refraction, determined by the single variation method, indicate anorthite contents as follows: border zone, An_{14}; muscovite-quartz zone, An_{5-6}; cleavelandite-quartz unit, An_3; cleavelandite unit An_3; crystals in cavities in the cleavelandite-quartz unit, An_{2-3}. There was no detectable difference between specimens from the zone or unit collected over a distance of almost 200 feet along the strike.

Conclusions.—There is no indication that the sheet-mica-bearing zone ends either down dip or along strike. The zone probably adjoins the footwall of the pegmatite as well as the hanging wall. However, the replacement of muscovite in the zone should be studied carefully during future operations for mica to determine if the distribution of replaced parts is influenced by geological factors. The quartz core probably extends down dip, and several thousand tons of quartz separable by hand may be available. There is nothing to indicate a deposit of potash feldspar down the dip. However, if the crest of the core is present beneath deep backfill in the southeastern end of the quarry, some feldspar may lie directly above the crest. A small reserve of spodumene is present in the pegmatite, but most of it is in crystals that are partly altered and so small that hand cobbing would be difficult. The abundance of beryl, columbite-tantalite, uraninite and other rare minerals of economic importance could not be determined because the pegmatite is insufficiently exposed. However, it is unlikely that the pegmatite contains sufficient quantities of any of these minerals to warrant commercial exploitation for them alone. One or more may be recovered as minor byproducts from operations not confined to the wall zone.

HARTFORD COUNTY

HOLLISTER MICA-BERYL PROSPECT

The Hollister prospect lies in the town of Glastonbury, 5.0 miles N. 22° E. of the center of Portland village. The prospect can be reached from Portland by traveling northward on State Highway 17 to its intersection with a poorly graded dirt and gravel road 0.35 mile N. of the Glastonbury-Portland town line. Follow this road 1.2 miles eastward to the property.

The prospect is on a tract of 30 acres owned by Dino L. Bertolini, 815 State Street, New Haven, Conn. The property is said to have been worked briefly for feldspar about 1930. It was prospected for feldspar and mica for several months in the spring of 1943 by Fausto Bertolini, 815 State Street, New Haven. The property was mapped by E. N. Cameron and V. E. Shainin in March 1943 (fig. 122). At that time the workings consisted of seven small excavations. The northernmost and largest was an opencut 65 feet long, 20 feet wide and 15 feet in maximum depth.

Three pegmatites, each striking due north, are shown on figure 122, but the northern pegmatite may be connected with either the southernmost or the middle pegmatite. The wallrock is Monson gneiss, the foliation of which strikes northward and dips gently westward.

Northern pegmatite.—The northern pegmatite, exposed for about 240 feet along strike, has an outcrop width of about 25 feet. The pegmatite probably dips steeply eastward. The pegmatite is roughly parallel to the strike of the wallrock foliation but differs markedly in dip. The bulk of the pegmatite consists of medium- to coarse-grained quartz, perthite, graphic granite, plagioclase, in various proportions, with subordinate muscovite and accessory garnet, tourmaline, beryl, and columbite-tantalite. In the south pits, this material seems to enclose small pods consisting of coarse perthite, quartz, graphic granite, and muscovite, with minor plagioclase, scattered crystals of beryl, and tourmaline, and traces of columbite, tantalite. In the quarry at the north end of the area mapped, a border zone 18 inches thick, consisting essentially of fine- to medium-grained quartz and plagioclase, lies along the west wall.

Near the east end of the headwall of the quarry and along the east wall, the pegmatite is cut by a tabular fracture-controlled replacement body, 4 inches to 2 feet thick. This body strikes N. 2° W. and dips 69° E., and extends across the headwall from top to bottom and northward along the base of the east wall to a point about 20 feet from the headwall, where it passes under overburden. It consists of book muscovite, plagioclase, and quartz. The east margin of the body is even, nearly straight, the west margin is highly irregular, as it is defined by the outer ends of muscovite books that project various distances into the adjacent pegmatite. The books are mostly arranged with cleavages perpendicular to the walls of the body or nearly so. In the overlying pegmatite a faint layering parallel to the fracture-controlled body is visible owing to alignment of small garnet crystals in discontinuous streaks. The garnet is associated with sugary plagioclase, quartz, and small muscovite crystals, and the whole group of minerals appears to have formed by replacement of the perthite-plagioclase-quartz pegmatite.

In the headwall of the quarry the pegmatite is cut by a reverse fault that strikes N. 17° E. and dips 20° to 33° W. The apparent displacement along it is not more than a few feet. It is marked by a crush zone filled with gouge and fragments of pegmatite.

Muscovite books from the northern pegmatite range from 2 inches to more than 1 foot in diameter, and from ¼ inch to 4 inches in thickness. Most of the books are hard, and free splitting, but they are marred by ruling, cross fracturing, and, less commonly, by "A" structure. The books seem to contain a satisfactory percentage of sheet mica, but as they range from fair-stained to heavy-stained only a small part of the sheet recovered would be of No. 1 and No. 2 qualities. The stain is of the grating type and probably due to magnetite.

Beryl is unevenly disseminated through the perthite-plagioclase-quartz pegmatite in green to yellow-green prisms in part intergrown with quartz and plagioclase, and as scattered crystals associated with the pod in the south pit. Most of the beryl is in crystals 0.1 and 0.4 inch in diameter and less than 1 inch long, but crystals as much as 2 inches in diameter and 4 inches long are present. A real measurement of 80 beryl crystals exposed in 142.9 square feet of the headwall of the northernmost cut indicated a beryl content of 0.09 percent.

The tabular fracture-controlled body is rich in book mica. It would surely have merited thorough prospecting and might even have supported a profitable small-scale mining operation during World War II had the mica books been less stained. The deposit could furnish small and medium-sized sheet for electrical uses, small amounts of high-grade potash feldspar, and moderate amounts of No. 2 feldspar. However, development work is needed to determine the extent of the mica deposit along the strike and down the dip. The extent along strike could be determined most economically by advancing the face of the quarry southward. Northward the bedrock surface slopes downward beneath overburden, and if workings were carried far in this direction, inflow of water from the low area north

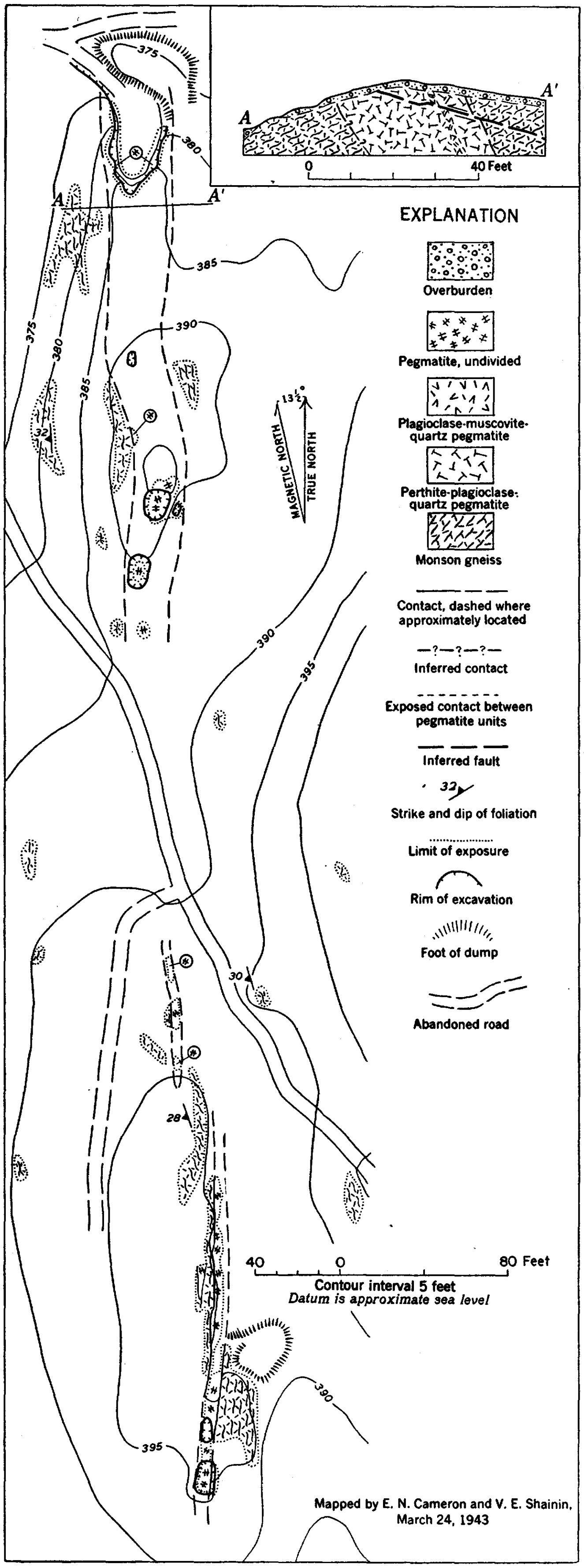


FIGURE 122.—Geologic map and section, Hollister mica-beryl prospect, Glastonbury, Conn.

of the quarry might significantly increase the cost of mining.

Most of the beryl crystals in the deposit are too small to be separated readily by hand, and the beryl content of the pegmatite is so low that the body is not a possible source of beryl-bearing rock for milling.

Middle pegmatite.—The middle pegmatite is poorly exposed and has not been studied in detail. It appears to resemble the northern pegmatite in mineral composition.

Southern pegmatite.—The southern pegmatite is exposed at intervals for 160 feet. It is 4 to 9 feet wide and seems to be almost vertical. Its walls are irregular. It consists of smoky quartz, perthite, massive plagioclase, cleavelandite, garnet, beryl and traces of lepidolite and columbite tantalite. The mica occurs along small pods of coarse-grained quartz.

Mica in the southern pegmatite is similar to that from the northern pegmatite. Beryl, in crystals ¼ to 2 inches in diameter and ½ to 5 inches long, is associated with quartz and cleavelandite, and is very unevenly distributed. Measurements of beryl crystals exposed in 74 square feet of pegmatite indicate a beryl content of about 0.11 percent.

The southern pegmatite contains a lean pod deposit capable of yielding only small amounts of muscovite of poor quality. Most of the beryl crystals are small and could not be separated economically by hand. Parts of the pegmatite could yield small quantities of high-grade perthite, together with larger amounts of feldspar more or less intergrown with quartz and other minerals.

KNAPP MICA PROSPECT

The Knapp prospect lies in the town of Canton 3 miles N. 30° W. of Canton village. It may be approached from Canton by traveling 3.5 miles west on U. S. Highway 44 to its junction with an asphalt road leading northward. Proceed on this road 1.1 miles to a dirt road which leads 0.4 mile to the prospect. The only working (fig. 123) is an irregular opencut 65 feet long, ½ to 4 feet deep, and about 25 feet wide, blasted into the side of a pegmatite knoll. Most of the cut is covered with back fill. The prospect was mapped by V. E. Shainin in March 1944. The exposed part of the pegmatite appears to be dome-shaped. It is at least 280 feet long and has an exposed thickness of 8 feet; its actual thickness is probably considerably greater. The wall rock is a medium-grained garnet-rich quartz-muscovite-biotite schist that is visible only where it overlies the pegmatite. At the southwestern end of the prospect the contact strikes N. 70° E. and dips 20° SE. Much of the wall rock that covered the southern part of the pegmatite has been eroded, so that the contact surface is exposed. In the northeastern part of the prospect, where erosion has cut more deeply into the pegmatite, the hanging-wall contact strikes approximately N. 25° E. and dips about 20° SE. At the top of the knoll, north of the opencut, the schist has also been removed by erosion. The contact there was almost horizontal. Probably some irregular patches of schist visible in the pegmatite are xenoliths and others are remnants of the overlying schist wall.

In the face of the opencut, where the pegmatite is best exposed, the following zones, from the wall inward, are present:

1. Border zone, 1 to 4 inches thick. Consists of fine-grained quartz, muscovite and plagioclase with accessory garnet and tourmaline. Milky and smoky quartz are common.
2. Quartz-muscovite zone, 6 inches to 1½ feet thick. Consists of coarse quartz and muscovite, medium-grained plagioclase and accessory fine-grained garnet. Quartz, much of it smoky, constitutes well over 50 percent of the unit. Rock mined from the zone has yielded 10 percent mine-run mica.
3. Quartz-perthite zone, minimum thickness 3 feet. Only the upper portion of this zone is exposed; it consists of coarse anhedral quartz and subhedral perthite, with accessory scrap muscovite.

Northeast of the opencut the quartz-perthite zone is not visible. Pegmatite underlying the quartz-muscovite zone there consists of medium-grained quartz, plagioclase and muscovite, subordinate amounts of perthite and accessory garnet and tourmaline. This unit has an exposed thickness of 2 feet. Its contact with the quartz-perthite zone is concealed by overburden.

The mica deposit is of the wall-zone type. The mica forms pale ruby books that range from 1 to 8 inches in breadth and average 3 inches in diameter. Most of the books are clay-stained, wedged, and reeved, and some show "A" structure, cross-fracturing, and ruling. The mica is hard but not flat. The percentage of sheet recovered from crude mica was low, largely because of the wedge shape of the books.

Assuming an average thickness of 1 foot for the quartz-muscovite zone, and a yield of 10 percent mine-run mica from the zone, indicated reserve of recoverable crude mica within the area of the geological map is estimated to be 50 tons. However, as probably not more than 1 percent of sheet mica could be recovered from the mine-run product, the prospect is not promising.

SPINELLI SAMARSKITE PROSPECT

The Spinelli prospect lies in the town of Glastonbury 3.2 miles S. 55° E. of Glastonbury village. To reach it from Glastonbury, travel 3.4 miles southeast on state route 2 to the house of P. Saglio. The workings lie about 320 feet southwest of Mr. Saglio's house.

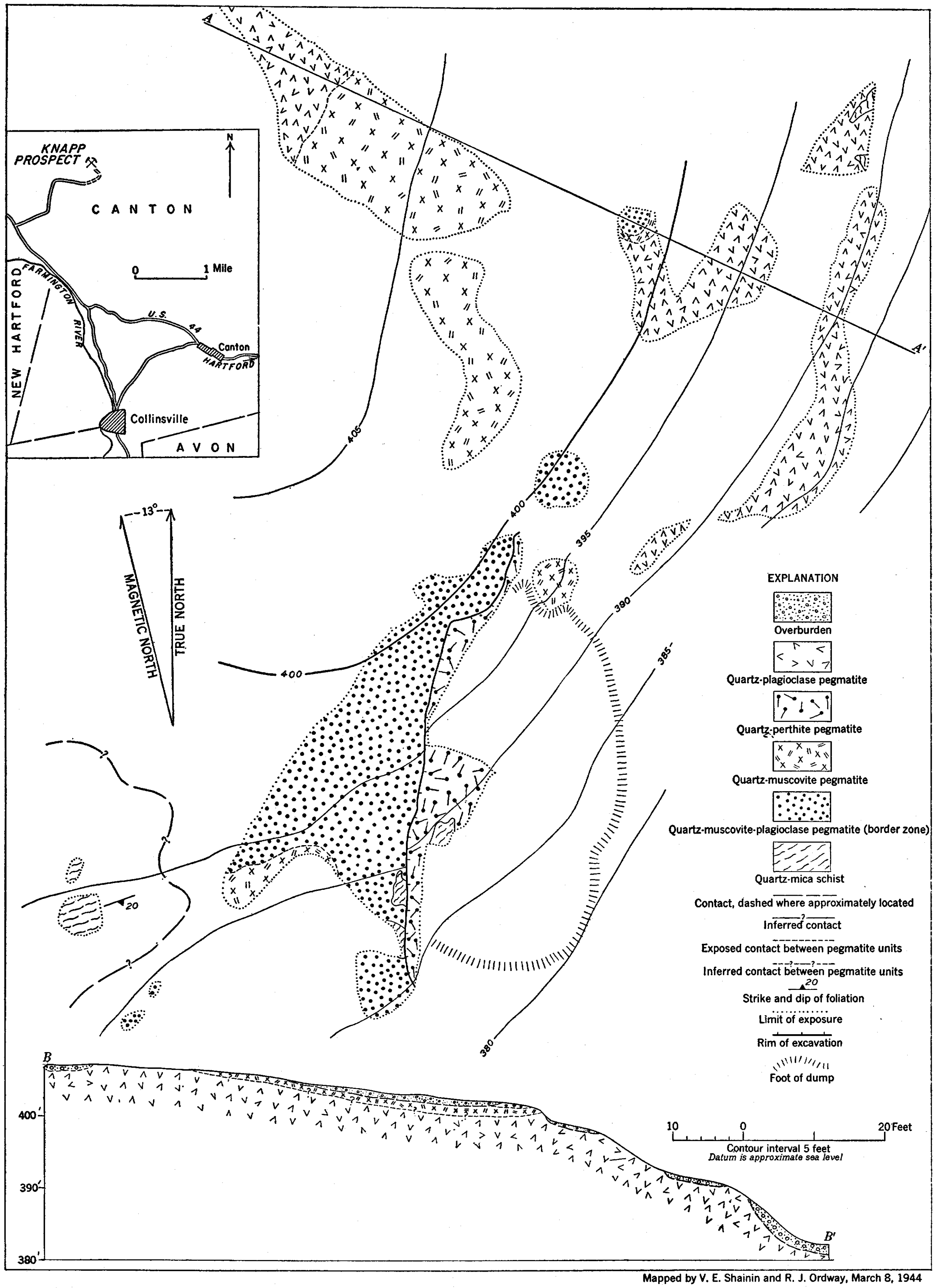


FIGURE 123.—Geologic map and section of the Knapp mica prospect, Canton, Conn.

The roads which formerly gave access to the property are overgrown with brush. The owner is unknown. According to local reports, Mr. Vito Spinelli of South Glastonbury worked the quarry in 1933, and recovered at least 50 pounds of samarskite and a small amount of mica. Nothing else is known of its history. The workings consist of an open pit about 135 feet in length, 15 feet in average width, and 1 to 15 feet in depth. V. E. Shainin made a geologic sketch map of the workings in June 1943 (fig. 124).

The pegmatite is at least 210 feet long, 30 feet in maximum outcrop width, and at least 6 feet thick. It is probably a tabular body that strikes N. 65° E. and dips about 40° SE. At least three small faults, two of which are shown in figure 168, cut the pegmatite roughly at right angles to its strike. All are probably normal faults, but displacements along them could not be determined.

The internal structure of the pegmatite is obscured by back fill and vegetation, but the dike probably possesses the following zones:

1. Border zone; 1 to 3 inches thick. Fine-grained quartz, feldspar and muscovite.
2. Quartz-perthite-plagioclase zone; thickness unknown. Consists of quartz and perthite, with subordinate plagioclase and accessory muscovite, garnet, tourmaline and samarskite.
3. Quartz core, at least 2 feet thick. The core is exposed for a length of 25 feet in the floor of the cut in the northeastern corner of the workings. It consists of coarsely crystalline quartz.

Samarskite was observed only at the southwestern end of the quarry, about 1 foot below the hanging wall. At the locality indicated by "S" on the accompanying map, an area 12 feet by 3½ feet is composed almost entirely of distinctive reddish-brown to salmon-pink perthite, with accessory quartz, samarskite and muscovite. The muscovite occurs in soft fractured green books as much as 4 inches in diameter. Seventy-seven irregularly shaped pieces of samarskite, ranging in size from 0.1 to 2.0 inches in diameter, and averaging roughly 0.3 inch in diameter, were counted in an area measuring 9 by 1½ feet, which represented the richest third of the feldspar mass. The surface of this area consisted of from 0.3 percent to 0.4 percent samarskite, but there were indications that richer material had been removed.

Very little muscovite is visible in the pegmatite, and the books, which have an average diameter of 3 inches, are widely scattered. Most are associated with small quartz masses.

Until the pegmatite is more fully exposed its internal structure and the distribution of samarskite cannot

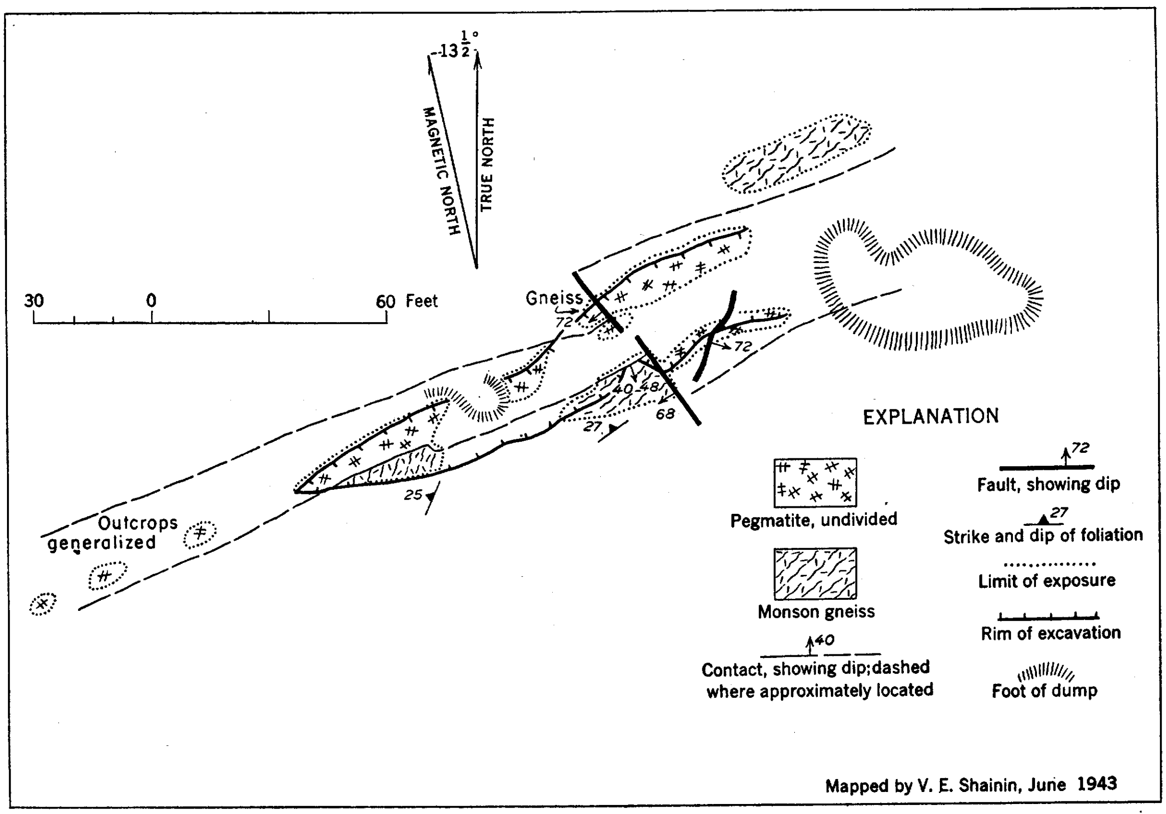


FIGURE 124.—Sketch map of the Spinelli samarskite prospect, Glastonbury, Conn.

be determined satisfactorily. More concentrations of samarskite may be found, but probably would not be rich enough to support mining operations.

LITCHFIELD COUNTY

GREEN MOUNTAIN MINE

The Green Mountain mine is 0.5 mile south of West Cornwall village, in the town of Cornwall. From the village follow the dirt road leading south along the railroad tracks for 0.5 mile. The deposit is on the west slope of a steep hill, about 150 feet east of the railroad tracks.

The property is owned by Edward A. Schleuter, West Cornwall. The mine was last worked many years ago for feldspar and mica. The workings are an opencut about 150 feet long, 15 to 40 feet wide, and 5 to 35 feet deep, and several trenches. They were examined briefly by E. N. Cameron in November 1942.

The opencut follows an irregular tabular pegmatite 15 to 25 feet thick. At the east end of the cut (the head) the pegmatite strikes east and dips steeply south. Westward toward the entrance the strike of the body changes to N. 50° W. and the dip changes to steeply southwest. The walls of the pegmatite are uneven, and several small pegmatite offshoots extend into the wall rock. The main body seems to pinch out eastward within 50 feet of the opencut. The wall rock is gray granitic biotite gneiss whose foliation strikes N. 70° E. and dips 43° SE. at the east end of the quarry.

Mica occurs chiefly along the footwall of the pegmatite, intergrown with quartz and plagioclase in an irregular layer 1 to 3 feet thick. The books range from ½ to 4 inches broad. The mica is hard, rum muscovite, in part showing biotite and magnetite "stains." All books seen were strongly ruled and cross fractured. Some would yield punch mica and small sheet, but most are of scrap quality.

Whether the mica zone extends beneath the debris on the floor of the cut is unknown. The quality of the books in sight is poor, and the content of sheet mica appears to be low.

ROEBLING MICA-FELDSPAR-BERYL MINE

The Roebling mica-feldspar-beryl mine lies in the town of New Milford, 5.5 miles N. 13° W. of New Milford village. From New Milford travel 3.5 miles north on state route 129 to an improved road leading northwestward. Follow this road 2.8 miles to the farmhouse of Jacob Orzech. The mine lies about ¼ mile northeast of the farmhouse.

The property is owned by Mr. Orzech. According to Sterrett (1923, p. 63–65) and Kunz (in U. S. Geol. Survey volumes on mineral resources for 1885, 1892, 1898 and 1899) the mine was operated for mica, feldspar, and gem beryl between 1880 and 1900. One ton of beryl is said to have been recovered from the no. 1 quarry by Mr. Orzech's sons since 1936. In the summer of 1944, Cyril Ulman of Guilford, Conn., worked the no. 2 quarry for mica for a period of 2 weeks. E. N. Cameron examined the mine in December 1942 and V. E. Shainin and F. H. Main mapped it in November 1944 (fig. 125).

The workings consist of two opencuts, from one of which a short underground crosscut and drift have been run. The no. 1 quarry is 420 feet long and 60 feet in maximum width and depth. It is covered by vegetation and partly backfilled. The no. 2 quarry is 90 feet long, 40 feet wide and 20 feet deep.

Five pegmatite sheets or lenses have been mined. The bodies dip moderately to steeply northwest and are enclosed in silicified quartz-mica schist (Berkshire schist). The schist has been injected with narrow pegmatites. Contact metamorphism has produced abundant subhedral metacrysts of garnet and tourmaline in the schist adjacent to the contacts with pegmatite.

The no. 1 quarry is in a pegmatite body that averages 30 feet in thickness, strikes N. 55° E., and dips 60° NW. Sterrett (p. 64) states that it is reported to be thinner near the bottom of the cut than at the surface. The small part of the pegmatite exposed in 1944 consisted of three lithologic units:

1. Border zone, lying adjacent to the wall rock contact.
2. Perthite-quartz zone, lying inside the border zone.
3. Muscovite-perthite unit, poorly exposed near the center of the pegmatite.

The border zone is 3 to 10 inches thick and consists of fine-grained quartz, plagioclase, perthite, muscovite, and tourmaline. Locally the zone is rich in strongly ruled muscovite books ½ to 1 inch in diameter. Tourmaline occurs in subhedral needles from ¼ inch to 3 inches long, oriented normal to the contact.

The perthite-quartz zone consists essentially of perthite and quartz with subordinate amounts of plagioclase and accessory muscovite, beryl, biotite, garnet, and tourmaline. Quartz occurs in coarse milky masses as much as 25 feet long, and also as granular (grain size ¼ inch) fillings of tension fractures in coarse perthite. The fractures are 5 feet in average length and are 3 to 5 inches wide; many have about the same attitude as the steeply dipping faults and joints. Perthite occurs in large anhedral crystals as much as 10 feet long. In the eastern part of the north wall, the zone is richest in massive perthite toward the center of the pegmatite, and this suggests the presence of a perthite core. Locally, the perthite is veined and partly replaced with granular milky quartz, deformed muscovite and pink-

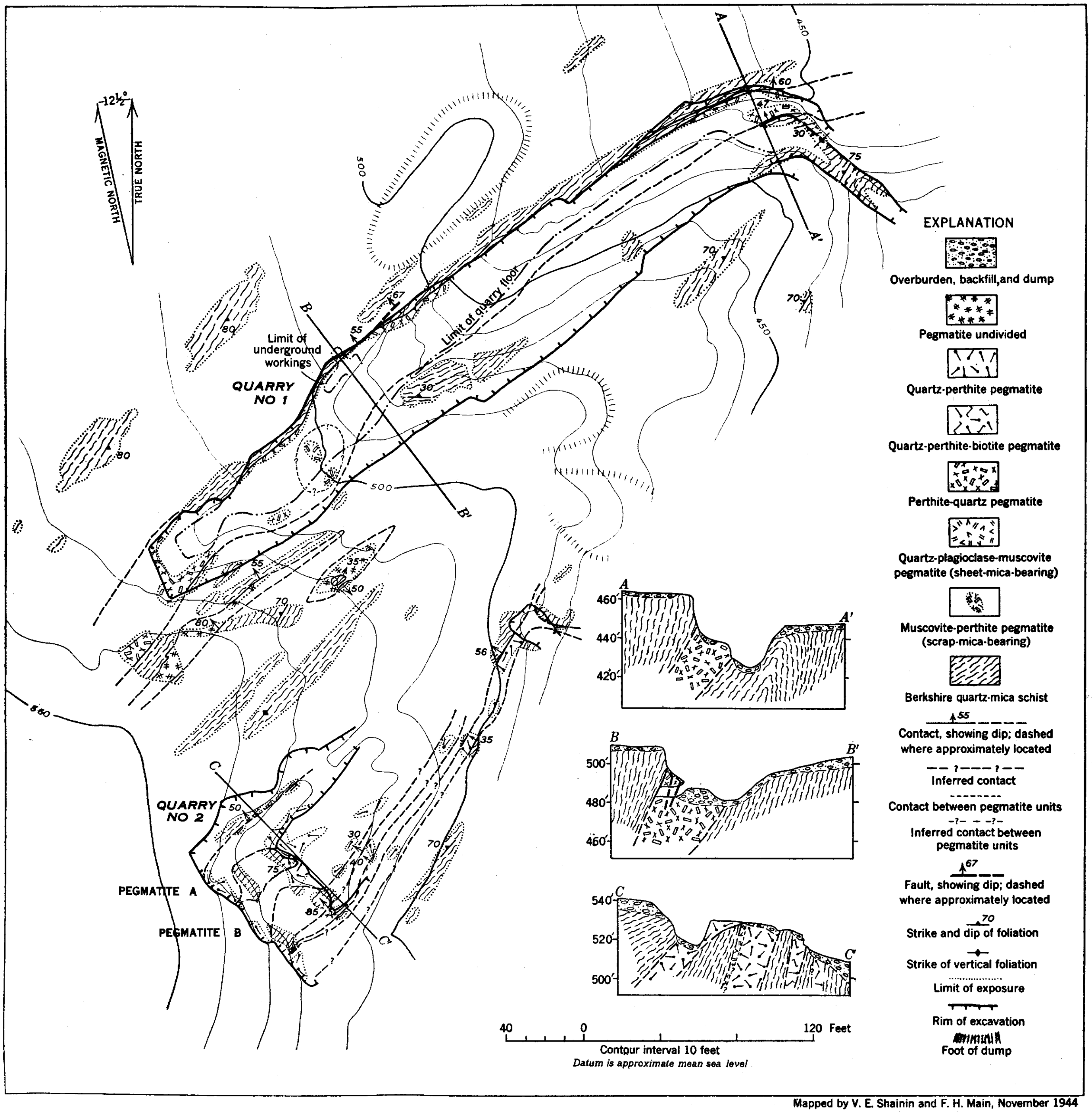


FIGURE 125.—Geologic map and sections of the Roebling mica-feldspar-beryl mine, New Milford, Conn.

red garnet. Graphic granite is fairly common. Muscovite books 3 inches in diameter occur in small quantities associated with milky quartz masses of equal size. There is no evidence of a concentration of sheet-bearing mica adjacent to either wall. Beryl occurs in pale greenish-white, short, subhedral prisms, 3 inches in average length and 2 inches in average diameter. Beryl may be a common accessory, but exposures are insufficient to indicate the beryl content. A 300-pound block of quartz and plagioclase found in the backfill contains at least 8 percent beryl. Sterrett (1923, p. 64) states that "the best mica and feldspar are reported to have come from the northeast half of the opencut, and the best beryl from the southwest half." He adds (p. 65) that "many crystals of beryl, some of them more than a foot in diameter" have been found and that "in 4 years

$17,000 worth of gem beryl is reported to have been sold."

The muscovite-perthite unit consists chiefly of scrap muscovite. Perthite and granular quartz are also present, and garnet is an accessory mineral. The exposed part of the unit is 20 to 25 feet in diameter and lies roughly halfway between the walls of the pegmatite. Its form, attitude and relation to the zones is unknown. Diversely oriented scrap muscovite books form 70 to 90 percent of the total volume. They average 1 inch in diameter but range from ⅛ to 6 inches across.

Several joints and faults cut the pegmatite in the north wall of the no. 1 quarry. The displacements along the faults could not be determined but probably are not great. Both faults and joints in general, strike N. 40° E. and dip 55° to 70° NW.

Four pegmatites (*A* to *D*, fig. 125) are exposed in the no. 2 quarry. They strike N. 40° E. and dip to the north at moderate to steep angles. Probably the two northermost pegmatites are roots of a single pegmatite which lay directly above the present topographic surface. Outcrops on the southwestern side of the quarry indicate a similar relationship between the two southernmost pegmatites.

The pegmatites range from 5 to 20 feet in thickness and consist essentially of quartz and perthite with various amounts of muscovite, plagioclase, and accessory biotite, and tourmaline, garnet, and beryl. Small biotite and muscovite books occur as fracture fillings in joints cutting pegmatite *A*.

There are three types of mica deposits in the no. 2 quarry: pod, wall-zone, and disseminated. Pegmatite *A* has a concentration of books as much as 1 foot in diameter, associated with pods of anhedral quartz that lie within 3 feet of the hanging wall. Pegmatite *B* exhibits a lean book mica-bearing zone composed of quartz, plagioclase, and muscovite. This zone is about 1 foot thick along the hanging wall, and the books are 3 to 4 inches in average diameter. Pegmatites *C* and *D* are disseminated mica deposits.

Mica books from both quarries are green to pale ruby in color. More than 90 percent of the books examined showed effects of extreme deformation. Tangle-sheet, herringbone, wedge-structure, "A" structure, warping, cross-fracturing, reeving and ruling are common defects. Sterrett (1923, p. 65) wrote that clear sheets several inches across were recovered from early operations in the no. 1 cut. Ulman, in 1944, soon abandoned his operation in pegmatites *A* and *D* in the no. 2 quarry, because the percentage of recoverable sheet in the mine-run product was extremely low. Present exposures in the no. 1 cut are inadequate for a satisfactory evaluation of the pegmatite.

MIDDLESEX COUNTY

ANDERSON NO. 1 MICA MINE

The Anderson No. 1 mica mine, formerly known as the Swanson lithia mine, lies in the town of East Hampton, 0.4 mile N. 35° W. of Haddam Neck village. It is one of the Anderson-Bailey group of mica mines. To reach the workings from the village of Middle Haddam, travel 1.7 miles southeast on state route 151 to the entrance of Hurd Park. A paved secondary road leads south from this point 1.2 miles to the house of the owner, Paul Anderson, Haddam Neck. From the house a poorly graded dirt road leads ½ mile eastward to the mine.

The pegmatite was first prospected before 1920 (Shannon, 1920, p. 82–84). From June to December 1941, and from May 1943 to March 1944, the Connecticut Mica & Mining Co., Portland, Conn., operated the mine. When the mine was abandoned the workings consisted of a vertical pit 52 feet deep and 10 to 15 feet wide. Two drifts, 50 and 30 feet long, were driven northward and eastward, respectively, from the bottom of the pit. When operations ceased, the northern drift was about 10 feet longer than shown on the accompanying map (fig. 126).

The mine was mapped in November 1942 by G. B. Burnett and J. T. Callihan, and studied by E. N. Cameron. It was examined periodically from November 1942 to May 1944, by E. N. Cameron and V. E. Shainin, and a revised map was made in November 1943.

The pegmatite is a very irregular body about 30 feet thick and at least 90 feet long. It seems to strike northward and to have a moderate eastward dip. Apparently its south end is in the workings. In part the pegmatite is concordant with the foliation of the eastward-dipping wall rock (medium-grained hornblende gneiss of the Bolton schist), in part it is sharply discordant.

The pegmatite consists of the following units:

1. Border zone, quartz-plagioclase pegmatite 4 to 8 inches thick. Consists of fine-grained quartz and plagioclase with accessory black tourmaline, biotite, and muscovite. The zone is cut by numerous fractures that are perpendicular to the contacts. The fractures are coated with films of pyrite.

2. Wall zone, quartz-plagioclase-muscovite pegmatite, 1 to 6 feet thick. Consists of coarse quartz, blocky plagioclase, muscovite and accessory tourmaline and garnet. The muscovite books are 2 to 18 inches broad and ¼ to 4 inches thick.

3. Intermediate zone, quartz-cleavelandite pegmatite, 5 to 25 feet thick. Consists of coarse quartz (in masses 6 feet in diameter), cleavelandite, muscovite and scattered large anhedral crystals of perthite. Mica books 3 inches

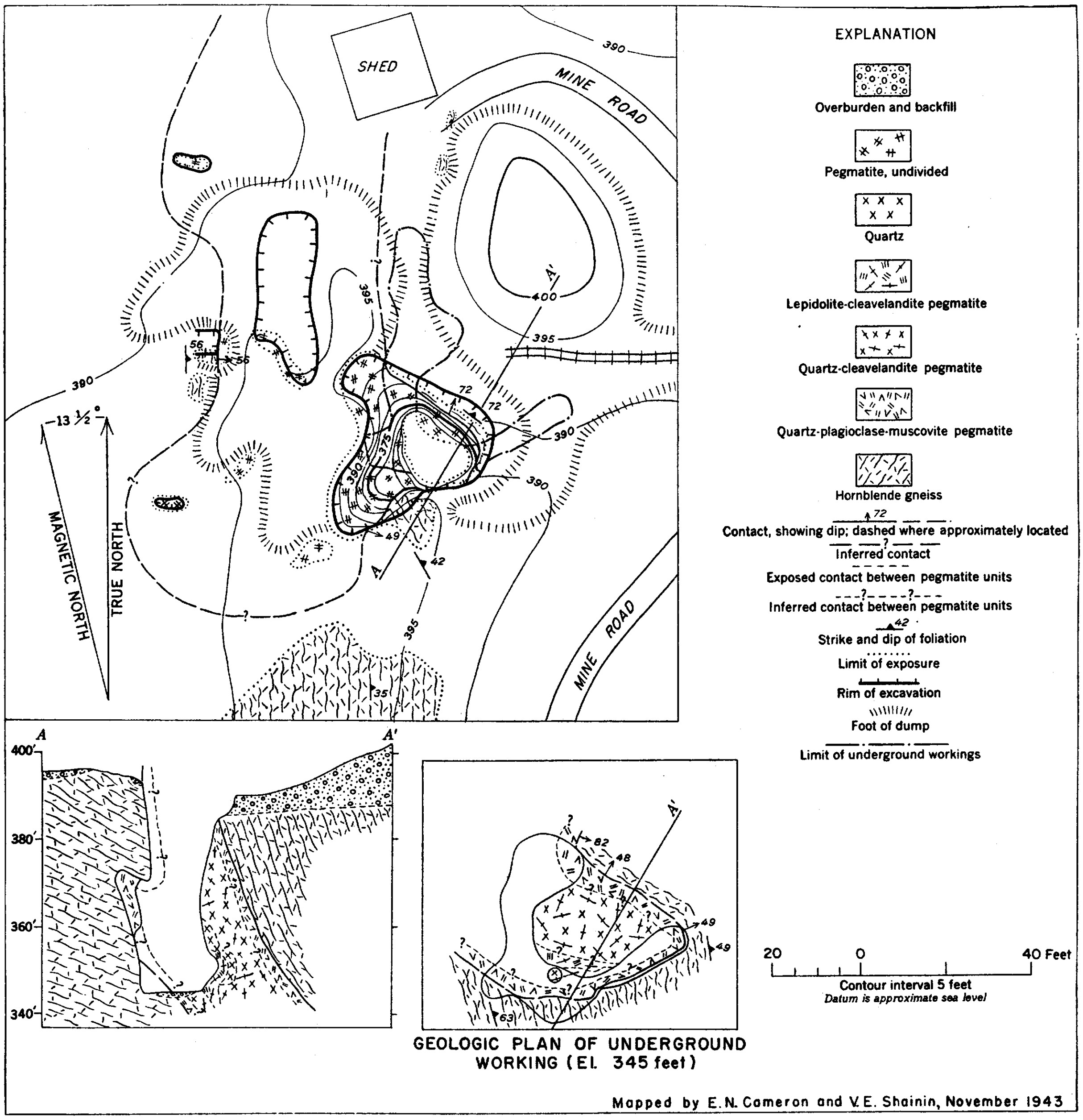


FIGURE 126.—Geologic map, plan, and section of the Anderson No. 1 mica mine, East Hampton, Conn.

in average diameter occur in places adjacent to the quartz masses. Black and green tourmaline and green beryl (rare) are accessory minerals.

4. Quartz pegmatite, as much as 10 feet thick, consisting of coarse milky to smoky quartz. Occurs typically as a hood-shaped body adjacent to the lepidolite-cleavelandite unit and, at most places, above it. It also forms pods enclosed in the intermediate zone.

5. Lepidolite-cleavelandite unit, 5 to 10 feet thick. Fine- to medium-grained lepidolite (pink to violet to gray) with subordinate cleavelandite, quartz, and accessory dark green apatite and green tourmaline. The principal lepidolite-cleavelandite body seems to be an elongate ellipsoid at least 35 feet long whose long axis pitches S. 60° E. at an angle of about 30°. It is exposed only in the southern portion of the pegmatite but apparently a similar body was mined in the pit northwest of the vertical pit. Either this unit or the quartz unit may be the true core of the pegmatite.

The wall zone is thickest along the hanging wall in the northern drift. The content of sheet in the mica is low, and the books seem to be poorest in quality in the thickest parts of the zone. Cross fracturing, ruling, reeving, and limonite-staining are the most common defects. Shearing, probably of small displacement, has occurred along the hanging wall in the northern drift, and mica there is badly fractured.

Some blocks of virtually pure lepidolite have been obtained from the pegmatite, but most is probably too heavily intergrown with cleavelandite and quartz to be of value. It is estimated that 15 to 20 tons are in sight in the workings and that 40 tons are stockpiled on the surface.

The pegmatite seems to end southward in the workings and it may not persist for more than 100 feet north of the northern drift, so probably total reserves of mica are not large. Experience has shown that only a small percentage of sheet can be recovered from the crude mica, because of the structural defects of the books and the limonite-staining.

ANDERSON NO. 2 MICA MINE

The Anderson No. 2 mica mine lies 400 feet S. 65° E. of the Anderson No. 1 mine, described above. The mine is owned by Paul Anderson of Haddam Neck. A small opencut is reported to have been made prior to 1915. The Connecticut Mica and Mining Company of Portland, Conn., operated the mine for about 6 weeks in the fall of 1942 and again from April 1, 1944, to July 25, 1944. When abandoned, the mine (fig. 127) consisted of an open pit 55 feet in length, 6 to 20 feet in width, and 40 feet in maximum depth. Underground workings consisted of a crosscut 13 feet long, 9 feet high, and 7 feet wide.

In November 1942, the mine was mapped by G. B. Burnett and J. T. Callihan and studied by E. N. Cameron. V. E. Shainin visited it periodically in 1944. In August 1944 the map of the workings were revised by Shainin and K. S. Adams.

The Anderson No. 2 pegmatite is concordant with the enclosing medium-grained, well-foliated quartz-muscovite schist (Bolton schist). The schist is rich in biotite, garnet, and tourmaline where it is in contact with pegmatite. The pegmatite appears to be a lens that strikes N. 10° W. and dips 65° NE. At the surface it probably has a strike length of less than 100 feet. It is about 10 feet thick at the surface but attains a thickness of 20 feet at the bottom of the workings.

The pegmatite consists of three units: a border zone 1 to 7 inches thick, that consists of quartz with subordinate plagioclase and muscovite, and accessory garnet and tourmaline; an intermediate zone that consists of medium- to coarse-grained quartz and perthite, with subordinate massive white plagioclase and accessory muscovite, biotite, black tourmaline, pink garnet, and green apatite; irregularly distributed pods, 6 inches to 7 feet long, consisting of coarse milky quartz.

The mica is deep ruby, and some is exceptionally hard and flat. Most books show ruling, reeving, "A" structure and cross fracturing, but some show only ruling and reeving. Inclusions of tourmaline are present in a few books. The average content of sheet in the crude mica is low.

The pegmatite contains both pod and disseminated mica deposits. Mica books occur along the outer margins of quartz pods in books averaging 4 inches across and ½ inch in thickness. White, massive plagioclase is commonly associated with the muscovite. Most of the book mica recovered came from this material. At several places, black euhedral crystals of tourmaline ¼ inch to 4 inches in diameter occur in abundance adjacent to pods. Book mica along the margin of these masses is deformed and contains much intergrown biotite and many euhedral inclusions of black tourmaline. Mica books also are disseminated through the pegmatite. These books average 3 inches across and ½ inch in thickness. Most are associated with small "blobs" of coarse gray quartz (averaging 4 inches in diameter) or with white massive plagioclase; some books seem to be associated only with anhedral perthite.

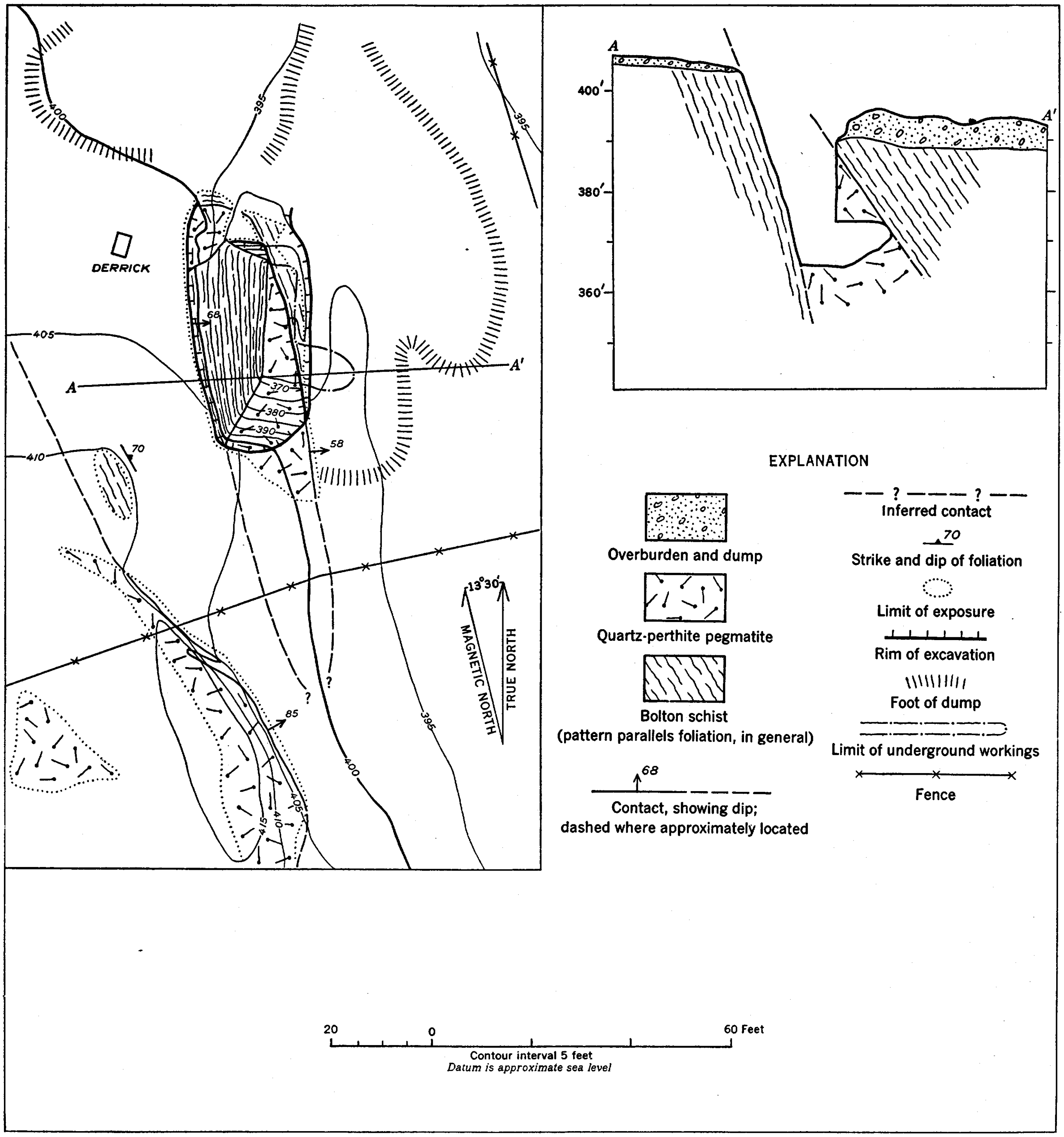
Mica comprises about 2 percent of the pegmatite. There is no geological evidence indicating that unexposed portions of the pegmatite differ in mode of occurrence, concentration, or quality of mica. The low content of crude mica and the low recovery of sheet mica from the crude prevented successful operation in 1943–44.

BAILEY MICA PROSPECTS

The Bailey mica prospects lie 100 to 500 feet north of the Anderson mines described above and may be reached by following the same directions. They are owned by Mr. A. W. Bailey of Haddam Neck, and were leased and mined intermittently by Mr. John Fiano, 764 Silver Lane, East Hartford, in the latter part of 1942 and in April 1943. G. B. Burnett and J. T. Callihan mapped the prospects in November 1942, and they were studied briefly by E. N. Cameron in November 1942 and April 1943.

The group consists of six opencuts averaging 20 feet in length, 5 to 10 feet in width and less than 10 feet in depth. The pits are in three or four separate pegmatites enclosed concordantly in quartz-mica schist (Bolton schist). The pegmatites strike north and dip eastward at moderate to steep angles. They range in thickness from 6 feet to perhaps 30 feet.

Mineralogically the pegmatites are similar in general. They consist of three poorly defined zones: border zone, consisting of fine-grained quartz, muscovite scrap, and plagioclase; wall zone composed of medium- to coarse-grained quartz, plagioclase, perthite, and muscovite; pods, composed of coarse quartz, perthite, muscovite, graphic granite, and minor biotite.



Mapped by V. E. Shainin and K. S. Adams, August 17, 1944

FIGURE 127.—Geologic map and section of the Anderson No. 2 mica mine, East Hampton, Conn.

BORDONARO BERYL PROSPECT

The Bordonaro prospect lies in the town of Portland, 3.8 miles N. 30° E. of the center of Portland village. From Portland travel northeastward on State Highway 17A to its intersection with State Highway 17. Continue 1.3 miles northward on highway 15 to a gravel road leading northward. Follow this road for approximately 0.2 mile past the Bordonaro farmhouse. A few hundred feet east of the house, a poorly graded dirt road leads northward to the prospect.

The property is owned by Sam Bordonaro, R. F. D., Portland. In 1929 Joseph Carini, R. F. D., East Hampton, worked one of the pegmatites on the property for feldspar and in 1935 Bordonaro worked it for feldspar and mica. The workings (fig. 128) consist of a cross trench leading to an opencut 85 feet long, 5 to 10 feet wide, and 5 to 15 feet deep. The opencut is largely free from water and backfill.

The property was mapped in June and July 1943 by E. N. Cameron and V. E. Shainin. The Bureau of Mines and Geological Survey cooperated in an exploratory project in July, August, and December 1943; four pits and two trenches were excavated and six diamond-drill holes were made (figs. 128 and 129). E. E. Maillot supervised the prospecting work done by the Bureau of Mines, and V. E. Shainin was project geologist for the Geological Survey.

Sheet-bearing mica occurs in the pegmatites chiefly in pod deposits, in books 2 to 3 inches broad. Most of the books show "A" structure, ruling, or cross fracturing, or combinations of these defects. Mica books also occur very sparsely scattered through the pegmatites.

Less than 1 percent of mine-run mica was recovered from the rock moved during Mr. Fiano's operation, and a substantially higher recovery from further mining is unlikely. The pods are lean, small, and sparsely distributed through the pegmatites, and very little mica is found away from the pods. The yield of sheet mica per ton of crude mica was low.

The property is underlain partly by Monson gneiss, partly by quartz-mica schist (Bolton schist). Locally, the foliation of the metamorphic rocks varies markedly in attitude, but strikes north to northwest over most of the area and dips west at moderate angles. Four pegmatite bodies are exposed in the immediate vicinity of the workings. Three are thin tabular, westward-dipping bodies that strike nearly north, and two of these transect the contact of schist and gneiss obliquely. The fourth is poorly exposed, but is probably a thick lens that is arcuate in plan and trends northwest to north. Its walls are concealed, hence its attitude is unknown.

DESCRIPTION OF THE PEGMATITES

The main pegmatite, the one worked for feldspar and mica, is a tabular body that has an average dip of about 45° W. At the surface, the pegmatite consists of two sections connected by a thin stringer. The south section is 38 feet long and 2½ to 3½ feet thick. It strikes slightly east of north and has an average dip of about 40° W. Its walls are irregular and discordant in detail, but it seems to be broadly concordant with the foliation of the schist. The schist along the walls is crumpled and folded on a small scale. The north end of the body seems to plunge irregularly southward, and the south end plunges gently in the same direction. The north section of the pegmatite is 130 feet long at the surface and ranges from 1½ to 6 feet in thickness. It strikes slightly west of north and dips 31°–55° W., transecting the contact of the schist and gneiss.

The south section has a striking zonal structure (fig. 128). It consists of the following units, in order from the walls inward:

1. Border zone, plagioclase-quartz-perthite pegmatite, 1 to 3 inches thick. Composed of fine- to medium-grained quartz and plagioclase, with subordinate muscovite and perthite, and accessory garnet and unevenly distributed beryl. The beryl crystals are ⅛ to 1½ inches in diameter and as much as 3 inches long.
2. Perthite-quartz zone, 3 inches to 1 foot thick. Composed of coarse perthite and quartz, with subordinate muscovite and plagioclase. The perthite crystals are euhedral against the quartz and also against quartz of the core described below. The zone is absent along part of the footwall.
3. Quartz core, 6 inches to 1½ feet thick. Consists of coarse, massive quartz.

The north section of the dike consists of the following zones:

1. Border zone, ½ inch to 2 inches thick, similar to the border zone of the south section. The zone is absent at a few places along the hanging wall.
2. Wall zone, plagioclase-quartz-perthite pegmatite, 1 to 8 inches thick. Composed of quartz and plagioclase, with subordinate perthite and muscovite and accessory beryl, tourmaline, and garnet. The zone is less than 4 inches thick in most places and is discontinuous. Along the footwall it is indistinct at most places. It is markedly quartz-rich north of the deep part of the open cut. The mica books are ½ inch to 6 inches broad, and ¼ inch to 2 inches thick. The mica is green, clear, and hard, but most of it is ruled, reeved, cross-fractured, and tangled. Inclusions of albite, quartz, tourmaline, and garnet are present in some books. Few books would yield even small sheet mica.
3. Perthite-quartz zone, 6 inches to 5 feet thick, This zone varies markedly from place to place in mineral proportions, but in general consists of quartz and coarse perthite, with subordinate medium-grained plagioclase and muscovite, and accessory beryl and garnet. Perthite forms

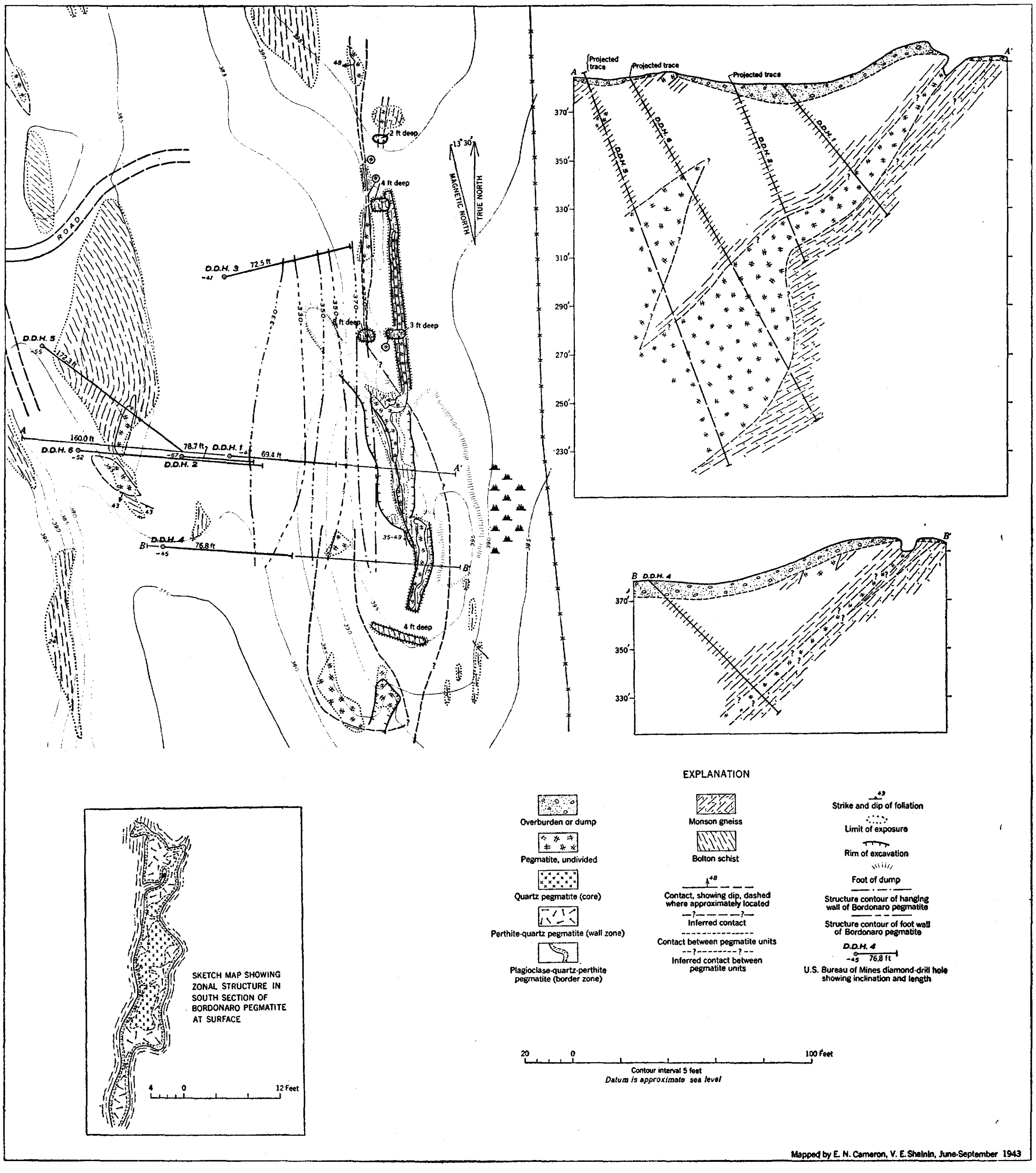


FIGURE 128.—Geologic map, plan, and sections, Bordonaro beryl prospect, Portland, Conn.

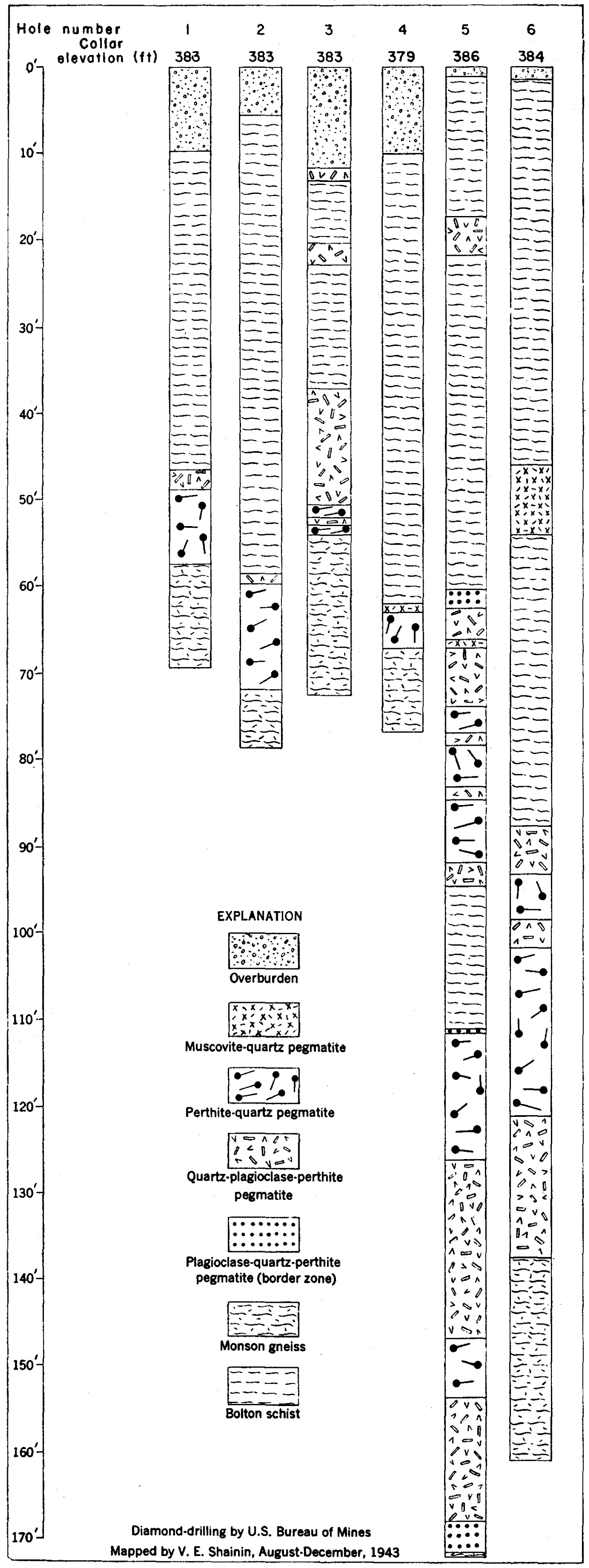


FIGURE 129.—Logs of diamond-drill cores, Bordonaro beryl prospect, Portland, Conn.

anhedral to subhedral crystals a few inches to 3 feet in diameter. Some of the crystals are intergrown with quartz. Light green to blue-green beryl crystals as much as 6 inches long and 2.5 inches in diameter are scattered unevenly through the zone. Some of the crystals seem to be pure and some are intergrown with or include quartz and feldspars or are veined by quartz and albite.

The other pegmatites exposed on the property are medium- to coarse-grained and consist essentially of quartz, plagioclase, perthite, and muscovite in various proportions. Apart from thin border zones, they appear unzoned.

EXTENT OF THE MAIN PEGMATITE

Surface exposures indicate that most of the pegmatites in the vicinity are small, thin lenses, and therefore the interpretations of the subsurface structure made from the diamond drill holes (fig. 128) are only tentative. The south section of the pegmatite may pinch out entirely between the surface and diamond-drill hole 4 (sec. BB′), and the pegmatite cored in the drill hole may be a separate body. Similarly, the thick pegmatite cored in the lower parts of drill holes 5 and 6 may be a separate body from the north section of the main pegmatite. Interpretation of the drill cores is especially difficult as the quartz-perthite zone of the north section of the pegmatite is markedly varied in mineral proportions.

Measurements of crystals exposed in the opencut were made to determine the beryl content of the main pegmatite. Exposures of pegmatite having a total area of 43,460 square inches showed 190 beryl crystals having of 303.33 square inches, indicating an average beryl content of 0.7 percent. If the interpretations of the subsurface structure are correct, and if the beryl content of the pegmatite is the same in depth as at the surface, indicated beryl amounts from 37 to 43 tons, and inferred beryl amounts to an additional 116 tons. At present, the beryl content of the pegmatite at depth is unknown. Beryl was found only in holes 1, 3, and 5 but, because beryl is very unevenly distributed, the beryl content of the core is not an accurate indication of the beryl content of the pegmatite. Additional drill holes, unless very closely spaced, are not likely to clarify the structure. An incline down the dip of the north section of the pegmatite would be considerably more informative.

Although part of the beryl in the main pegmatite is readily separable by hand, the average beryl content is not sufficient to repay mining even at prices similar to those that prevailed during World War II. Beryl could be recovered as a byproduct of operations for feldspar, but as the upper part of the pegmatite is thin, and its attitude does not favor low-cost mining, it is doubtful whether operations would be profitable, particularly as the pegmatite is not very rich in perthite separable by hand.

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CASE BERYL PROSPECTS

The Case prospects lie in the town of Portland, 4.5 miles N. 39° E. of the center of Portland village. To reach them from Portland travel eastward oa State Highway 17A to its intersection with State Highway 17. Proceed 0.3 mile eastward on a paved town road, then turn left and travel northward about 1.3 miles, bearing right at two road forks. At this point turn left for 0.7 mile to an intersection. Proceed eastward 0.1 mile then turn northeastward on a poorly marked dirt road that leads into woodland just east of a farmhouse. Follow this road about 2,500 feet to the prospects.

The property is owned by Myron N. Case, Rose Hill, Portland. The Worth Spar Co., Inc., of Cobalt quarried three pegmatites on the property for feldspar from 1933 to 1935. In the summer of 1939 Frank Bajorek of Portland mined the westernmost pegmatite (no. 1 quarry, pl. 43) for feldspar. The Worth Spar Co. prospected the no. 2 pegmatite for sheet mica in August and October 1942. The workings are opencuts that range from 60 to 110 feet in length, 7 to 45 feet in width and 10 to 25 feet in maximum depth. All are flooded.

The pegmatites were mapped by E. N. Cameron and V. E. Shainin in March 1943 and were studied periodically until December 1943 (fig. 130 and pl. 43). The U. S. Bureau of Mines and Geological Survey cooperated in surface and subsurface exploration of the pegmatites

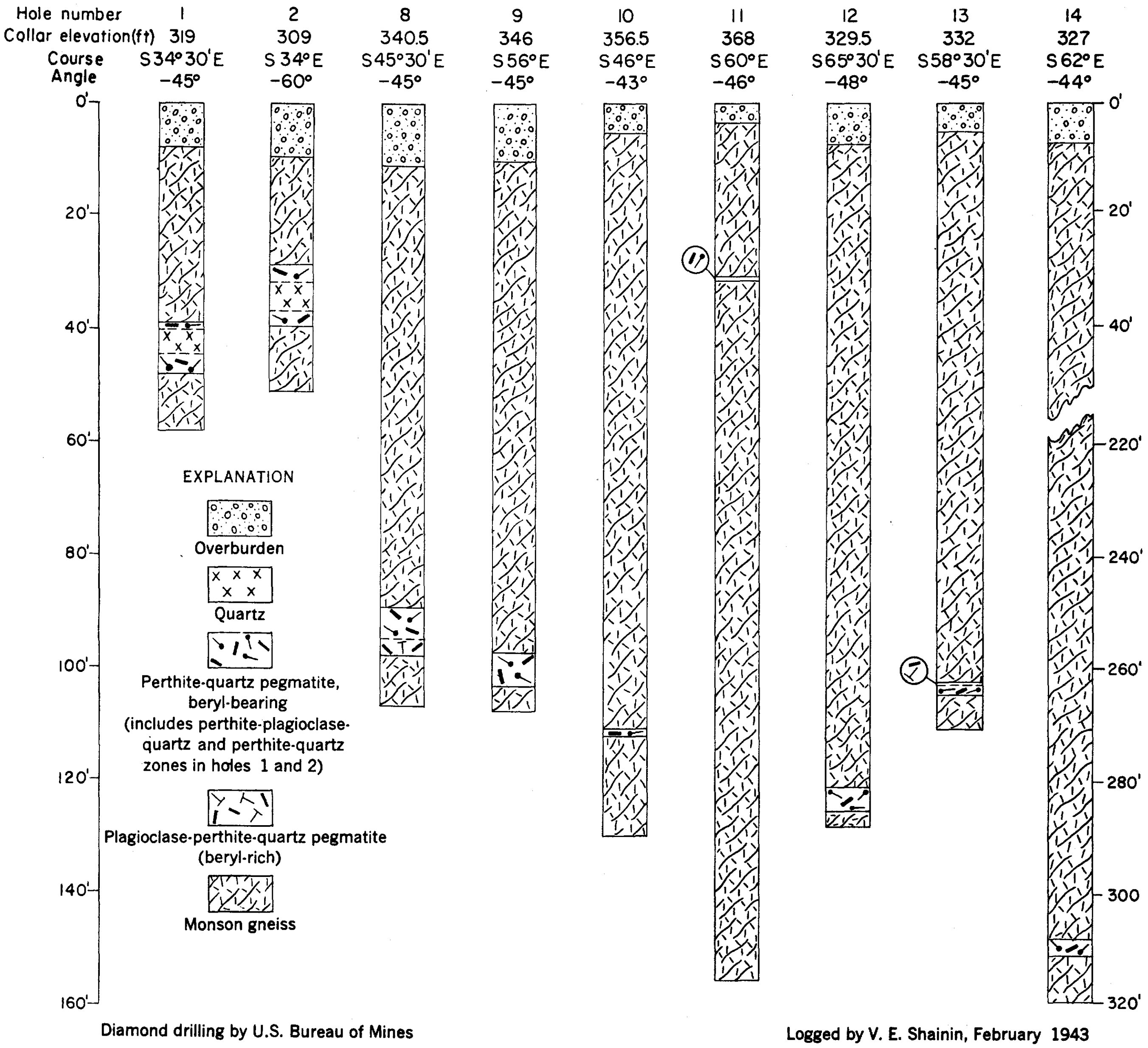


FIGURE 130.—Logs of 9 of 14 cores taken by U. S. Bureau of Mines, Case beryl prospects, Portland, Conn.

from May to November 1943. E. E. Maillot was in charge of the project for the Bureau of Mines and V. E. Shainin studied the subsurface geology for the Geological Survey. The no. 2 and 3 quarries were pumped, and 14 holes totaling 1,673.5 feet were made by diamond-drill.

The three pegmatites on the Case property lie within 500 feet of one another. They strike north to northeast and differ in direction and magnitude of dip. The pegmatites cut granite-gneiss (Monson gneiss), the foliation of which strikes generally northward and dips 20°–30° W.

The no. 1 pegmatite, westernmost of the group, is 5 to 7.5 feet thick, strikes N. 7° E. and dips 35°–45° SE. It has been quarried for about 100 feet along strike and to a maximum depth of 17 feet. It may have terminated upward a short distance above the rim of the workings. The pegmatite has a border zone ½ to 1 inch thick consisting of fine-grained granular quartz, plagioclase, perthite, and beryl. The rest of the pegmatite (designated perthite-quartz zone on pl. 43) consists of medium- to extremely coarse-grained perthite and quartz, with subordinate plagioclase and muscovite, and accessory beryl, garnet, and columbite-tantalite. Muscovite forms small, colorless to gray-green, heavily stained books, irregularly distributed. In general, the texture of this material is progressively coarser toward the center of the pegmatite. There is no clearly defined quartz core exposed, but in places in the central part of the pegmatite there are irregular bodies of quartz, against which the perthite crystals are euhedral. Offshoots of the quartz bodies extend outward across the surrounding pegmatite along fractures. In addition, veins of quartz occur along the contacts with wall rock. Debris left in the north end of the opencut suggests the presence of a small quartz core flanked by a perthite-quartz zone similar to that of the no. 2 pegmatite described below.

High-grade perthite constitutes at least 50 percent of the perthite-quartz zone visible. Beryl occurs chiefly in the border zone and the outermost 12 to 18 inches of the perthite-quartz zone, and is most abundant in the footwall part of the perthite-quartz zone. The crystals range from ⅛ inch to 4 inches in length and from ⁵⁄₁₆ inch to 3 inches in diameter. Measurements of all crystals in the cross-section of the pegmatite in the northern face of the quarry indicate a beryl content of 0.15 percent. However, the exposures available for measurement are few, and the accuracy of the figure obtained for grade is doubtful. Waste rock on the dump seemed to show considerably more beryl in material derived from the perthite-quartz zone than is indicated by the crystal measurements. Measurements of beryl crystals in the footwall part of the border zone indicated 0.41 percent beryl.

The no. 2 pegmatite (mined in the no. 2 quarry) is a tabular lens that strikes N. 17° E. and dips 15° NW. At the surface, it has a strike length of 60 feet. It probably terminates beneath overburden less than 40 feet northward from the quarry. The south edge of the lens plunges southward from the open cut at a moderate angle. One hundred and eighty feet down dip from its surface outcrop, the inferred strike length of the pegmatite is 155 feet. The thickness of the body ranges from 10 feet at the surface to about 16 feet at a point 180 feet down dip.

The pegmatite is distinctly zoned. The border zone, 2 to 4 inches thick, is composed of fine-grained quartz, perthite, and plagioclase, with accessory muscovite, garnet, beryl, and tourmaline. The wall zone, 2 to 6 inches thick, consists of medium-grained perthite, plagioclase, and quartz, with accessory muscovite, beryl, and garnet. The intermediate zone, 1 to 4 feet thick, is similar to the wall zone but is composed chiefly of quartz and extremely coarse perthite. The core averages 5 feet in thickness and is composed of coarsely crystalline milky quartz, accessory perthite in scattered large, euhedral crystals, and rare beryl. Perthite crystals in the perthite-quartz intermediate zone are euhedral against quartz of the core. The zonal structure was clearly recognizable in 3 of the 4 drill holes that intersected the pegmatite 1, 2, and 5. Cores from holes 5 and 7 were inadequate for the construction of logs.

Beryl occurs in the border and wall zones in scattered crystals ¼ to ¾ inches in diameter and as much as 3 inches long. Some crystals in the perthite-quartz zone are 9 inches in diameter and 10 inches long. Measurements on exposures in the quarry (230 square feet) suggest that the average beryl content of the pegmatite is 0.34 percent. On the basis of this figure, and diamond drilling, 53 tons of beryl are indicated and 27 tons are inferred to lie beneath the surface to a depth of 180 feet down the dip.

The percentage of high-grade feldspar in the no. 2 pegmatite is less than that in the no. 1 pegmatite but perthite in the perthite-quartz zone is mostly pure and separable by hand sorting.

The no. 3 pegmatite, northernmost of the group, is a tabular lens that strikes N. 25° to 48° E. and dips 63° to 71° NW. The crest of the lens plunges gently northward and southward from the quarry. The strike length of the pegmatite ranges from 70 feet at the surface to at least 350 feet at a level 120 feet down dip from the workings. Along strike the dike is thickest in the center (7 feet) and thins to less than 2 feet both north and south of the workings. The pegmatite was probably not intersected by drill hole 14. It is believed to terminate above the hole but below elevation 240 feet (pl. 43, sec. A–A′).

The dike exhibits a fairly distinct zonal structure in the no. 3 quarry. The border zone, ½ to 1 inch thick, is composed of quartz, perthite, and plagioclase, with accessory black tourmaline, muscovite, beryl, and garnet. The wall zone, 1 to 2 feet thick, is irregular and in places absent. It is composed of quartz and plagioclase with various amounts of coarse-grained perthite, subordinate muscovite, accessory beryl, tourmaline, and columbite-tantalite. The pegmatite inside the wall zone consists of coarse-grained perthite and quartz with accessory beryl and plagioclase. There is no true quartz core, but irregular bodies of quartz are present in the quartz-perthite zone. Neighboring perthite crystals are euhedral against the quartz bodies. The zonal structure of the pegmatite was recognized in the diamond-drill hole cores, although it was less clearly defined than at the surface.

Beryl occurs in the border zone in crystals less than ¼ inch in diameter and 1 inch long, and in the wall zone crystals as much as 2 inches in diameter and 5 inches long. The footwall part of the wall zone appears to contain more beryl than the hanging-wall part, and the beryl crystals are larger. Counts made on the northern and southern faces of the quarry (250 square feet of pegmatite), before and after exploratory blasting, indicate an average beryl content of 0.22 percent. From this figure and data of the Bureau of Mines, 25 tons of beryl is indicated and 6 tons inferred to lie beneath the surface to a depth of 120 feet down the dip.

The Case nos. 2 and 3 pegmatites are inferred to contain slightly more than 100 tons of beryl, mostly in small crystals. Recovery by hand-cobbing would unquestionably be difficult. Each of the three pegmatites contains limited tonnages of high-grade, hand separable perthite, and the no. 2 pegmatite probably contains at least 6,000 tons of coarse milky quartz that appears to be of high purity and could be separated readily by hand.

ENEGREN (POWER) MICA MINE

The Enegren mine lies in the town of East Hampton 2.6 miles S. 36° E. of Middle Haddam village. It may be approached from Middle Haddam by traveling 3 miles southeastward on State Highway 151 to an asphalt road leading southward. Follow this road for 0.25 mile to the house of David E. Enegren, of Middle Haddam, owner of the property. A gravel road leads westward 0.15 mile from Mr. Enegren's house to the mine.

The mine was worked for a short time prior to 1940. It was reopened in July 1942 by the Power Mica Co., Hopkinton, Mass., who operated it intermittently until November 1944. Peter Armando of Glastonbury operated the mine from November 20 to December 20, 1944. Rock moved during 1944 contained slightly more than 2 percent mine-run mica.

Workings consist of opencuts and underground workings (fig. 131). The no. 1 cut has a maximum length of 53 feet, a width of 30 feet and a depth of 75 feet. It is connected with two small stopes and with an inclined shaft 25 feet deep. Cut no. 2 is 21 feet long, 12 feet wide, 22 feet deep; cut no. 3 is 25 feet long, 27 feet wide, 15 feet deep. All the cuts were flooded in February 1945. It is believed that none were backfilled.

Mapping was done in December 1942 by E. N. Cameron, G. B. Burnett, and J. T. Callihan; in July 1943 by Cameron and V. E. Shainin; and was restudied in August 1944 by Shainin and K. S. Adams. George Switzer and Harry Mikami, of the Connecticut Geological and Natural History Survey, made progress maps in the fall of 1944, and furnished data on operations during this period.

The workings lie in four pegmatite bodies, all probably lens-shaped in plan. The pegmatites are enclosed in medium-grained quartz-mica schists and mica quartzites of the Bolton schist and are concordant with foliation and bedding. The foliation strikes N. 10°–30° W. and in general dips 70° E. The no. 1 pit is in a tabular lens about 80 feet long and 5 to 10 feet thick. The lens has been mined to a depth of 75 feet. It strikes N. 10° W. and dips 65° E. It is thinnest in the bottom of the workings. The pegmatite appears to pinch out a foot or two north of the shaft. In the ceiling of the stope in the south end of the workings the pegmatite ends on strike at an altitude of 375 feet. The plunge of this edge of the lens appears to be vertical.

The no. 1 cut has been the chief source of book mica, as it contains a higher percentage of mica than the other pegmatites. The pegmatite mined in the cut consists of a border zone and a core. The border zone, 4 inches to 1 foot thick, lies adjacent to the wall. It is fine-grained and consists of gray quartz and colorless to pale ruby muscovite. Subordinate minerals are albite (An_2) and accessory red garnet, black tourmaline and pyrite.

The core of the pegmatite is medium- to coarse-grained (grain size ½ inch to 4 inches). It consists of salmon-pink perthite and gray quartz with subordinate amounts of albite (An_2), in part cleavelandite, and rum-colored muscovite. Accessory minerals are black tourmaline, red garnet, green apatite, and pale green

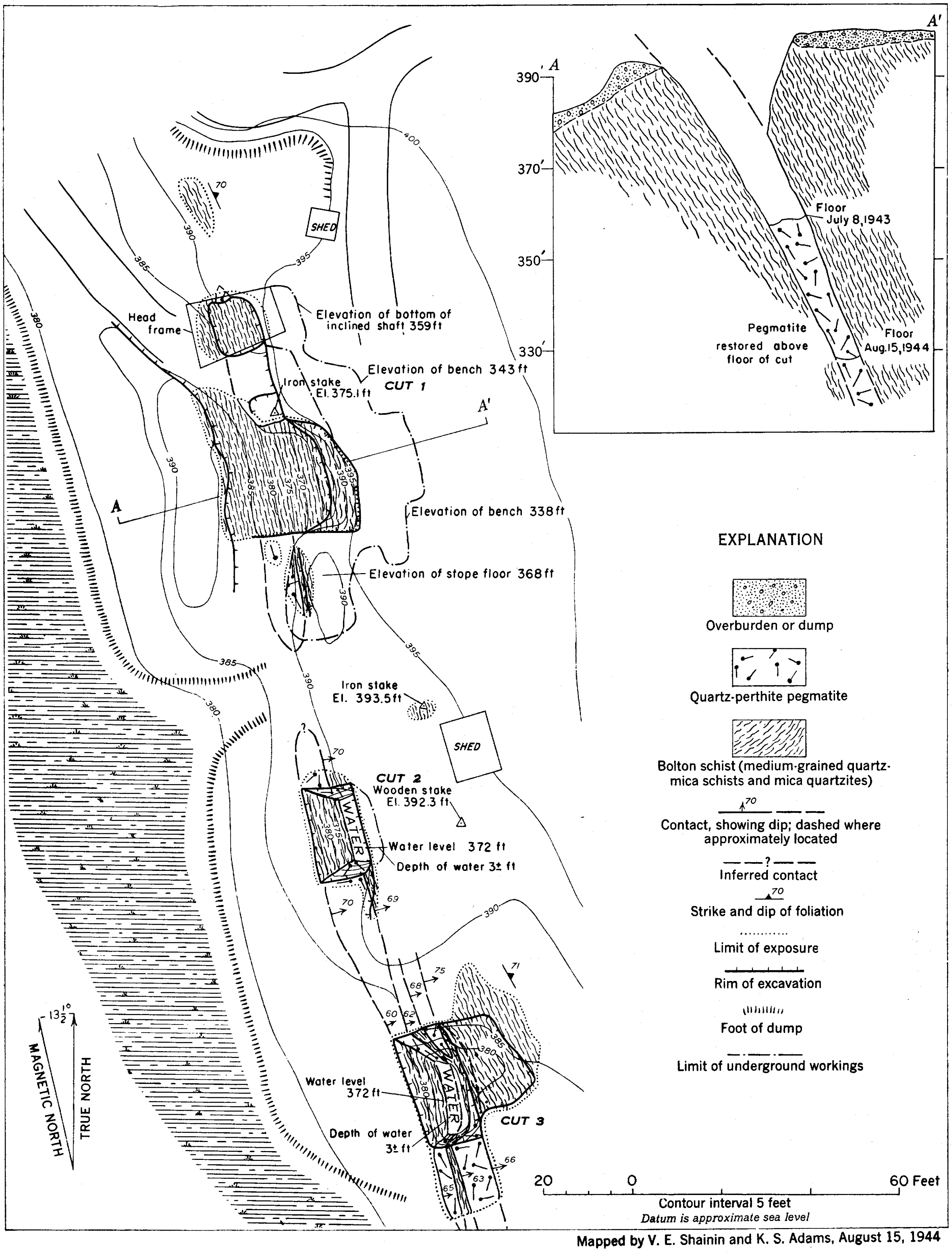


FIGURE 131.—Geologic map and section of the Enegren (Power) mica mine, East Hampton, Conn.

beryl. Beryl forms rare euhedral prisms 1½ inches long, embedded in quartz and albite.

The pegmatite in the no. 1 cut is a disseminated mica deposit. Mica books ranging from 2 inches in diameter and ⅛ inch thick to 2 by 3 feet across and 6 inches thick occur distributed unevenly throughout the core. Most of the books are associated with masses of coarse quartz, and with either albite or perthite. Probably most of the mica books occur in the central portion of the pegmatite. Book mica from the no. 1 cut is light to deep rum and ranges from hard to very hard. Some books contain inclusions of black tourmaline. Structural defects are fairly common and include reeving, ruling, cross-fracturing, tanglesheet and "A" structure. The sheets are free-splitting and nearly flat. Production records show that the northern end of the pegmatite lens, mined in the inclined shaft, contained considerably less book mica than the part of the pegmatite mined south of the shaft.

Most of the sheet-bearing mica was obtained from the central and southern parts of the lens, so these should be explored first in a new operation. The strike length of the pegmatite is so small that deep operation would be required to obtain large amounts of mica. Unfortunately, water accumulates rapidly in the cuts, making frequent pumping necessary.

The no. 2 cut is situated in a tabular pegmatite that is probably about 120 feet long and 5 to 6 feet thick. It strikes N. 15° W. and dips 70° E. The no. 3 pit is in three narrow pegmatites, which strike N. 15–20° W. and dip 60–70° N. The two easternmost pegmatites end along strike within the workings; the southward termination of one and the northward termination of the other are exposed. The westernmost pegmatite is the one worked in the no. 2 cut.

The pegmatites in the no. 2 and no. 3 cuts are similar in composition and texture, and each has a fine-grained border zone, 1 to 6 inches thick, consisting of quartz and muscovite with subordinate albite. The cores of the pegmatites consist of salmon-pink perthite and gray quartz, with subordinate albite and accessory muscovite, black tourmaline, red garnet and green apatite. Perthite occurs commonly in anhedral crystals 6 inches to 1 foot in length, and less commonly in subhedral crystals. Muscovite, in pale rum books, ½ to 8 inches in diameter, is irregularly scattered throughout the pegmatite. Most books are of very poor quality and contain structural defects, especially ruling.

Like the main productive pegmatite, these are disseminated mica deposits. Production records show that they were too lean in book mica to repay mining, and the unexposed portions are probably no better.

GILLETTE QUARRY (J-J MINE)

The Gillette (Haddam Neck) quarry is in the town of East Hampton, 5.4 miles S. 25° E. of Cobalt (fig. 132). To reach it from Cobalt travel 3.5 miles southeastward on State Route 151. At this point turn southward on a town road and travel 1.6 miles to a poorly graded road leading southeastward. Follow this road for 1 mile to the house of the owner, S. C. Gillette, R. F. D., East Hampton. The quarry lies directly west of Mr. Gillette's house.

The quarry, a well-known mineral locality (Bowman, 1902; p. 97–121; Foze, 1922, p. 4–12; Gillette, 1937, p. 333), was opened in 1896, and was worked for gem tourmaline, mineral specimens, and feldspar by a Mr. Schernikow and J. C. Wilkes. According to E. S. Bastin (1910, p. 48–49) the quarry was operated in 1907—but it was abandoned before 1914. B. E. Johnson, of Haddam, mined feldspar at the quarry for 3 months in 1934. Johnson and E. H. Johnson, 168 Liberty Street, Middletown, worked the quarry for mica and feldspar from November 1942 to November 1944.

The workings (fig. 132) consist of two open crosscuts leading to a very irregular opencut 350 feet long. The workings and vicinity were mapped in November 1942 by E. N. Cameron, G. B. Burnett and J. T. Callihan. Cameron and V. E. Shainin made periodic examinations during 1943 and 1944, and a revised map of the workings was made by Shainin, F. H. Main, and R. Digman in June 1945.

A complex pegmatite consisting chiefly of steeply dipping, interconnected lenses is exposed in the quarry. The lenses strike north to N. 35° W. and are exposed for a strike length of at least 330 feet. They range from 15 to 80 feet in thickness. The crest, or upward termination of one southward-plunging lens, is visible. The flanks of a part of the pegmatite that is shaped like half a dome, exposed at point *G*, dip westward, southward and eastward. The walls of the pegmatite are characterized by irregular rolls and "keels," most of which plunge gently northward, and by sharp bends related to joints. Pronounced rolls are most common in the part of the west wall between points *C* and *D*, (fig. 132).

The wall rock consists of interbedded quartz-mica schist, mica-quartzite, calc-silicate gneiss and marble of the Bolton schist. Foliation and bedding in the wall rock are parallel and, in general, are concordant to the pegmatite-contacts. The pegmatite is sharply discordant in places, however, as at the crest of the southward-plunging lens and at the southern flank of the domical portion.

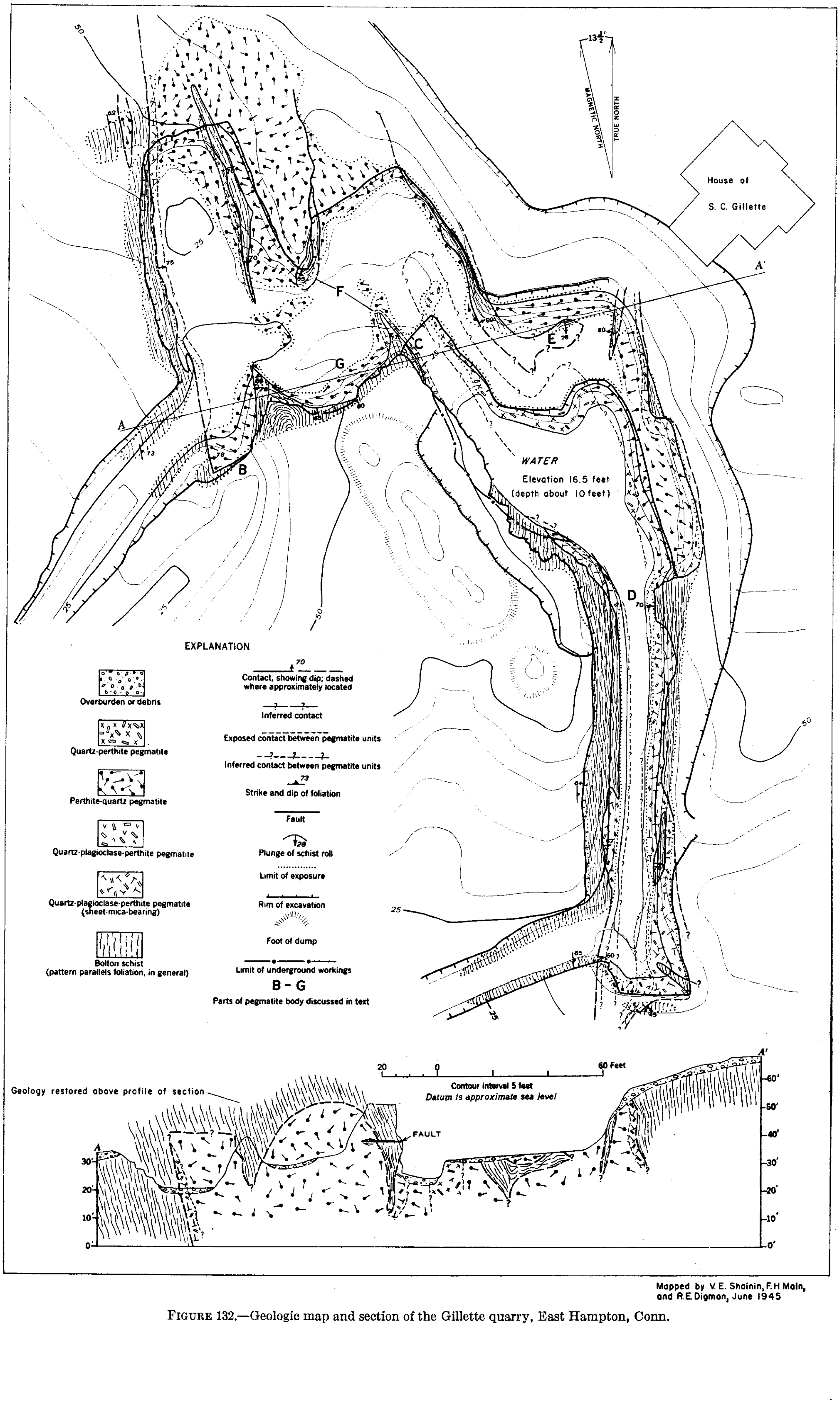


FIGURE 132.—Geologic map and section of the Gillette quarry, East Hampton, Conn.

Both pegmatite and wall rock are cut by many joints and by at least one reverse fault of slight displacement. The joints and faults strike, in general, a few degrees west of north. Some are horizontal; others dip as much as 10° W. Some of the joints are irregular surfaces and locally dip eastward. The crest of the pegmatite at *B* (fig. 132) follows a horizontal joint.

The pegmatite is zoned. For convenience in description, it is divided into two parts, called the western part (west of the schist screens found at point *F* on the geological map) and the eastern part (east of the screens of schist at *F*).

Western part.—The sequence of zones inward from the walls, is as follows:

1. Border zone, 1/2 inch to 18 inches thick, composed of fine-grained quartz, plagioclase, muscovite, garnet and black tourmaline. The zone is present wherever the contact between pegmatite and wall rock is visible.
2. Wall-zone, sheet-mica bearing, 1/2 foot to 6 feet thick, composed chiefly of quartz and plagioclase with subordinate perthite and muscovite and acccessory green apatite and black tourmaline. Muscovite probably constitutes less than 5 percent of the zone. The unit ls discontinuous and its distribution is best indlcated by the geologic map.
3. Perthite-quartz zone, 10 to 45 feet thlck, composed of white and salmon-pink perthite, pale green milky quartz, and graphic granite, with subordinate plagioclase and green muscovite (mostly books 1/4 to 1 inch across), and accessory black tourmaline, green and rose beryl, red fluorite, apatite and lepidolite. Some of the quartz is granular (grain size 1/4 inch) and occurs in branching, vein-like bodies which may have replaced other minerals of the zone. Albite, green tourmaline, green fluorescent apatite and green muscovite flakes are associated chiefly with the granular quartz. Cavities, 1 to 5 inches broad, are common only in this material. The cavities are lined with euhedral muscovite, albite and quartz crystals. At point *A*, several books of scrap muscovite, 1 inch broad and 5 inches thick, occur in a mass of granular quartz.

The sheet-mica-bearing wall zone is probably too lean to repay mining even under economic conditions similar to those of World War II. The books range in size from 1 inch to 1½ feet broad and 8 inches thick. Most of the mica is marred by ruling, wedge-structure, cross-fracturing, hair-cracks and "A" structure. Green tourmaline inclusions are common. Most of the feldspar in the perthite-rich zone is intergrown with quartz and black tourmaline, and a high-grade product probably could not be obtained easily by hand cobbing. Beryl occurs in quartz and perthite in prisms up to 1½ feet long and 5 inches in diameter. It probably constitutes much less than 0.2 percent of the pegmatite.

Eastern part.—The walls of this part of the pegmatite in this area are characterized by deep rolls in places, especially northward from point *D*. The sequence of zones in this part of the pegmatite, inward from the walls, is as follows:

1. Border zone, ½ inch to 10 inches thick, similar to border zone in the western part of the pegmatite.
2. Quartz-plagioclase-perthite wall zone, 4 to 6 feet thick, composed of coarse-grained quartz, perthite and massive plagioclase with subordinate cleavelandite, black, green, and pink tourmaline, scrap muscovite and traces of pink lepidolite (some of the variety schernikite), pale green apatite, red fluorite, and green and rose beryl. The subordinate minerals commonly occur together in irregular masses in which are numerous small cavities. The unit is present for about 30 feet northward from point *D*. The zone was covered by water at the time of latest mapping.
3. Intermediate zone, sheet-mica bearing, 2 to 6 feet thick. This consists of quartz, plagioclase, perthite and muscovite with accessory garnet, black tourmaline and green apatite. The hanging wall part has an average thickness of 4 feet, and is more uniform in thickness and richer in mica than the footwall part. The zone is very lean along both walls of the pegmatite at the southern end of the quarry.
4. Quartz-plagioclase-perthite intermediate zone, 3 to 5 feet thick, composed of coarse quartz, subordinate plagioclase and perthite, and accessory black tourmaline and muscovite (books 1 inch broad). This zone is exposed only in the southernmost face of the cut, where it lies adjacent to both parts of the wall-zone.
5. Perthite-quartz intermediate zone, 4 to 20 feet thick, similar to the perthite-quartz zone of the western part but with less graphic granite and less granular quartz and associated minerals. Perthite occurs in larger masses; some are nearly pure anhedral crystals 5 feet long.
6. Quartz-perthite core, maximum thickness about 35 feet. About 85 percent of the unit consists of granular milky quartz (⅛ to 1 inch grains): coarse-grained (crystals 5 inches to 4 feet in diameter) white to pink perthite anhedra make up almost 10 percent. Green muscovite (books ¼ to ⅛ inch broad), black tourmaline, pale green apatite, and red fluorite make up the remainder of the zone. The margins of some of the perthite masses have replaced quartz and the minor minerals. No evidence could found, however, to indicate whether replacement occurred on a large scale at the expense of pre-existing pegmatite, or was merely a minor process in the development of the core.

Mica from the sheet-mica-bearing zone of the pegmatite is greenish amber to pale ruby and soft to moderately hard. Most books are stained by tourmaline inclusions that range from microscopic grains to crystals 4 inches long, and some are in fanlike radiating aggregates nearly parallel to the mica laminae. Films of quartz and plagioclase occur along many cleavage surfaces. Ruling, cross fracturing, tanglesheet, hair cracks, wedge structure, and "A" structure are conspicuous defects. The percentage of sheet recovered from crude mica was low, especially for mica from parts of the zone intersected by the gently dipping joints mentioned above. Adjacent to some of these, the books are crumpled, broken and stained by limonite.

The sheet-mica-bearing zone along the western side of the eastern part has yielded most of the mica and seems the only part of the pegmatite likely to yield much book mica. However, its persistence in depth is unknown and, owing to the irregularity of the wall, its location is difficult to predict. The low content of sheet mica in the crude product will probably deter further operations.

Large amounts of feldspar have been recovered from the perthite-quartz zone, but probably the amount of No. 1 and No. 2 feldspar still remaining is small, as much of the felspar is intergrown with quartz and is stained with limonite. Moderate reserves of low-grade feldspar are probably still present in the eastern part. The beryl content of the pegmatite is very low, but handsome specimens of rose and green beryl have been recovered.

GOTTA-WALDEN MICA-BERYL PROSPECT

The Gotta-Walden mica-beryl prospect lies in the town of Portland, 2.1 miles N. 42° E. of Gildersleeve village. From Gildersleeve, follow State Highway 15A eastward to its intersection with State Highway 15. Continue 1.1 miles north on Highway 15 to a gravel road leading right. Follow this road 0.15 mile to a fork. Follow the right fork for 0.5 mile eastward to the mine. The road was passable by automobile in 1945.

Part of the property (pl. 44) is owned by J. Gotta, part by E. C. Walden, both of Portland. The property was prospected prior to 1942 for feldspar, and two small opencuts (8, 19) and several shallow pits (10, 12, 15, 21) were made. In July 1942, the New Haven Traprock Corp. of New Haven leased the property and tested it briefly for mica and beryl.

The property was mapped in October 1942 by E. N. Cameron and G. B. Burnett, and the map was periodically revised and extended by Cameron and V. E. Shainin in 1943. The property was re-examined by Cameron in July 1945. Plates 44, 45, and figure 133 are a summation of observations made during prospecting and the later exploration. Some features shown on figure 178 are now concealed beneath debris. During the period February to August 1943, the U. S. Bureau of Mines carried on exploratory work to determine reserves of beryl and mica present. Surface exploration consisted of nine trenches and nine small pits (1–7, 9, 11, 13, 14, 16–18, 20). A test shaft was sunk to a depth of 30 feet. Subsequently, 17 diamond-drill holes, aggregating 2,538 feet in length, were made. E. E. Maillot supervised exploration for the Bureau of Mines, and E. N. Cameron was project geologist for the Geological Survey.

The pegmatite prospected and explored is a tabular body 2 to about 30 feet thick. At the surface, it strikes about N. 45° W. in general, but drilling indicates that down dip at the north end the strike changes to N. 80° W. The dip of the body ranges from 25° to nearly 50°. The walls of the pegmatite, where exposed, are uneven, showing sharp rolls and angular breaks across the structure of the wall rocks. The pegmatite is thickest near the surface between cuts 8 and 19, thinning irregularly down dip and along strike from this portion. Numerous inclusions of wall rock are present in it. It has been exposed for a distance of about 315 feet along strike at the surface and has been traced underground by drilling for at least 410 feet along strike and for a maximum distance of 360 feet down dip.

The pegmatite is tabular in general but in cut 8 it is complicated by an irregular outward (southwestward) bulge of the hanging wall, and large irregular apophyses extend outward and upward from the main body. Owing to this structure, the pegmatite was struck in the small pit in the floor of the cut, and at shallow depth beneath schist in pit 3. The pegmatite forks at its southeast end, and the drill cores suggest that it branches in places underground.

The wall rocks of the pegmatite are biotite-hornblende granite gneiss (Monson gneiss) and quartz-mica schist (Bolton schist). The contact between these two major rock units is uneven, and irregular interfingering is suggested by the distribution of outcrops north and west of the mine. The strike of the foliation of the gneiss ranges between northwest and east-north-east; the dip ranges from 11° – 30° in angle and from south to west in direction. The attitude of foliation in the schist is varied. In general, it parallels the foliation of the gneiss and the contact of schist and gneiss, but local deviations are numerous and in places the schist is strongly contorted.

The Gotta-Walden pegmatite trends obliquely across the contact of gneiss and schist, so that its southeast end is enclosed in gneiss at the suface, its northwest end is schist. The drill holes indicate that the pegmatite has a similar trend underground. It lies farthest below the schist-gneiss contact in the southern part of the map area. Northward the interval between the contact and the pegmatite decreases; and in hole 10 the pegmatite seems to lie above the contact.

Identification of the Gotta-Walden pegmatite in the drill holes is based on its relation to the schist-gneiss contact and on its lithology. Correlations are made for holes 1–9, 13, 14, 15 and 17 with considerable confidence. Correlations for holes 10, 11, 12, and 16, however, are in doubt. Holes 11 and 12 suggest a

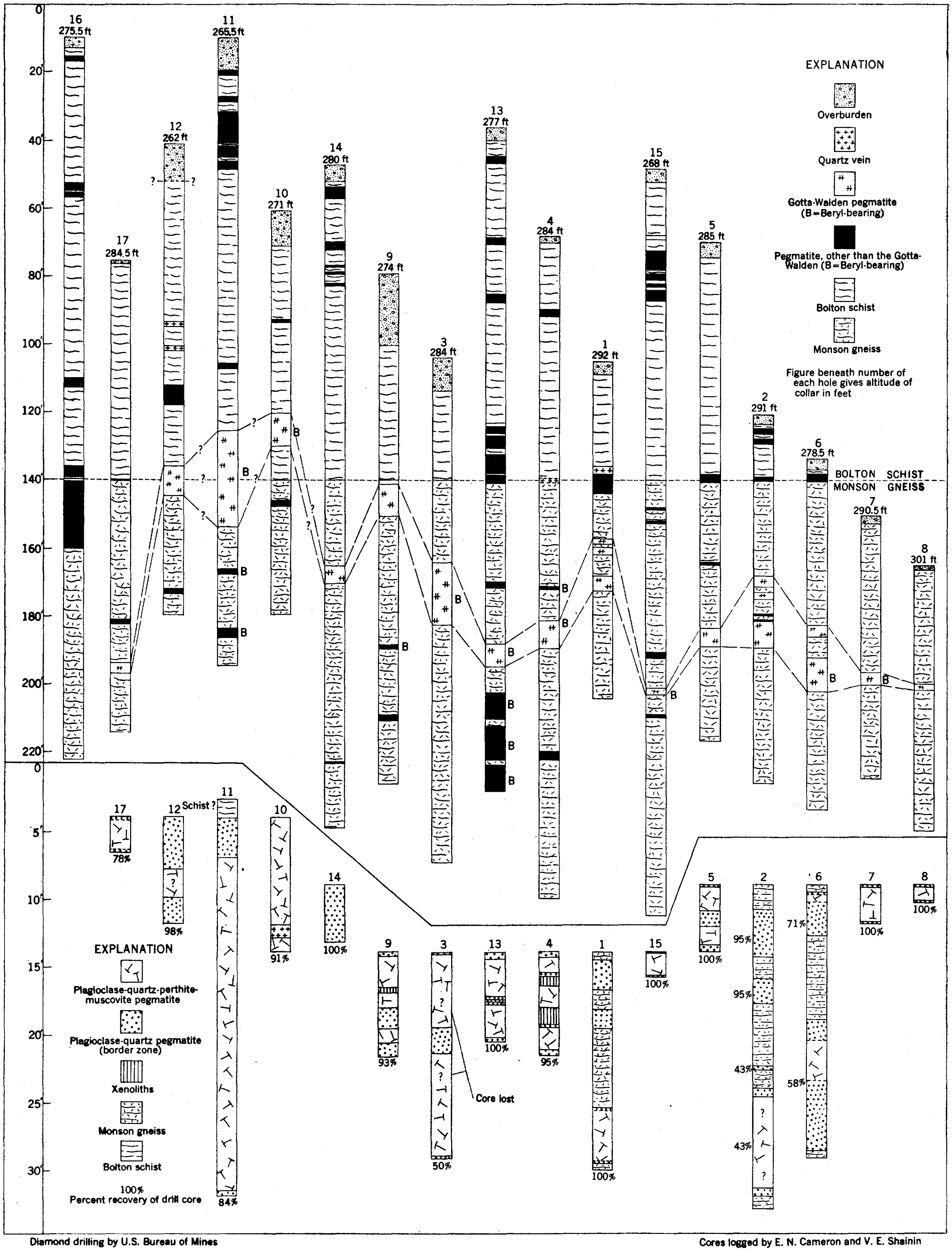


FIGURE 133.—Logs of diamond-drill cores, Gotta-Walden beryl-mica prospect, Portland, Conn.

possible large extension of the pegmatite to the west, but the structure in this area is complex and additional holes would be required to clarify it. The Gotta-Walden pegmatite is one of several of pegmatites exposed in the area mapped. Most of the larger bodies are in schist. None, so far as known, contains either sheet mica or beryl in significant amounts, and they have not been studied in detail.

Adjacent to the Gotta-Walden pegmatite the schists are tourmalinized, enriched in coarse muscovite, and in places intruded by small lenses of quartz and feldspar. The contract of the schist with the pegmatite, however, is everywhere sharp. The gneiss adjacent to the pegmatite has likewise been impregnated with tourmaline in places and enriched in granular muscovite. The effects described commonly extend only a few inches or a few feet from the contact. Xenoliths of gneiss, however, show various degrees of soaking, recrystallization, and impregnation with quartz, feldspar, and beryl. In the first stage biotite and hornblende disappear and the gneiss is enriched in granular dark-gray muscovite. In advanced stages, the amounts of quartz and feldspar increase, beryl appears, the texture of the muscovite coarsens, and the outlines of the xenolith become vague. Many xenoliths have been exposed by quarrying and exploration; most are a few feet or less in diameter.

The Gotta-Walden pegmatite is a fine- to coarse-grained mixture of quartz, plagioclase, and muscovite, with subordinate perthite and accessory beryl, garnet, tourmaline, apatite, columbite-tantalite(?), pyrite, and flourite. The minerals are grouped into the following zones from the walls inward:

1. Quartz-plagioclase border zone, ½ to 5 feet thick. Fine-grained to medium-grained quartz and plagioclase, with accessory muscovite, garnet, tourmaline and beryl. Much of the zone has an aplitic texture.
2. Muscovite-quartz-plagioclase wall zone, 1 to 5 feet thick. A medium- to coarse-grained mixture of quartz and plagioclase with muscovite books 2 to 25 inches in diameter and ½ to 12 inches thick. Many of the mica crystals are elongate parallel to the *C*-axis. Accessory minerals are beryl, garnet and tourmaline.
3. Plagioclase-quartz-perthite-muscovite zone, 3 to at least 20 feet thick. This seems to be the core of the pegmatite. Plagioclase (cleavelandite in part) and quartz are the predominant minerals. Perthite is abundant in places, but commonly is present only as scattered anhedral crystals as much as 39 inches long and 12 inches thick. Muscovite books 2 inches or less in diameter are abundant in places. Beryl, tourmaline, garnet, and columbite-tantalite are minor accessories.

The border zone is peresent along the margins of the pegmatite everywhere at the surface and in all the drill holes except hole 10, which is one of the three holes in which the Gotta-Walten pegmatite cannot be identified with certainty. The wall zone, however, appears to be present only along the hanging wall. At the surface it extends from pit 9 and the main opencut about 100 feet southeast along strike. It was present in the shaft along the line of section *B–B′*. It probably was struck in drill hole 2, in the lowest or main branch of the pegmatite, and may be represented by core losses in drill holes 3 and 6. In other drill holes it was either absent or, if small core losses in a few drill holes represent the mica zone, so thin as to be negligible as a source of mica. The plagioclase-quartz-perthite-muscovite zone was found in most of the drill holes, but is absent in holes 9 and 14.

The structure is complicated by the zoning of the pegmatite in relation to the xenoliths and also to the walls. The xenoliths have various positions in the pegmatite. Most of the xenoliths are enveloped in border zone material, and two exposed in the largest cut are rimmed by book-mica zones. The presence of xenoliths and accompanying border zones in probably responsible for much of the repetition of zones shown in the drill logs.

In 1942, three parallel veinlike bodies, 4 to 8 inches wide, striking N. 69° E. and dipping 55° NW. were exposed in pit no. 15. The veins cut the pegmatite but apparently did not extend into the walls. One body was composed entirely of quartz, but the other two showed discontinuous selvages of plagioclase ½ to ¾ inch thick along their walls. The centers of the bodies were composed of fine-grained to coarse-grained quartz with scattered euhedral crystals of microcline, plagioclase, and beryl. Similar veinlike bodies have since been exposed in the face of pit 19.

Beryl occurs as golden, yellow-green and green subhedral to euhedral crystals. Most of the crystals are less than 2 inches long and less than 1 inch in diameter, but a few crystals 6 to 8 inches long and 3 to 5 inches in diameter have been found, and one crystal 16 by 13 inches is exposed. The crystals are commonly glassy and free of intergrown minerals. Most of the crystals are too small to separate by hand cobbing.

Beryl is present in all the units of the pegmatite, including the late veinlike bodies, and is also found in the partly digested xenoliths. It appears to be most abundant in the border zone, the wall zone, and the upper part of the plagioclase-quartz perthite zone. On the basis of counts of beryl crystals exposed in the trenches and pit faces, the average beryl content of the pegmatite at the surface is estimated to be 0.84 percent. The tonnage of pegmatite underlying the area outlined on plate 44 is about 71,500 tons. If the grade of 0.84 percent beryl is maintained in depth approximately 600 tons of beryl is present in the area outlined. However, the figure for grade is based on counts on surface exposures only. The drill cores show clearly that at depth the pegmatite varies in the proportions of the various units, and corresponding variations in grade are probable.

Book mica from the deposit is hard to moderately hard, greenish to grayish rum muscovite. All of the many books examined are fit only for scrap, owing to ruling, cross-fractures, warping, hair-cracking, tangle-sheet, pinholes, and minute mineral inclusions. So far as known, no sheet or punch mica was recovered during 1942.

The predominant feldspar is plagioclase, mostly intergrown with quartz. It seems unlikely that the pegmatite could be mined and the feldspar separated profitably by hand sorting. Milling and separation by flotation or other means would be required to recover beryl from the pegmatite. Byproducts of such an operation would presumably be scrap mica, quartz, and feldspar of high soda content. The attitude of the pegmatite would permit opencut mining above the level of opencut 8, but below this level underground mining would shortly be necessary. Under technologic and economic conditions of 1942–44 the operation of the deposit was not considered feasible.

HALE-WALKER BERYL PROSPECT

The Hale-Walker prospect lies in the town of Portland, 1.1 miles N. 26° E. of the northwestern end of Jobs Pond. It may be approached from Portland by travelling eastward on U. S. Highway 6A to its junction with State Highway 15. Travel 0.6 mile northwestward on Highway 15 to an asphalt road that leads northeastward. At a point 0.2 mile from this junction a woods road, passable only in dry weather, leads north from the gravel road. The woods road follows a winding course for about 1,400 feet to the dump of the workings.

The pegmatite (fig. 134) crops out on land owned jointly by Charles F. Walker, R. F. D., Portland, and Harry L. Walker, R. F. D., Glastonbury. It may extend eastward beneath overburden to land owned by Clifford Hale, R. F. D., Portland. In 1932 two small cuts were opened on the Walker property by the Eureka Flint & Spar Co., Portland, and were worked for 3 or 4 months for feldspar. According to Mr. William Wilkes, superintendent, about 70 tons of no. 1 feldspar was recovered. Both quarries have since been idle. The upper opencut is 25 feet long, 9 feet wide, and 1 to 10 feet deep. The lower opencut is 38 feet long, 10 feet wide, and 5 to 18 feet deep. Both pits are free of water and probably contain little backfill. The prospect was mapped by E. N. Cameron and V. E. Shainin in May 1943.

The pegmatite is a tabular body at least 180 feet long and 6 to 8 feet thick. It ranges in strike from N. 79° W. to east and dips 63° to 74° SW. The dike is sharply discordant to the enclosing granite-gneiss (Monson gneiss), whose foliation strikes N. 20° W. and dips westward at moderate to steep angles. The contact between the Monson gneiss and the Bolton schist lies 60 feet west of the westernmost exposure of the pegmatite. The pegmatite does not seem to extend across the contact.

The dike, a disseminated type of beryl deposit, consists chiefly of quartz and perthite. It has a border zone and a core. The border zone is ½ to 1 inch thick and is composed of fine-grained quartz, plagioclase and tourmaline. The core consists of medium- to coarse-grained quartz and perthite with subordinate amounts of plagioclase, muscovite, and accessory beryl, tourmaline, columbite-tantalite and monazite. Monazite is rare.

Most of the beryl occurs in the core, either with small anhedral crystals of perthite scattered in a matrix of coarse quartz, plagioclase and accessory tourmaline, or with fine-grained quartz, plagioclase, and accessory tourmaline.

The beryl is green to blue-green and occurs in crystals 0.2 to 2 inches long and 0.1 to 2 inches in diameter, but most of the crystals are very small. Beryl is visible in all outcrops of the pegmatite. Counts and measurements of crystals were made on carefully cleaned surfaces at both the upper and lower quarries. At each quarry the surfaces measured across the dike, but the areas could not be distributed uniformly over the full width. Therefore, each surface was subdivided into sections to determine whether the beryl distribution is systematically related to the dike walls. No such relationship was found; therefore a simple average of the results for each quarry is deemed sufficient. The data are presented below.

Quarry	Number of crystals	Area of beryl (square inches)	Total area of rock (square inches)	Percent beryl
Upper	162	25.3	12,343	0.21
Lower	101	13.5	5,826	.23
Total or average	263	38.8	18,169	0.21

Assuming an average beryl content of 0.21, about 2.2 tons of beryl should be present for every 10 feet the pegmatite extends down dip if it maintains an average thickness of 7 feet.

Books of green to gray-green muscovite are small, scarce, and marred by structural defects. It is doubtful whether they are capable of yielding a satisfactory

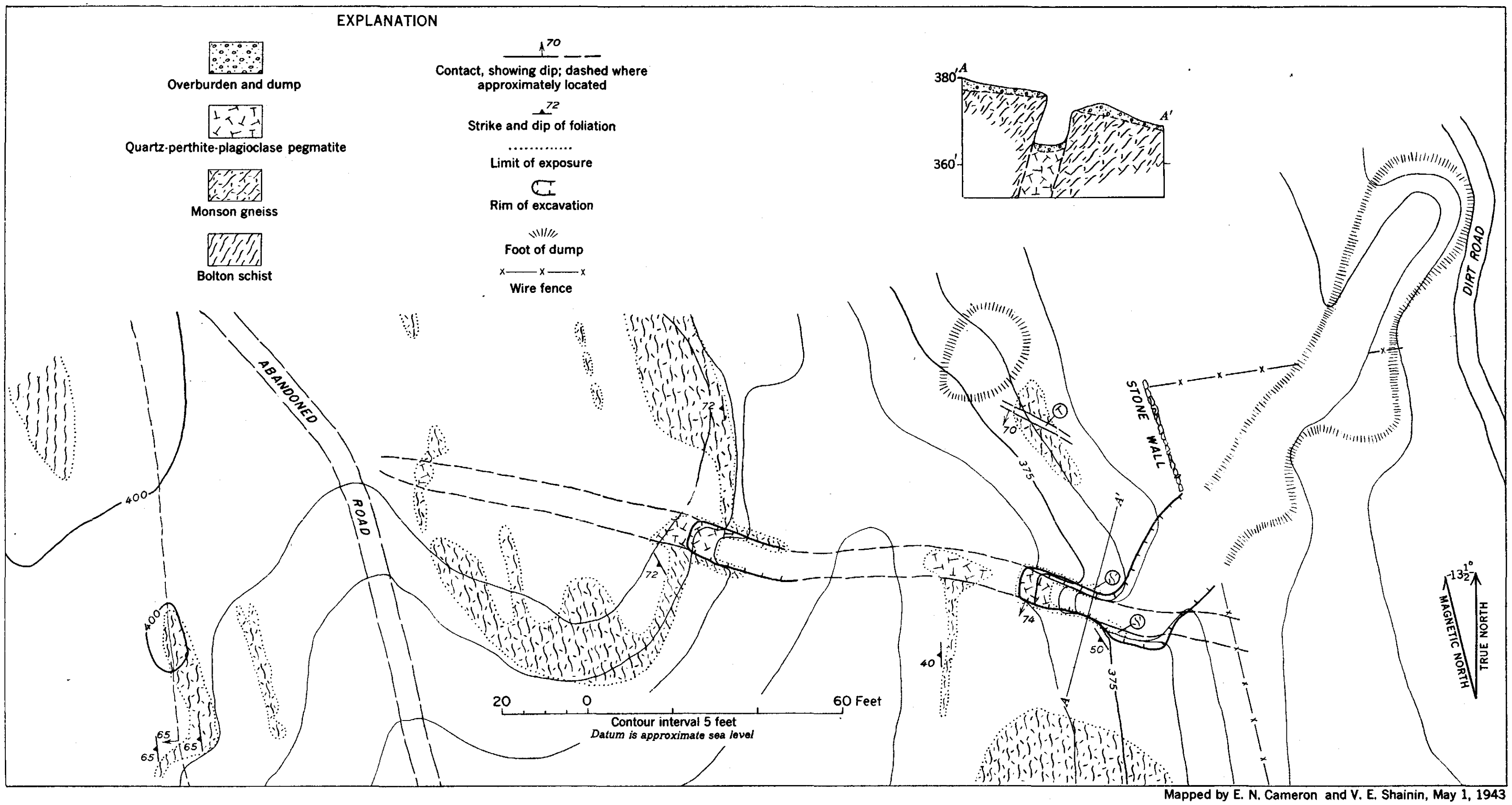


FIGURE 134.—Geologic map and section of the Hale-Walker beryl prospect, Portland, Conn.

percentage of sheet mica. Small amounts of coarse pure perthite are present but most of the perthite is intergrown with quartz and other minerals.

MARKHAM MICA MINE

The Markham mica mine lies in the town of East Hampton, 1.5 miles S. 45° E. of the village of Cobalt. From Cobalt travel 0.8 mile east on U. S. Route 6 to the Colchester road; proceed east on this road for 0.4 mile; turn southward on a gravel road that leads 1.3 miles to the deposit. The workings lie in rolling woodlands, about 100 feet east of the gravel road.

The property is owned by Mrs. Grace Markham and her two sons. Mining was started by Peter Armando, of Glastonbury, and Romano Milanese, of Higganum, who leased the property and operated it intermittently from November 1943 to April 1944. In March 1944, when exaimned by V. E. Shainin, the working was an open pit 25 feet long, 12 feet wide, and 14 feet in average depth. The long axis of the cut had a trend of N. 65° W.

The opencut is in an irregular pegmatite that strikes N. 30° E. and dips 65° NW. The pegmatite is exposed only in the cut. It is about 20 feet thick, and is concordant with the foliation of the enclosing medium-grained quartz-mica schist (Bolton schist). Two schist screens lie 4 to 6 feet below the ground surface. The screens are roughly parallel to the walls of the pegmatite, extend across the width of the opencut, and each is about 2 feet thick.

The pegmatite is composed chiefly of quartz and perthite; it possesses a border zone and core. The border zone is 1 to 6 inches thick and consists of fine-grained quartz, plagioclase, and muscovite. Essential minerals in the core are medium- to coarse-grained quartz, perthite and muscovite. Garnet, tourmaline, biotite and apatite are accessories.

The pegmatite is a disseminated mica deposit. Hard, pale green and pale ruby mica occurs in scattered books that range from ½ to 4 inches in diameter and average 2 to 3 inches in diameter. The books are heavily intergrown with tourmaline, feldspar, and quartz, and probably contain less than 1 percent of sheet mica. Common defects are "A" structure, reeving, limonite-staining and cross-fracturing. Subhedral inclusions of flattened tourmaline are common; ruling and wedging are present, but are uncommon.

The workings were abandoned because the percentage of mica in rock moved was low and the content of sheet mica in mine-run mica was low. The exposed part of the pegmatite is unpromising as a source of sheet mica, and it is unlikely that a better deposit exists at depth.

REEB MICA MINE

The Reeb mine lies in the town of East Hampton, 1.6 miles S. 39° E. of Cobalt Village. From Cobalt travel 0.7 mile eastward on State Highway 6A to State Highway 16A. Drive 0.7 mile eastward on Highway 16A to its intersection with a gravel road; follow the gravel road 1.6 miles southward to the mine road, which leads 700 feet northwestward to the workings.

The property (fig. 135) is owned by J. Reeb of East Hampton. Operations were conducted on a small scale prior to 1942. The mine was operated intermittently from July 1942 to July 1944 by Joseph Carini, R. F. D., South Glastonbury. It was mapped by E. N. Cameron and V. E. Shainin in May 1943. At that time, the working consisted of a quarry 75 feet long and 15 feet in average width and depth, and three small prospect pits. When visited in September 1944 the quarry was flooded.

The pegmatite is an irregular body, probably lenticular, containing many large inclusions or projections of wall rock. It is at least 800 feet long and has an outcrop width of 250 to 300 feet. Only the footwall contact is exposed. It strikes due north, dips 50° to 70° E. and in general is concordant with interbedded quartz-mica schist and mica quartzite. The wall rock contains abundant tourmaline crystals adjacent to the pegmatite contact. Several shear joints that strike about due north and dip gently west cut both pegmatite and wall rock.

The pegmatite consists of quartz, plagioclase, perthite, muscovite, and small amounts of garnet and tourmaline. A poorly defined zonal structure is visible in the workings. The border zone, 3 to 6 inches thick, consists of quartz, muscovite and subordinate plagioclase. The wall zone, 1 to 3 feet thick, contains quartz, plagioclase, muscovite, perthite, and accessory garnet and tourmaline. Mica forms books up to 15 inches broad and 5 inches thick. The zone is present throughout the length of the quarry but the mica content varies considerably from place to place. The probable core of the pegmatite consists of coarse-grained quartz, plagioclase, scrap muscovite, and subordinate perthite. Accessory minerals are tourmaline, garnet, and a little beryl.

The mica books are pale ruby and range from soft to hard. Most of the books are stained by limonite, and quartz and feldspar films occur along many of the cleavages. "A" structure, ruling, cross-fracturing, and tanglesheet are common. In part, the structural defects are probably due to movement along shear surfaces.

Most of the feldspar in the pegmatite is heavily intergrown with quartz. Some pure perthite is present and

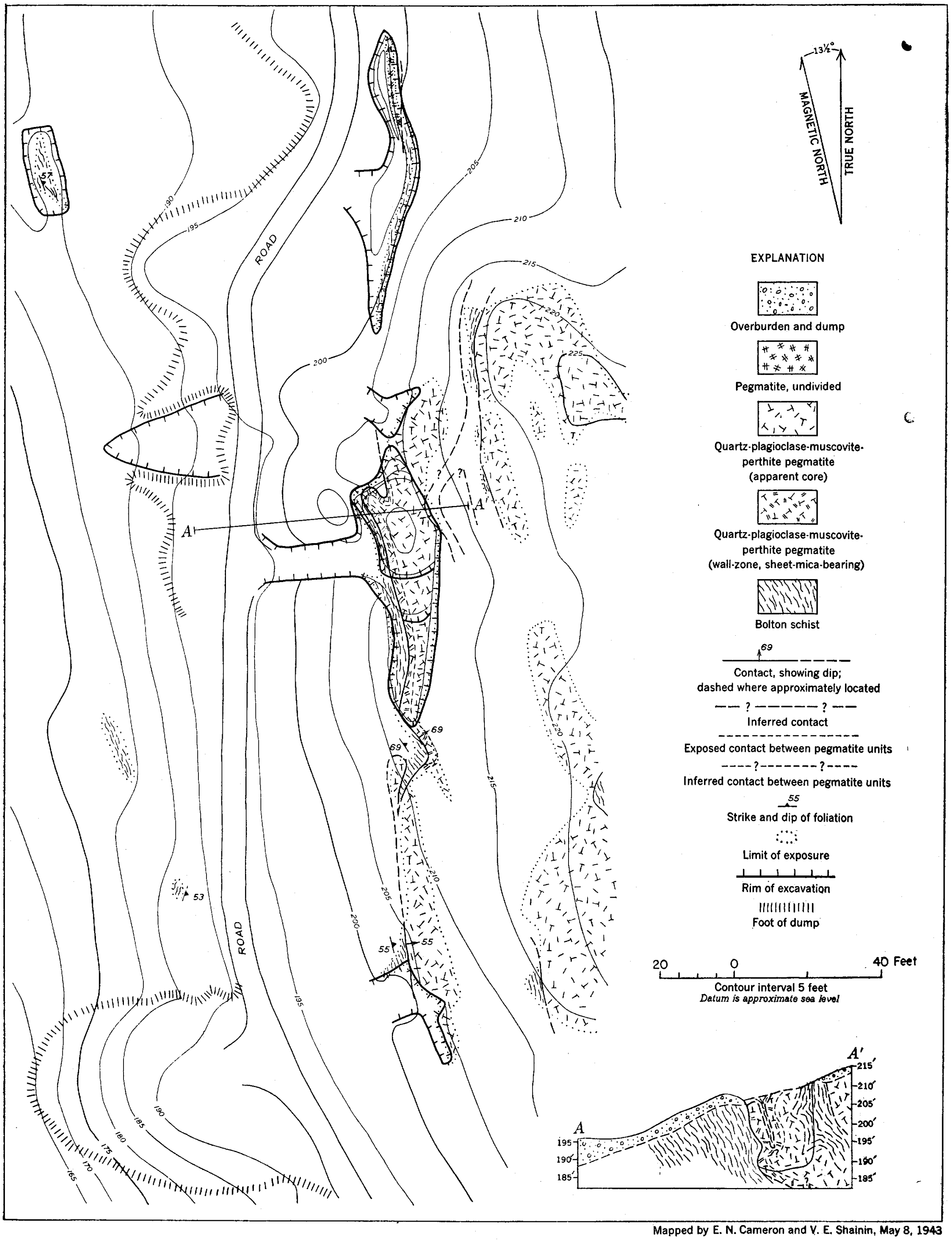


FIGURE 135.—Geologic map and section of the Reeb mica mine, East Hampton, Conn.

could be separated by hand cobbing, but much of it is stained by limonite.

The extremely irregular form of the footwall proved a hindrance to operations. Limonite-staining of the mica books can be expected to disappear below the level of oxidation, but structural defects, which have caused an abnormally low recovery of sheet mica, cannot be expected to disappear. It is doubtful that enough sheet could be recovered to support a profitable operation even under economic conditions such as those of 1943 and 1944.

RIVERSIDE QUARRY

The Riverside quarry lies about 0.5 mile west of Benvenue, in the town of Middletown. A short distance west of the underpass of the road along the river beneath the railroad, an overgrown road leads south and west for about 800 feet to the quarry.

The quarry was described briefly by Bastin (1910, p. 50). In February 1943, E. N. Cameron and V. E. Shainin examined it briefly for beryl and mica. It is an opencut, about 85 feet long and 10 to 40 feet deep, that trends about N. 80° E. The pegmatite is an irregular body intruded into biotite-hornblende gneiss, the foliation of which strikes east. According to Bastin the pegmatite extends at least 300 feet southwest of the cut. Bastin found some beryl, but none could be found in 1943. Bastin reported that feldspar of good quality was being extracted in 1907, but that operations ceased in 1908. No large body of high-grade feldspar was visible in 1943. All mica seen was of scrap quality.

ROBERTS MICA PROSPECT

The Roberts prospect lies in the town of Haddam, 5.5 miles S. 15° E. of the city of Middletown. From Middletown drive 3.6 miles south on Chauncey Road to an unpaved road, then 1.9 miles south on this road. The prospect lies on rolling upland, about 3,000 feet south of this point along a poor woods road. The property is owned by Earl C. Roberts of Chauncey Road, Middletown. It was not under lease, and no exploration work had been done when it was examined by V. E. Shainin in March 1944.

The pegmatite lies in quartz-mica schist (Bolton schist) and appears to be a nearly vertical lens that strikes approximately N. 10° E. It seems to be 200 feet long and 100 feet thick. It has a poorly defined border zone and a core that encloses irregular pods and is cut by a fracture-controlled mica deposit.

The pegmatite consists essentially of medium- to coarse-grained quartz and perthite, with minor amounts of muscovite and plagioclase. An area of about 400 square feet at the northern end of the pegmatite consists almost solely of coarse quartz and subhedral perthite crystals associated with books of sheet mica. The books occur clustered around the margins of the many irregular quartz pods. The books average about 3 inches in diameter, but some are 6 inches in diameter and 4 inches thick. About 20 percent of the books are wedge-shaped. The mica is colorless or very pale ruby and appears to be fairly hard. No staining of any kind was observed in the books examined.

Books of mica, slightly smaller than those described above, occur also in a fracture filling extending from the coarse quartz and perthite into medium-grained pegmatite. The vein is about 15 feet long and ½ foot wide; its attitude could not be determined.

Experience with pod and fracture-filling mica deposits has shown they are commonly sporadic in distribution and separated by considerable volumes of barren pegmatite. It seems, therefore, that this prospect could yield only small amounts of book mica per ton of rock moved.

SELDEN PROPERTY

The Selden property is in the town of East Hampton, 2.9 miles S. 30° E. of Cobalt village. From the intersection of Highways 6 and 151 in Cobalt, follow Highway 151 for 2.45 miles to the intersection at Hurd Park entrance. Turn left and drive 0.35 miles. At this point the gravel mine-access road turns right. Follow the gravel road for 0.25 mile to the property.

The Worth Spar Co., of Cobalt, has owned and operated the property since August 1942, and has been engaged partly in prospecting for sheet mica, but chiefly in mining feldspar for use in floor-cleaning compound. Four opencuts in two pegmatites have been made on the property. The pegmatites are enclosed concordantly in quartz-mica schists and mica gneiss of the Bolton schist.

Three of the opencuts are in the west pegmatite, a tabular body about 25 feet thick that strikes N. 27° W. and dips about 70° E. The pegmatite can be traced for at least 800 feet along strike. In the southernmost quarry its keel seems to plunge north at a low angle. The pegmatite is a varied mixture of perthite, graphic granite, plagioclase, and smoky quartz, with accessory muscovite, biotite, garnet, tourmaline, and rare beryl. The muscovite is amber, clear, and hard. The books are mostly less than 4 inches broad and are commonly cross fractured. They are sparsely scattered through the central part of the pegmatite. The mica is largely scrap, but some small sheet mica has been obtained. Some coarse perthite and graphic granite is found, but most of the feldpsar produced is intergrown with other minerals.

The East Selden prospect (pl. 46) consists of an irregular opencut. It is in a pegmatite lens that strikes N. 25° W., dips about 70° E. and seems to plunge southward. The lens is about 200 feet long and has a maximum thickness of 34 feet. At the north end its keel is exposed; its plunge is uncertain. At the south end, the enclosing schist extends partly over the pegmatite, and the crest seems to plunge southward at an angle of 20°–30°. The contacts show sharp rolls. Those at the south end of the deposit plunge south. The most conspicuous roll, however, exposed along the footwall at the north rim of the cut, plunges N. 35° W. at an angle of 40°. A thin, steeply dipping basic dike cuts the pegmatite south of the opencut.

The pegmatite consists of quartz, plagioclase, and muscovite, with subordinate perthite, and accessory beryl, garnet, tourmaline, and columbite-tantalite(?). Quartz is the most abundant mineral. The pegmatite is poorly zoned. The border zone, 1 to 6 inches thick, consists of quartz, muscovite, and plagioclase. Inside this is a wall zone consisting of fine- to medium-grained quartz, muscovite, and plagioclase, in highly varied proportions, with minor amounts of perthite and accessory beryl, garnet, and tourmaline. Unevenly scattered through this are pods of coarse quartz, perthite, plagioclase, muscovite, and beryl. The largest pod lies under the roll at the north rim of the quarry, but prior to mining both roll and pod extended 25 feet south along the headwall. The pod was about 8 feet by 6 feet in maximum cross-section. Beryl, feldspar, and muscovite were concentrated in a zone around the margins of the pod. Similar, but smaller pods were found just east of the opencut, at the north end of the pegmatite, and south of the trap dike that cuts the pegmatite.

In the north end of the lens, along parts of the footwall and along the hanging wall near the keel, the part of the wall zone 1 to 3 feet from the wall is notably richer in beryl than elsewhere. No distinct beryl-bearing zone can be traced at present, but it might be possible to do so if the exposures were less obscured by lichens. Along the hanging wall near the keel, some of the beryl crystals extend inward from the contact, increasing in size toward the center of the pegmatite.

Book mica from the pods, the only source of sheet mica in the pegmatite, is amber, hard muscovite, clear or stained with rust. Some books contain tourmaline inclusions. Cross-fractures, "A" structure, and ruling are common defects, but some sheet is reported to have been obtained. Books up to 12 by 8 by 2 inches are numerous around some pods, but the pods are small and sparsely scattered. The average content of book mica large enough to yield sheet is very low for the pegmatite as a whole.

Beryl forms light-green to white, sharp-edged crystals ranging from 1 inch long and ⅛ inch in diameter to 10 inches long and 3 inches in diameter. The larger crystals are zoned. Some show intergrowth with feldspar and quartz, but most seem pure. In an attempt to determine the average beryl content of the pegmatite, the beryl crystals visible in 722 square feet of exposures were measured. On this basis, the average beryl content is estimated at 0.34 percent and inferred reserves of beryl for every 12 feet the pegmatite extends in depth with its surface dimensions would be 15.7 tons. The estimate is open to two objections. First, a considerable part of the beryl is associated with pods along the footwall, and there is no basis for predicting the size, beryl content, or abundance of pods in depth. Second, another large part of the beryl is in the part of the pegmatite along the footwall. Owing to the distribution and condition of the exposures, most of the surfaces measured were in the footwall half of the pegmatite, and a thorough sampling of the full width of the pegmatite was impossible. If the part of the pegmatite lying within 5 feet of the footwall is taken, the average beryl content indicated by crystal measurements is 0.48 percent. On this basis, inferred reserves for every 12 feet this part of the pegmatite extends into depth would be approximately 4.8 tons.

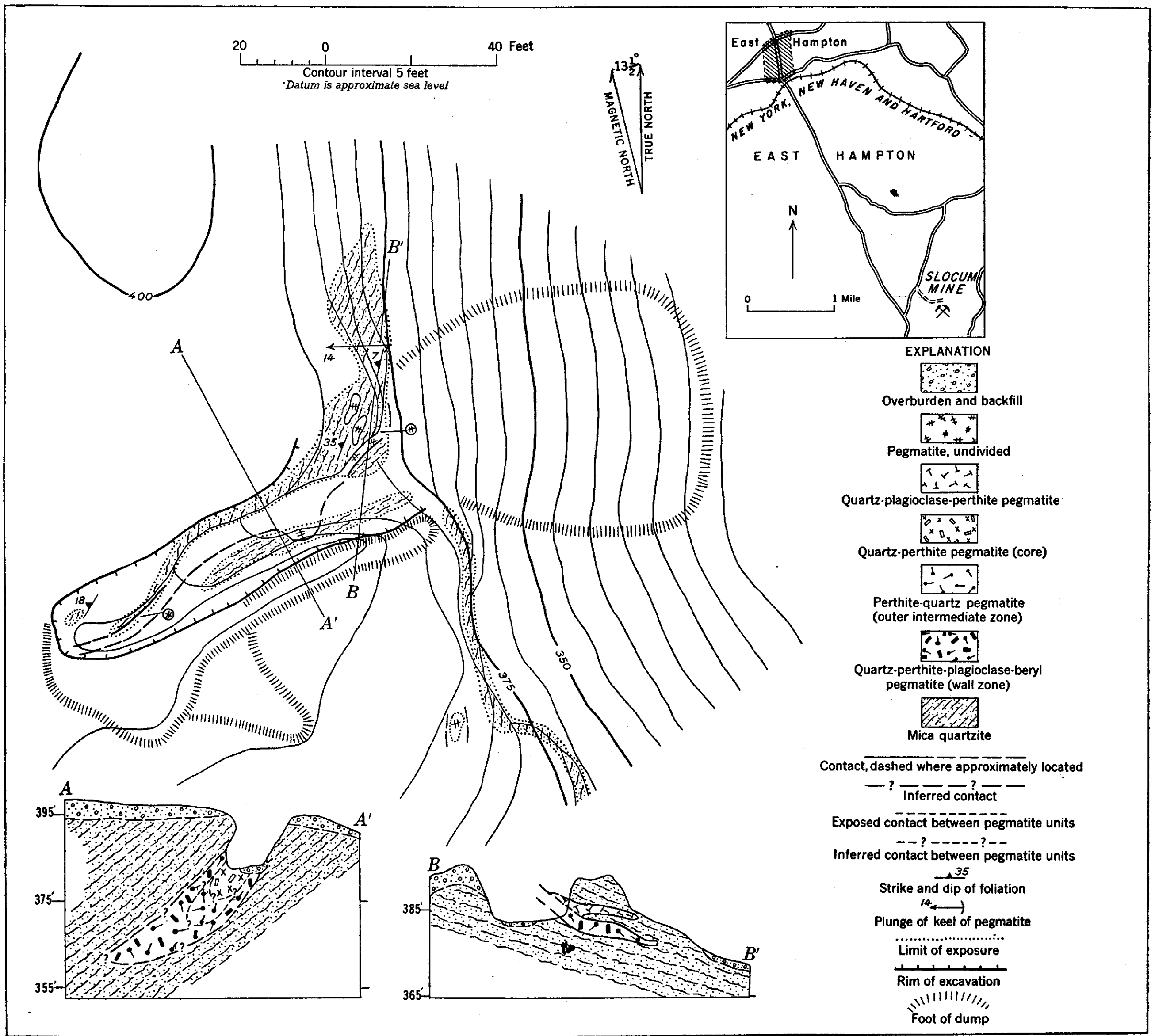
Reserves of high-grade feldspar in the deposit appear small. Columbite-tantalite(?) is present in minute, rare crystals.

SLOCUM BERYL PROSPECT

The Slocum prospect lies in the town of East Hampton, 3.5 miles S. 43° E. of East Hampton village. From East Hampton travel southward on an asphalt road from the intersection of State Highways 16 and 16A. The asphalt road leads southeastward 2.7 miles, to the land of Edwin Slater. From this point a wood road leads across the Slater property ½ mile to the deposit.

The property is owned by Edwin Slater, R. F. D., East Hampton. According to local reports, feldspar mining was begun about 1890 by John White. F. A. Slocum later purchased the property and mined feldspar between 1920 and 1922. The prospect was mapped by E. N. Cameron and V. E. Shainin in August 1943 (fig. 136). It is a partly backfilled opencut 90 feet long, 20 feet wide, and 2 to 15 feet deep.

The pegmatite is a lenticular body at least 80 feet long. It ranges from 1 to about 10 feet in thickness and has an average thickness of 8 feet. It strikes N. 70° E. and dips 18°–60° N. In the cliff east of the quarry the pegmatite ends down dip 25 feet from its exposure in the working. Its keel plunges S. 82° W. at a gentle angle. East of the quarry the pegmatite has been completely removed by erosion, but it may extend westward beneath glacial till. East of the cut the beryl-bearing pegmatite truncates an older, barren, pegmatite. The latter consists of quartz, plagioclase,



Mapped by E. N. Cameron and V. E. Shainin, August 1943

FIGURE 136.—Geologic map and sections of the Slocum beryl prospect, East Hampton, Conn.

perthite, and minor muscovite. The beryl-bearing pegmatite is discordant to thin-bedded mica quartzites whose bedding and foliation strike slightly north of east and dip gently westward.

The pegmatite is distinctly zoned. The border zone is ¼ to 12 inches thick and consists of fine-grained quartz, plagioclase and perthite, with accessory garnet, tourmaline, and beryl.

The wall zone, 1.2 to 1.6 feet thick, consists of quartz, perthite, and plagioclase, with accessory beryl, black tourmaline, scrap muscovite, and rare biotite and columbite-tantalite. The zone becomes progressively coarser-grained toward the center of the pegmatite. Its inner part is nearly free of beryl.

The outer intermediate zone, 1 to 6 feet thick, consists of coarse-grained white to cream-colored perthite and granular quartz. The zone is exposed only at the eastern end of the core where it is an indistinct hood-shaped body between the wall zone and the core.

The core-margin zone, 6 inches to 1 foot thick, consists of granular milky quartz, coarse-grained perthite, and subordinate beryl. Quartz and perthite are about equal in abundance. Thiz zone is too thin to be shown on structure section A–A′ (fig. 136). Its relations to the outer intermediate zone are not clearly shown.

The core is probably 5 to 7 feet thick but only its upper margin is visible. It consists of granular milky quartz and a few scattered perthite crystals.

Beryl occurs in the pegmatite in yellow ("golden"), green, and blue euhedral crystals. In the border zone they range in size from 1/32 to 1/2 inch in diameter and from 1/2 inch to 2 1/2 inches long. Crystals as much as 8 inches in length and 1 inch in diameter occur in the core-margin zone.

The long axes of most of the beryl crystals in the pegmatite lie perpendicular or nearly perpendicular to the walls of the pegmatite. Many show a progressive increase in diameter toward the center of the pegmatite. Beryl is associated with all the other minerals and shows no preferred association. Black tourmaline forms mantles around some beryl crystals.

Measurement of all the beryl crystals exposed in the opencut (including parts of the wall zone, core-margin zone, intermediate zone and core), gave a beryl content of 0.54 percent. Measurements covering only the wall and border zones along the line of section B–B′ (fig. 136) gave 0.07 percent beryl. The difference in the values obtained for the beryl content is due to the absence of the rich core-margin zone in the part of the pegmatite included in the second count.

The pegmatite as exposed at present is of small extent along strike. The chief hope of finding substantially more beryl lies in the chance that the pegmatite may extend westward beneath overburden, and that the quartz core, with its rich marginal deposit of beryl, may be longer than it seems, because of the plunge of the pegmatite. The average beryl content of the whole pegmatite is unknown, but present exposures indicate that it may be 0.5 percent or more.

STATE FOREST NO. 1 QUARRY

The State Forest No. 1 quarry lies in the town of East Hampton, 2.3 miles N. 55° W. of the center of East Hampton village. From East Hampton travel northward along the western shore of Lake Pocotopaug for 1.5 miles to an asphalt road leading westward. Follow this road for about 1.5 miles, then turn northward on a gravel road that leads about 1/2 mile to the quarry.

The property is owned by the State of Connecticut and is administered by the Forestry Department, State Office Building, Hartford. The New Haven Trap Rock Co., 67 Church Street, New Haven, quarried the pegmatite in October and November 1942, and the Worth Spar Co., Inc., Cobalt, operated the deposit for 3 months in the summer of 1943. The workings consist of an opencut about 90 feet long, 40 feet wide and 15 feet deep. E. N. Cameron examined the property in November 1942.

At the time of examination, the pegmatite was so poorly exposed that its form, attitude and extent could not be determined. Probably it strikes north-northeast. At the entrance to the quarry, and on the east side of the cut, pegmatite is exposed in irregular crosscutting contact with quartz-mica schists. However, it is not certain whether the schists are the true walls of the pegmatite or merely inclusions in it.

The pegmatite is composed chiefly of coarse-grained quartz and plagioclase, intergrown in various proportions. Muscovite, garnet, tourmaline, and beryl are also present. Pods of perthite and of quartz and perthite as much as 4 feet long and 2 feet wide are irregularly distributed through the pegmatite.

Mica books 2 to 15 inches in diameter and 3/4 to 4 inches thick are present in the pegmatite. At the time of examination, however, the quarry walls were obscured to such an extent that the distribution of the mica could not be determined satisfactorily. According to the quarrymen, most of the mica mined in 1942 was associated with a pod of coarse-grained quartz and perthite.

The mica is a clear, light rum, moderately hard, free-splitting muscovite. Most books are free of inclusions, but some contain garnet and plagioclase crystals. All the books are more or less marred by "A" structure, ruling, and cross-fracturing, and many books are wedge-shaped. Beryl occurs as crystals 1 to 8 inches in length and 1/2 to 5 inches in diameter.

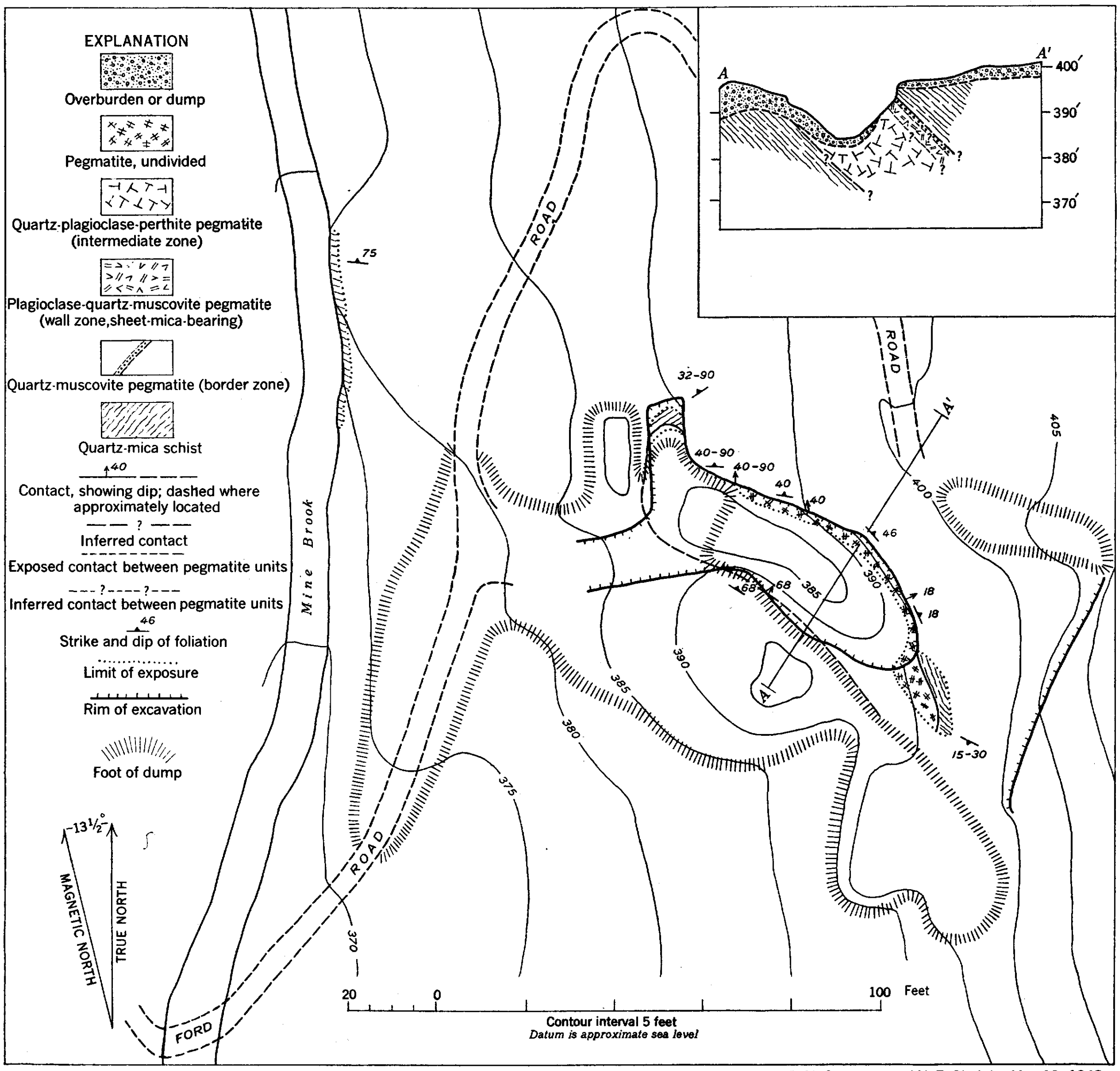
Mica was found associated with one or more pods, and scattered books of mica occur elsewhere in the pegmatite. The average percentage of crude mica recovered from rock mined was very low, however. Neither of the attempts made to mine the deposit in 1942 and 1943 was successful.

STATE FOREST NO. 2 MICA MINE

The State Forest No. 2 mine is in Meshomasic State Forest about 0.8 mile north-northeast of Cobalt village. From Cobalt an all-weather road leads north toward Great Hill Pond. At 0.65 mile, a dirt road turns off eastward and follows a winding course for 2,200 feet to the west bank of a brook opposite the mine.

The mine is owned by the Forestry Department of the State of Connecticut. During the summer of 1942, it was worked by J. Carini, South Glastonbury, who recovered a few tons of mica. From February to August 1943, the mine was operated by F. and J. Burrone Bros., North Branford, and a small production of mica was maintained. The mine was visited in March 1943 by E. N. Cameron and V. E. Shainin and was mapped in May 1943 (fig. 137). At that time the only working was an opencut about 80 feet long, 10 to 20 feet wide and 10 to 20 feet deep, but the cut was largely backfilled.

The mine is in a tabular pegmatite enclosed in, and roughly concordant with, northward-dipping quartz-mica schist (Bolton schist). The body strikes N. 5°



Mapped by E. N. Cameron and V. E. Shainin, May 19, 1943

FIGURE 137.—Geologic map and section of the State Forest No. 2 mica mine, East Hampton, Conn.

W. to N. 50° W. and has been traced for about 90 feet. The dip of the hanging wall ranges from 18° NE. to vertical, but in general is 40° to 45° NE. The footwall is uneven but is probably about parallel to the hanging wall. The pegmatite ends at the northwest end of the cut in a blunt nose that plunges steeply northward. Just southeast of the quarry rim, the pegmatite seems to plunge beneath schist, but this may be due to a roll in the wall similar to several found during mining.

The pegmatite shows border, wall, and intermediate zones and a discontinuous core. The border zone, 2 to 3 inches thick, consists of fine-grained quartz and muscovite, with accessory apatite and tourmaline. The wall zone consists of coarse plagioclase and quartz, with scattered muscovite books 2 to 10 inches broad and ¼ to 5 inches thick. Accessory minerals are biotite, apatite, tourmaline, and garnet. The wall zone is 3.5 to 4 feet thick along the hanging wall where exposed. The corresponding part of the pegmatite along the footwall was not exposed.

The intermediate zone consists of coarse quartz, perthite, and plagioclase with subordinate muscovite and accessory biotite, apatite, tourmaline, and beryl. The zone encloses lenses of quartz with books of muscovite around their margins. The quartz lenses are probably segments of a discontinuous core, with a poorly defined discontinuous muscovite-bearing core-margin zone.

Mica from the mine is light rum moderately hard muscovite, mostly free splitting, and clear except where stained by limonite. Structural defects, expecially ruling, crumpling, cross-fracturing, and waves, mar most of the books, but an average yield of about 3.8 percent equivalent sheet was obtained from the crude product. Most of the mica came from the wall zone, but some was obtained from the margins of the quartz lenses. The yield of crude mica from rock moved was about 1.3 percent.

Light-green beryl occurs in crystals 1 to 5 inches in diameter and 1 to 17 inches long. Most of the crystals are large enough to be sorted by hand but some are intimately intergrown with quartz and plagioclase. Beryl was found chiefly in the nose of the pegmatite at the northwest end of the quarry, in the intermediate zone. The average content of the zone is very low.

Both coarse plagioclase and perthite are present in the intermediate zone, but commonly are intergrown with quartz, tourmaline, and other minerals. The deposit is not promising as a source of feldspar.

The pegmatite appears to be small and the book-mica content is low, but recovery of sheet mica from the crude product was satisfactory. Under conditions comparable to those of 1943–44, it might repay efficient opencut mining, but it is doubtful whether the underground operations that would soon be required could be maintained profitably. The removal of backfill from the workings would involve considerable expense, especially as the topography does not favor disposal of waste.

STRICKLAND AND CRAMER MINES

The Strickland and Cramer mines are on Collins Hill, 2 miles east-northeast of Portland village. Follow Route 17A from the village center for 1.2 miles, to an intersection at a monument. Turn right and follow a hard-surfaced road 0.64 mile to the west side of Collins Hill. From this point follow a gravel road northeast 0.3 mile to the mines, which are on opposite sides of the road.

The Strickland mine (pl. 47) lying south of the road, is owned by F. E. Strickland, Portland, Conn. It was opened before 1900, but its early history is not known. In 1907 the property was leased to Eureka Mica & Mining Co., which operated it steadily until 1937. In 1907, according to Bastin (1910, p. 51–53, "the working extended along the hillside for 100 feet but was not excavated to any considerable depth." Sterrett (1923, p. 65–67) reports that by 1914 the west cut was about 200 feet long, 50 feet wide, and 25 feet deep, whereas the main (east) cut was about 300 feet long, 65 feet wide, and 10 to 40 feet deep. The two workings were connected by a crosscut trench leading to dumps on the hillside west of the mine. After 1914, operations appear to have been confined chiefly to the main cut, which is largely in the Strickland pegmatite. The north end was deepened to an altitude of about 180 feet (main floor level) between 1914 and 1937, and high chambers were opened southward and northward from it. A tunnel was run into the west wall between the lines of sections EE′ and FF′ (pl. 48) and parallel to the wall of the cut, from which it was left separated by a narrow partition. From the west wall of the tunnel, a crosscut drift was run 95 feet to intersect another pegmatite overlying the Strickland pegmatite. A room was excavated in this pegmatite northward and southward from the drift. From the south end of the main cut, at elevation 242 feet, a chamber 7 to 10 feet high was run southwestward so as to form an extension of the upper part of the high chamber already excavated southward from the main floor level.

The mine was shut down in 1937. Operations to this time were conducted primarly for feldspar, but mica deposits were struck as the cut was deepened, and there was a large production of mica from 1930 to 1937. Quartz and small amounts of beryl were also obtained.

In June 1942, unwatering of the main pit began, and mining was resumed in September. Between this time and January 15, 1945, mica and feldspar were mined from the east wall at the north end of the main pit, from pillars at the north end of the quarry and just inside the north chamber, and from the west wall. The west wall was sliced down between the north end of the quarry and the mouth of the south chamber, and the partition separating the opencut from the drift was removed. Debris from this work covers the floor of the pit between section lines EE′ and FF′ (pl. 48) to depths of 10 to 30 feet. A winze was sunk in the floor of the north chamber and another just south of the line of section EE′, and from these short drifts were run at an altitude of about 165 feet.

There are other small openings on the Strickland property, made at various times prior to 1937. None were markedly productive.

The Cramer property is owned by Charles W. Cramer, Hartford, Conn. Mining on the property began in 1934, when the property was leased to Connecticut Mica & Mining Co. A shaft 24 feet square was sunk to intersect the northward extension of the Strickland pegmatite at an altitude of about 200 feet. The pegmatite was stoped up-dip to about 240 feet. Sub-levels were then carried northward along strike. The shaft was later deepend to an altitude of about 180 feet. The *A* level was then extended northward to the crest of the pegmatite, reaching it in the summer of 1942. Above this level the workings consist of a single inclined open stope, supported by pillars. Between 1942 and the closing of the mine in May 1945, an inclined winze from a point near the south end of the mine was sunk to about 125 feet, the *B* and *C* levels were driven, and pegmatite between the *C* level and the *A* level was partly stoped out.

The Cramer mine was operated primarily for mica, but some feldspar was produced prior to 1942, and a few tons of beryl was obtained.

The mines are one of the best-known pegmatite localities in New England, and the literature contains many discussions, of the pegmatites, of their minerals, and of related problems of paragenesis (Bastin, 1910; Foye, 1919, 1920, 1922, 1929; Sterrett, 1923; Schairer, 1926; Schairer and Lawson, 1926; Rice and Foye, 1927; Foye and Lane, 1934; Jenks, 1935).

The mines were mapped by E. N. Cameron, G. B. Burnett, and J. T. Callihan in November and December 1942. Periodic examinations were made by Cameron and V. E. Shainin in 1943 and 1944, and the mapping was revised and extended periodically by them and by Cameron and J. J. Page. Shainin made numerous visits during 1943, 1944, and 1945 to examine the workings and extend the maps. From June to October 1944, exploratory diamond drilling was done by the U. S. Bureau of Mines in cooperation with the Geological Survey (fig. 138). S. B. Levin was project engineer for the Bureau, and V. E. Shainin was project geologist for the Geological Survey.

GEOLOGIC RELATIONS

The summit of Collins Hill is underlain partly by the Bolton schist, partly by Monson gneiss. The Bolton schist consists of interbedded quartz-mica, schists and micaceous quartzites, with thin amphibolite lenses. Bedding and foliation seem to be essentially parallel except at crests of minor folds. Drag folding is conspicuous along axes that in general plunge northeast at angles of 10° to 30°. The Monson gneiss is a biotite-hornblende granite-gneiss showing either well-developed foliation or lineation, or both. The contact between the two rock units runs roughly parallel to the crest of the hill and close to its crest. Both rock units have been invaded by pegmatites. Some of these have been mined or prospected, but the principal mining has been done in a series of steeply dipping pegmatite lenses intruded into the Bolton schist.

Most of the pegmatites are massive or poorly zoned; only the Strickland pegmatite and the pegmatite mined in the west cut show well-developed zonal structures. The pegmatites strike roughly north and dip steeply west. Exposures in the workings, together with exploratory work of the Bureau of Mines, indicate that the bodies are greatly elongated lenses, with principal axes that plunge northward or southward at low to moderate angles. Their walls seem to parallel the wall rock foliation but locally are sharply cross-

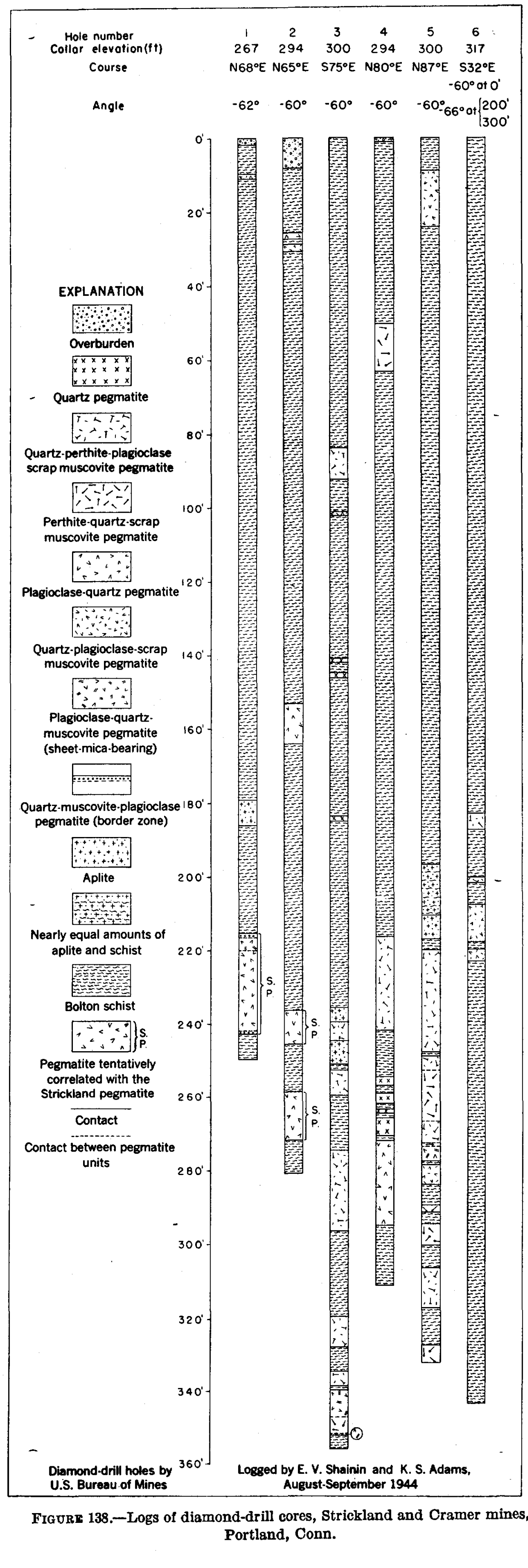


FIGURE 138.—Logs of diamond-drill cores, Strickland and Cramer mines, Portland, Conn.

cutting. However, the relations of the pegmatites to the regional foliation are obscured by secondary foliation, crumpling, and shear structures adjacent to contacts. In the north end of the Strickland mine, the Strickland pegmatite transects an alaskitic pegmatite and southward progressively approaches the next overlying pegmatite. Evidently, either these two pegmatites or the Strickland pegmatite is discordant to the regional foliation.

Schist-pegmatite contacts are typically sharp. Adjacent to pegmatites the schists are tourmalinized, with local silicification and feldspathisation.

STRICKLAND PEGMATITE

The Strickland pegmatite is probably the largest pegmatite lens on the property. It has been exposed for 720 feet along strike in the workings, has a maximum breadth of at least 240 feet measured along the dip, and ranges from 8 to about 60 feet in thickness. Its strike ranges from N. 20° W. in the south end of the Strickland mine to N. 20° E. in the north end of the Cramer mine. It dips 30° to 75° westward. The crest of the lens is exposed in both ends of the main quarry, from which it plunges gently northward and southward. The keel was exposed in the Cramer workings between the 140-foot and 125-foot levels, at a point where it is nearly horizontal, and its position can be partly inferred from the drill holes. The position and shape of the keel beneath the Strickland mine, however, are uncertain.

In cross section the pegmatite is characterized by deep outward synclinal rolls separated by sharp keels. The axes of most of the rolls plunge northward at angles of 5° to 25°, but there is much variation, even within parts of the mines, so that individual rolls are not satisfactory guides to the plunge of the pegmatite. The axes of a few synclinal rolls encountered are nearly parallel to the dip of the pegmatite. In the anticlinal rolls the schist is minutely crumpled along axes parallel to the rolls and is sheared along the axial planes of the crumplings.

The pegmatite is composed essentially of quartz, plagioclase, perthite, graphic granite and muscovite. Biotite, tourmaline, spodumene, garnet, apatite, and beryl are minor constituents, but are abundant in places. Lepidolite, uraninite, columbite-tantalite, potash-albite (?), lithiophilite, pyrite, fluorite, cookeite, montmorillonite, amblygonite, and other minerals have been observed during the present studies or reported in the literature, but are not abundant.

The pegmatite is divisible into five principal lithologic units: border zone, plagioclase-quartz-muscovite wall zone, perthite-graphic granite-quartz-plagioclase zone, plagioclase-quartz zone, and quartz-plagioclase core.

1. The quartz-muscovite-plagioclase border zone, 1 to 8 inches thick, is composed essentially of fine-grained quartz, muscovite, and subordinate albite (An_{5-9}), with accessory garnet and tourmaline. In general, the zone contains more plagioclase along the footwall than along the hanging wall. It is a nearly continuous envelope enclosing the rest of the pegmatite.
2. The plagioclase-quartz-muscovite wall zone is 1 to 7 feet thick. It is medium- to coarse-grained rock and contains accessory black tourmaline and garnet. Muscovite forms books 2 inches to 6 feet broad and ½ to 12 inches thick. Small amounts of cleavelandite (An_{1-4}) are present in places, but most of the plagioclase is massive (An_{5-10}). The mica zone is restricted to the intermediate and lower levels of the north end of the Strickland workings. In the Cramer mine its upper edge, along both the foot and hanging walls, lies roughly along the upper limit of the workings (pls. 46, 47). Where the zone is thick two parts are recognizable. The outer 1 to 2 feet are rich in blocky, medium- to coarse-grained plagioclase and books of muscovite. The inner part contains more quartz. The larger books of muscovite commonly extend across both parts of the zone. The matrix of the books grades inward into the plagioclase-quartz zone (zone 4) described below, in parts of the pegmatite in which zone 3 is absent.
3. The perthite-graphic granite-quartz-plagioclase intermediate zone ranges from 1 to about 22 feet thick. The principal mineral is coarse blocky perthite in crystals as much as 15 feet in maximum diameter, with subordinate quartz, in part graphically intergrown with perthite, various amounts of plagioclase (An_{4-8}), and accessory black tourmaline and garnet. In places the perthite is veined and partly replaced by quartz, cleavelandite, and associated minerals. Mineral proportions within the zone are various. It is very rich in perthite at the north end of the Strickland quarry, in the intermediate levels. Toward the crest, however, the grain size decreases, and graphic granite, plagioclase, and quartz are more abundant. Southward the content of quartz and plagioclase gradually increases, and toward the south end of the quarry, the zone merges with the plagioclase-quartz zone to form a telescoped zone consisting of anhedral crystals of perthite and graphic granite embedded in a matrix of medium-grained quartz and plagioclase. This unit is designated plagioclase-quartz-perthite pegmatite on the maps and sections.

   The perthite-graphic granite-quartz-plagioclase zone is probably a composite of two ill-defined zones—an upper and outer zone, found in the crest of the pegmatite and the south workings, characterized by abundant graphic granite as well as perthite and subordinate plagioclase, and an inner zone, characterized by abundant perthite and containing little graphic granite. The boundaries between the two units cannot be traced satisfactorily, partly because they intergrade, partly because in the main quarry the pegmatite has been largely mined out or is concealed beneath debris.
4. The plagioclase-quartz intermediate zone is as much as 45 feet thick, and composed essentially of medium-grained quartz with subordinate plagioclase (An_{4-8}), sparsely scattered coarse perthite anhedra, and accessory garnet and black tourmaline. Boundaries between this zone and the perthite-graphic granite quartz-plagioclase zone

are gradational, except where obscured by later quartz, cleavelandite, and associated minerals.

5. The quartz-rich core is composed almost entirely of quartz, but contains small amounts of massive plagioclase. This unit is exposed only on the *A* level of the Cramer mine (pl. 48, sec. *B–B'*), where it is enclosed in material of the plagioclase-quartz zone.

Relationships of the inner zones are not entirely clear, largely because key portions of the pegmatite have been removed or are concealed. In the south end of the Strickland quarry (plan of 242-foot level, sections *F–F'*, *G–G'*), plagioclase pegmatite is overlain and underlain by quartz-perthite-graphic granite pegmatite. Inferences drawn from this relationship are shown in the sections and the plan of the 242-foot level. In the Strickland north underground workings, however, and in the south end of the Cramer mine, the relationships are uncertain, but in general, the plagioclase-quartz zone occupies the entire center of the pegmatite in the lower levels of the mine, whereas the perthite-graphic-quartz zone occupies it in the upper levels. In the south end of the Strickland mine the two zones merge.

Relationships between the two zones have been obscured by the develooment of quartz and fine- to coarse-grained cleavelandite, with small amounts of golden and green beryl; black, blue, and green tourmaline; manganapatite, amblygonite, columbite-tantaline, garnet, spodumene, lepidolite, and probably other minerals. These minerals are found throughout the pegmatite but are most abundant in the intermediate and lower levels of the mines, especially in the north end of the Strickland mine and in the Cramer mine. Their distribution is irregular, and it has not been feasible to show them separately except in section *E–E'*. In other sections they are included mostly in the plagioclase-quartz zone. Much perthite has been replaced marginally and along fractures by these minerals, so that the original extent of the perthite-graphic granite-quartz-plagioclase unit down dip is no longer clear.

In the present studies, a distinction is made between cleavelandite (An_{1-3}) and blocky massive plagioclase (An_{5-10}) of the zones. The possibility that the plagioclase-quartz unit is not a zone but a unit developed by replacement of the perthite-graphic granite-quartz plagioclase zone cannot at present be excluded. However, much cleavelandite, quartz, and associated minerals clearly have been formed by replacement of perthite along fractures, whereas perthite replaced by massive plagioclase along fractures appears to be rare. Development of the plagioclase-quartz zone by replacement of perthite is suggested chiefly by the presence of anhedral masses of perthite in the zone, but this feature likewise may be due to reaction of the crystals with rest liquid at an early stage in the development of the zone.

Biotite is not a common mineral in the pegmatite, but is abundant in highly irregular patches in the southern half of the Strickland main quarry. It occurs as tourmalinized strips intergrown with muscovite and associated with plagioclase and quartz. These patches cut across zone boundaries in places and are evidently due to replacement, probably controlled by fractures.

MICA FROM THE STRICKLAND PEGMATITE

Mica mined from the Strickland pegmatite is rum to greenish amber, soft to moderately hard, clear to stained muscovite, forming books ½ to 12 inches thick and 2 inches to 6 feet broad. The books are marred in various degrees by reeving, A-structure, ruling, and cross-fractures. Magnetite inclusions are present in many books, especially in mica from the part of the wall zone along the footwall. Minute transparent inclusions, probably of quartz and garnet, are abundant in many books. The larger inclusions cause pinholes that are readily apparent to the unaided eye, but the smaller ones cause holes which, although troublesome, are much more difficult to detect. In general, mica recovered from the Strickland workings during 1942–45 was superior to that from the Cramer mine, which was softer and more severely marred by structural defects. Sheet recovery was below the average for New England in the Cramer mine, above average in the Strickland. Of the sheet recovered, a high percentage of both mines was of No. 2–A or better quality. The output of the two mines places the Strickland pegmatite among the most productive mica pegmatites in the country with a total yield estimated at more than 4,500 tons of mine-run mica.

OCCURRENCE OF SHEET MICA

Sheet mica has been recovered chiefly from the wall zone. The zone is richer and more persistent and contains mica of higher quality along the hanging wall than along the footwall, and the hanging-wall part of the zone was the major source of mica in both mines during the period 1942–45. Sheet mica was also found in scattered bodies of quartz, cleavelandite, and associated minerals, especially in the Cramer mine, but mica of this type is softer and, in general, inferior to that of the wall zone.

The wall zone has been mined for nearly 600 feet along the strike, and for as much as 150 feet down-dip. Drill-hole 1 indicates that the zone may continue, in the Strickland quarry, below an altitude of 70 feet, which would give the zone a dip length here of more than 170 feet. The known extent of the zone is indicated by the plans and sections. Many of the thickest portions of the zone accompany rolls of the walls. Some of these shoots have been extraordinarily productive, but they are relatively small in proportion to the mica zone as a whole. In the Cramer mine, however, the thickness varies systematically on a much larger scale than that of the rolls. (See pl. 47, isopach map.)

Up-dip from a line followed roughly by the east limit of the present workings, the hanging-wall mica zone is lacking. Down-dip from the line, the hanging-wall zone is present and thickens within a short distance to 3½ to 7 feet. The thickened part occupies an irregular belt 65 to 95 feet broad, measured along the dip, and it plunges irregularly northward. Down-dip, the belt is bounded by thinning of the wall zone to 1 to 3 feet, with local barren spots. When the original isopach map was made, the shoot had been tapped only down to the "*A*" level. Since then it had been struck successively in the "*B*" and "*C*" levels. A well-defined ore shoot thus exists within the wall zone. Production of mine-run mica from this zone has ranged from 2 to 3 times the production from other parts of the zone. The ore shoot seems to extend into the north end of the Strickland mine.

Along the hanging wall, below the main ore shoot, small areas of the wall zone are barren. The largest barren area was found in the winze just south of the line of section *E–E′*. Here the zone contained little book mica.

Whether a similar shoot exists in the footwall part of the zone is uncertain. Large parts of this zone have been removed, and most of the rest is concealed by debris. In places it is lacking, and plagioclase-quartz material is directly in contact with the border zone.

The yield of crude mica from rock mined in the Cramer mine during 1942–45 was 9.1 percent. In the Strickland mine the yield was less, but large sections of wall rock were removed along with pegmatite. Data available suggest a relation between content of recoverable sheet and the distribution of quartz-cleavelandite rock. Where this material underlies or penetrates the wall zone, sheet recovery, in general, has been lower than elsewhere. Probably deformation during the development of quartz-cleavelandite material influenced not only its distribution but also the character of the mica. In places, quartz and cleavelandite have penetrated or partly replaced muscovite books along cleavages.

Other variations in sheet content are obviously related to post-pegmatite deformation. In the north end of the mine, the pegmatite is much sheared in all the lower levels. The mica books are crushed and broken and have yielded little sheet.

Book mica in the central part of the pegmatite is found with quartz-cleavelandite pegmatite and appears to have formed with it. The mica "pockets" share the irregular distribution of the quartz-cleavelandite material, but are only sparsely scattered through it. Much of the quartz-cleavelandite material is barren of book mica.

RESERVES OF MICA IN THE STRICKLAND PEGMATITE

Reserves of mica remaining in the Strickland pegmatite are largely in the wall zone in pillars or down dip from the present workings. In pillars the only appreciable reserves are contained in the long partition in the upper part of the Cramer workings and between the *A* and *C* levels. Parts of these pillars might be removed, but in some places the roof is weak, and two large falls from the roof have already taken place. In the lower levels of the Cramer mine the wall zone is relatively lean, except at the north end, and there the mica is badly broken.

Most of the mica minable at the price and cost levels of 1942–44 lies beneath the present workings of the two mines. Their size depends on the position of the keel of the pegmatite and on the extension of the wall zone. The keel was struck in the Cramer mine at an altitude of 125 feet. Nearly horizontal there, north of the line of section *B–B′* it plunges northward at a moderate angle. Drill holes 6 and 3 seem to indicate, however, that north of section *B-B′* the pegmatite does not lie far below the "*C*" level.

South of the line of section *B–B′* the structure below the workings is not clearly indicated. Pegmatites struck in holes 4 and 5 differ in lithology from the Strickland pegmatite. The pegmatite struck between depths of 220.3 and 248.5 feet in hole 5 occurs in the anticipated position and has a thickness of the order anticipated, but may be another lens. In hole 1, however, at a considerably greater depth, pegmatite was cored that strongly resembles the Strickland pegmatite, lacking only the wall zone along the footwall. This seems to indicate a southward pitch of the keel between hole 4 and hole 1. South of hole 1 the structure is likewise unclear. Two pegmatites encountered in hole 2 are interpreted in the section as apophyses of the Strickland pegmatite, but they may well be different lenses. In any case, the mica zone probably does not extend as far south as the line of section *F–F′*. With these considerations in mind inferred reserves as of August 1944, below the workings, were estimated at 1,880 tons of mine-run mica. Most of this lies beneath the northern and middle parts of the Strickland mine.

FELDSPAR

The Strickland quarry was operated primarily as a feldspar mine until 1937. The source of feldspar was the perthite-graphic granite-quartz-plagioclase zone, from which No. 1 and No. 2 feldspar were separated by hand-cobbing. The feldspar is a light-buff perthite, said to be somewhat "soft," perhaps due to intergrown cleavelandite. Perthite was mined from the same zone in the large stope at the south end of the Cramer mine. The bottom of this unit was reached at an altitude of about 190 feet. Apparently, the unit was richest in potash feldspar between the lines of sections *C–C′* and *F–F′*. South of this area, the percentage of potash feldspar is less. Some soda spar has been obtained from parts of the pegmatite rich in cleavelandite, but most of the cleavelandite is heavily intergrown with quartz and no attempt has been made to separate it.

Minable reserves of potash feldspar are confined to the south end of the Strickland quarry and the part of the crest remaining north of the main quarry. The unmined part of the crest contains high-grade feldspar, but its extraction would be costly. The average potash feldspar content of the pegmatite in the south end of the quarry is visually estimated at about 30 percent. Part of this is in graphic granite.

BERYL, COLUMBITE-TANTALITE, AND URANINITE

Crystals of golden, green, yellow, and rose beryl as much as 12 inches long and 6 inches in diameter have been recovered from time to time. Almost all the beryl is in quartz-cleavelandite pegmatite, and its distribution is correspondingly uneven. The average content of beryl in the pegmatite as a whole is very low. Some of the beryl crystals are massive and apparently pure; others are heavily intergrown with quartz and cleavelandite.

Columbite-tantalite was observed as scattered small crystals in the plagioclase quartz zone. The amount of the mineral in the pegmatite, however, is neglibible. The only uraninite known to have been recovered from the pegmatite is in the collection of Wesleyan University at Middletown.

Reserves of beryl, spodumene, lepidolite, amblygonite, columbite-tantalite, and uraninite are negligible.

OTHER PERMATITES ON THE STRICKLAND AND CRAMER PROPERTIES

The other pegmatites exposed on the Strickland-Cramer property are mixtures of quartz, plagioclase, perthite, and muscovite in various proportions, with minor amounts of biotite, apatite, tourmaline, cleavelandite, and other minerals. Most are massive or poorly zoned, but the pegmatite worked in the west cut has a quartz core flanked by feldspathic zones. None of the pegmatites appears to have a high content of commercial feldspar or sheet mica. Their beryl content is negligible.

GENESIS OF THE STRICKLAND PEGMATITE

Jenks (1935, p. 181–182) inferred that crystallization of the pegmatite took place in three main phases, as follows:

1. Magmatic phase. Precipitation of quartz, microcline, and muscovite. Conditions essentially magmatic but system perhaps not entirely closed.
2. Transitional stage. Formation of cleavelandite, quartz, tourmaline spodumene, muscovite, lepidolite, beryl, apatite, columbite-tantalite, etc. The stage is termed transitional "because there was at some time during it a change from the magmatic system described above to a mobile, open system dominantly characterized by replacement." (p. 182)
3. Hydrothermal phase. Beginning when albite deposition ceased except as a minor feature. Potash-bearing albite, tourmaline, sulfides, calcite, fluorite, and manganese and lithium phosphates were deposited.

The structural and lithologic units fall into two groups; an earlier group consisting of the zones, and a later group consisting of the replacement bodies. Plagioclase was formed in both groups. Possibly, the quartz-plagioclase zone was developed by replacement of the perthite-graphic granite-quartz-plagioclase zone, but there is no evidence that the border zone, wall mica zone, perthite-graphic granite-quartz-plagioclase zone, and quartz-rich core were developed by successive replacement of existing massive pegmatite. The persistence of the first three of these zones and the constancy of their spatial arrangement contrast sharply with the structural pattern of the quartz-cleavelandite replacement bodies and suggest a different mode of origin. Two main stages in the development of the pegmatite indicated, an early stage during which the zones were formed, and a later stage during which quartz, cleavelandite, and associated minerals were developed along channels provided chiefly by fracturing of the zones. Evidently the early state was considerably more complex than indicated by Jenk's study, and the internal structure of the pegmatite was largely determined by the events of the early stage.

TOLL GATE MICA-FELDSPAR MINE

The Toll Gate mine lies in the town of Middletown, 3.0 miles S. 50° E. of the city of Middletown. To reach it from Middletown travel southeast on State Route 9 to a point 0.3 mile south of the junction of State Routes 9 and 155. Follow an asphalt town road 480 feet eastward to a gravel road running northeastward. The mine lies at the end of the gravel road, which is 300 feet long.

The property is owned by Ernest S. Bidwell of, Middletown. Most of the mining is said to have been done for feldspar and mica prior to 1896, but intermittent operations were conducted between 1896 and 1926. Fausto Bertolini of New Haven, Conn., worked the mine for mica and feldspar from July 1943 to January 1945.

Surface workings (fig. 139) consist of an open pit 350 feet long, 65 feet in average width, and 30 feet in average depth. Underground workings consist of two inclines, each 45 feet long, and two drifts, each 40 feet long. The underground workings are flooded but not backfilled. The mine was mapped by E. N. Cameron, G. B. Burnett, and J. T. Callihan in November 1942 and resurveyed by V. E. Shaninin and K. S. Adams in August 1944.

The pegmatite is a tabular lens with irregular walls. It is at least 500 feet long and has been mined for a maximum distance of 140 feet down dip. It ranges from 4 inches to 60 feet in thickness, and averages 20 to 25 feet. The pegmatite strikes north-south and dips 50° W; it seems to terminate just north of the workings. It is concordant with the foliation and bedding of fine- to medium-grained quartz-muscovite-biotite schist that has layers of fine-grained quartzite, 1 to 6 inches thick. The wall rock adjacent to the contact is rich in tourmaline and garnet.

The border zone, 1 to 7 inches thick, consists of fine-grained quartz and muscovite with minor massive white plagioclase. The wall zone, 1 to 6 feet thick, consists of fine- to coarse-grained milky quartz, white plagioclase (locally cleavelandite) and accessory sheet-bearing muscovite, perthite and garnet. The zone seems to be present only between the north end of the north drift and the south end of the pit. It is well exposed along the hanging wall, but occurs along the footwall only in the bottom of the southern incline, which, in 1944, was covered by backfill. Mica books are sporadically distributed within the zone. Large parts of the unit are barren; other parts contain more than 30 percent book mica. Possibly some of the concentrated portions form pipelike shoots that pitch northwestward parallel to subdued rolls in the hanging wall. Most of the concentrations, however, seem to be irregular and unrelated to wall rock structure.

The quartz-perthite zone is coarse-grained. It consists of quartz and perthite, with subordinate plagioclase and muscovite, and accessory biotite, apatite, garnet, tourmaline, columbite-tantalite, autunite and torbernite. The outer part of the zone—adjacent to the wall zone—seems to be richer in plagioclase and perhaps, if better exposures were available, the quartz-perthite zone could be divided into 2 zones. Pods of milky quartz as much as 4 by 30 feet lie in the quartz-perthite zone. Mica books of poor quality lie near the margins of some pods. Apatite occurs in aggregates of subhedral pale green crystals that average ¼ inch in diameter. The aggregates are 3 inches to 2 feet in diameter and occur chiefly in perthite masses. Almost all of them contain subhedral plates of columbite-tantalite ⅛ to 1 inch long.

The mica books in the wall zone are pale ruby, and are 4 inches in average diameter and ¾ inch in thickness. Some books exceed 5 feet in diameter and are more than 1 foot thick. Most of the mica is clear, but many books are wedge-shaped and marred by "A" structure, ruling are reeving. The average mica content of the wall zone is probably much less than 5 percent.

Perthite is erratically distributed throughout the quartz-perthite zone. It is estimated that about 20 percent of the zone consists of potash feldspar recoverable by hand-sorting, and that 5 to 8 percent of this might be classified as No. 1 grade. The feldspar occurs in salmon-colored anhedral to subhedral crystals, 6 inches to 7 feet long, and in 1-inch grains in quartz-feldspar aggregates.

Although probably a satisfactory percentage of sheet could be obtained from mine-run mica in future operations, the sporadic distribution of mica in the wall zone would probably require the removal of large amounts of barren rock. It is doubtful that the mine could be operated profitably for muscovite except under economic conditions similar to those of 1943–44.

WHITE ROCKS FELDSPAR QUARRIES

The White Rocks feldspar quarries are located on the slopes and summit of the high knob known as White Rocks, 2.5 miles east of Middletown, on the south side of the Connecticut River. In 1943 E. N. Cameron and V. E. Shainin examined five of the quarries to determine whether they warranted exploration for beryl or mica. No attempt was made to study structural or mineralogical features in detail. Ownership was not investigated, but according to local report (see also Bastin, 1910, p. 49) the quarries were worked many years ago by the Consolidated Feldspar Co.

The quarries are in pegmatites that seem to be large tabular bodies; one has a strike length of more than 1,200 feet. The bodies strike roughly north and dip west at moderate to gentle angles. They are enclosed in feldspathic gneiss and quartz-mica schist.

The pegmatites consist essentially of quartz, plagioclase, perthite, and muscovite, with accessory garnet, tourmaline, beryl and other minerals. Biotite is abundant in one of the quarries. Beryl occurs most commonly in pods, associated with coarse quartz, perthite, and muscovite. Tourmaline is present in some pods. The beryl crystals are as much as 12 inches long and 6 inches in diameter. The pods are small and widely scattered, so that the average beryl content of each

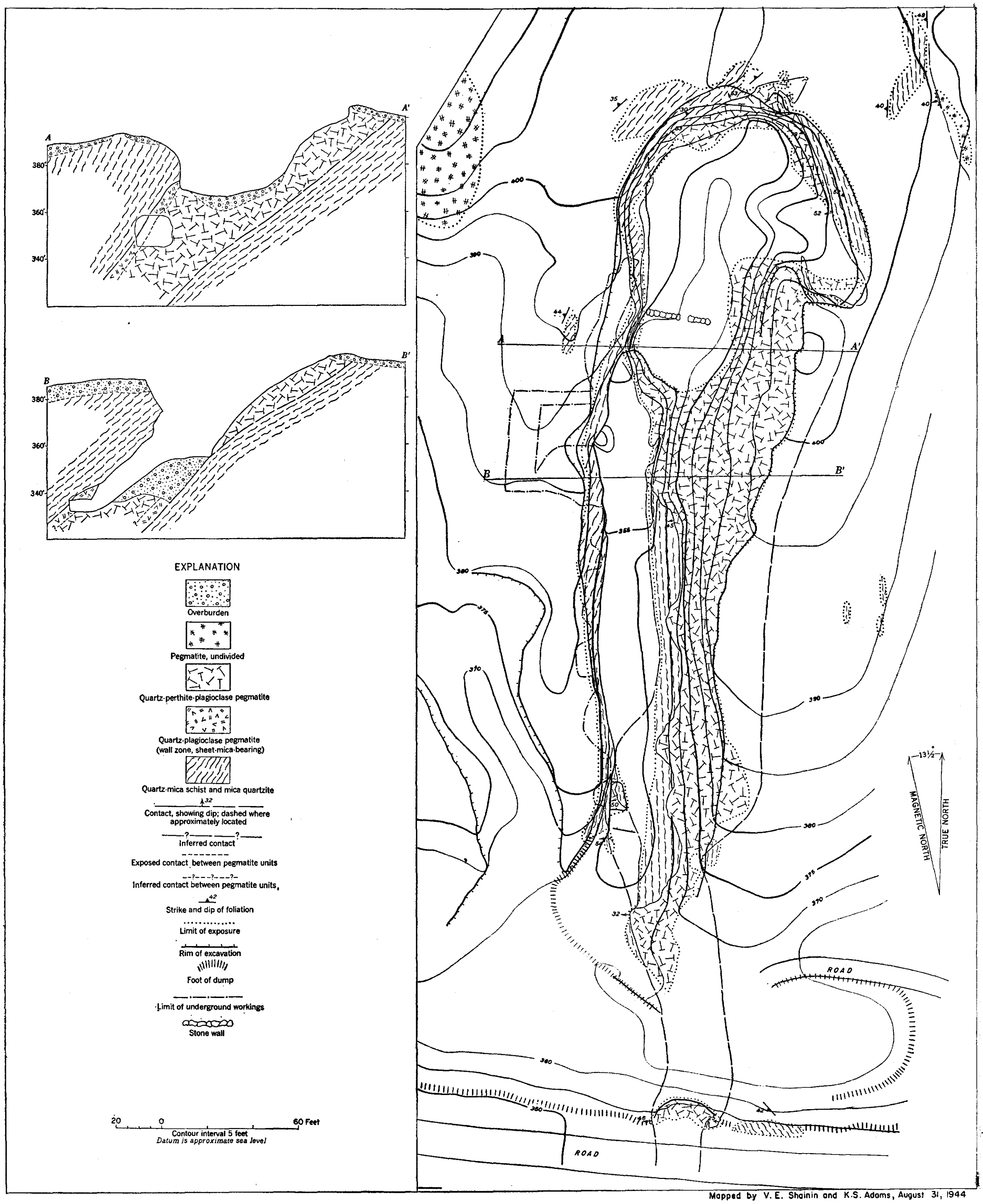


FIGURE 139.—Geologic map and sections of the Toll Gate mica-feldspar mine, Middletown, Conn.

pegmatite is low. In a quarry about 200 feet long, on the north slope of White Rocks just below the summit, beryl occurs also as crystals ¼ to 1 inch in diameter and as much as 1 inch long, sparsely scattered in a medium-grained matrix of quartz, plagioclase, muscovite, and accessory garnet and tourmaline. The average percentage of beryl in this material is very low.

None of the quarries revealed mineable amounts of book muscovite, which occurs only in the pod deposits.

NEW HAVEN COUNTY

SOUTHFORD QUARTZ-FELDSPAR QUARRY

The Southford quarry lies in the town of Southbury, 1.3 miles S. 32° W. of Southford village. From Southford turn west from State Route 118 at the second intersection south of the village. The quarry is 1.3 miles from the intersection and 25 feet east of the road.

V. E. Shainin examined the workings in April 1943. According to Bastin (1910, p. 53–54) the pegmatite was worked for quartz during 1906 and 1907 by the Bridgeport Wood Finishing Co., Bridgeport, Conn. The pit was then about 200 feet long, 100 feet in maximum width, and 40 feet in average depth. In April 1943, it was abandoned and flooded by about 30 feet of water. Insofar as they could be determined, the dimensions were about the same as given by Bastin.

In 1943, pegmatite was exposed only in the south wall of the quarry, where it is locally discordant to overlying contorted biotite-hornblende gneiss. The irregular contact strikes about N. 35° E. and dips 45° to 65° SE. No other contact with wallrock was visible.

Exposed parts of the pegmatite consist chiefly of quartz and microclineperthite with subordinate plagioclase and muscovite, and accessory garnet and tourmaline. Bastin states that chalcopyrite and sulfides of bismuth and lead also occur in the pegmatite.

Despite the inadequacy of the exposures, three zones were distinguished in the pegmatite in 1943. They are, from the gneiss contact inward, as follows:

1. Border zone, 3 inches thick. Fine-grained quartz, plagioclase and muscovite.
2. Quartz-perthite zone, thickness more than 14 feet. Coarse-grained milky to smoky quartz and subhedral pink to white perthite, with minor amounts of plagioclase, garnet, tourmaline, and scattered small deformed books of very heavily stained muscovite, averaging 2 by 3 inches broad.
3. Quartz zone, thickness more than 5 feet. This unit may be the core of the pegmatite. The upper margin is exposed for a length of 20 feet and a maximum depth of 5 feet. It consists of coarsely crystalline milky quartz, apparently pure. Large areas are amethystine.

Bastin reported that beryl is moderately abundant, and that "one crystal on the waste pile was 2 feet long and 1½ feet in diameter." Beryl was not observed in place in 1943, and only a few small pale green crystals could be seen in the old dumps.

The pegmatite evidently yielded fairly large quantities of quartz and feldspar in the past, but because of its flooded condition in 1943 little could be determined regarding its present value as a source of these minerals.

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