Mica and Beryl Pegmatites in Idaho and Montana

GEOLOGICAL SURVEY PROFESSIONAL PAPER 229

Mica and Beryl Pegmatites in Idaho and Montana

By W. C. STOLL

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A description of mines and prospects examined in each district, some illustrated by maps and structure sections

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1950

UNITED STATES DEPARTMENT OF THE INTERIOR

Oscar L. Chapman, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $1.50 (paper cover)

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MICA AND BERYL PEGMATITES IN IDAHO AND MONTANA

By W. C. Stoll

ABSTRACT

In Idaho, pegmatites occur in the metamorphic rocks of the Belt series, of Algonkian age, and in the marginal parts of granodioritic batholiths intruded during late Jurassic or early Cretaceous time. All the pegmatites from which appreciable amounts of sheet mica have been produced lie in mica schist or gneiss. High-quality sheet mica has been produced from 14 properties in Latah County, 1 in Adams County, and 1 in Idaho County. The largest producer is the Muscovite mine, in Latah County. Beryl production has been small. Beryl is present as an accessory mineral in many of the mines, but only in the Muscovite mine does it occur in commercially significant quantities.

Small amounts of sheet mica have been produced from several pegmatites in the Tobacco Root Mountains, Madison County, Mont. These pegmatites lie in the Cherry Creek series, of pre-Beltian age. None of them contains more than accessory amounts of beryl.

The mines and prospects examined in each district are described, and some are illustrated by maps and structure sections.

INTRODUCTION

PURPOSE OF INVESTIGATION

During the period 1939–45 the Geological Survey carried on a program of strategic minerals investigations designed to increase knowledge of domestic resources of minerals needed in war. The geologic information gained was made available to the War Production Board, Metals Reserve Company, Bureau of Mines, and other Government agencies concerned with the production and procurement of strategic minerals. A great number and variety of mineral deposits were examined in detail, and the results of many of the studies are embodied in Geological Survey publications already available or in preparation.

Until the end of 1944 the supply of high-quality sheet muscovite was short, and the Government carried on an extensive program for the encouragement of domestic mica production by private persons. The chief responsibility for increasing the supply was vested in the Colonial Mica Corporation, a Government organization subsidiary to the Metals Reserve Company. A notable increase in production was obtained by payment of subsidy prices to producers, by operation of custom-rifting and trimming plants, and by advancing funds to operators for the development of promising deposits. The establishment of a profitable market stimulated interest and activity in all the mica-producing areas of the United States. Mica mining greatly increased in the older producing regions such as New England and the Southern States. Mines in the southern Black Hills of South Dakota and the Avon district of Idaho, which had previously been idle or producing greatly below capacity, came quickly into production. The Geological Survey assisted the Colonial Mica Corporation and other interested agencies by geologic and economic studies and likewise made useful data available to mine operators. The field work consisted in examining and mapping mica mines and prospects, preparing reserve estimates, and compiling detailed data on production, grade of deposits, and operating costs. The results of the work in Idaho and Montana are given in the present report, which forms part of a broader study embracing most of the major pegmatite areas in the United States.

FIELD WORK AND ACKNOWLEDGMENTS

Most of the known mica and beryl deposits in Idaho and Montana were examined during parts of 1942, 1943, and 1944. The greater part of the field work was done in the Avon mica district, Latah County, Idaho. During several weeks in August and September 1942, E. W. Heinrich made a reconnaissance of the mines and prospects of the district and with L. R. Page made a detailed survey of the Muscovite mine. Unpublished reports and maps[1] based on these examinations were available to the writer and were used in the preparation of the present report. Descriptions of two other mica localities in Idaho, written by R. P. Full and I. G. Sohn, are included herein.

Most of the known deposits in Idaho and Montana were visited by the writer during several weeks in the fall of 1943 and about 4 months in the summer and fall of 1944. Many of the mines and prospects of the Avon district were mapped by S. C. Creasey and the writer

[1] Heinrich, E. W., Some mica-beryl prospects, Avon district, Latah County, Idaho: U. S. Geol. Survey unpublished rept., September 1942.
Page, L. R., and Heinrich, E. W., Beryl-mica deposit, Muscovite claim, Latah County, Idaho: U. S. Geol. Survey unpublished rept., August 1942.

in October 1944. On other occasions the writer was assisted briefly by I. G. Sohn, of the Geological Survey, and William W. Freebury, of Deary, Idaho. Mapping was restricted almost entirely to the immediate vicinities of mines and prospects. During 1943 and 1944 some of the mines were visited by H. M. Bannerman, P. J. Shenon, J. J. Collins, and L. R. Page, all of the Geological Survey.

Data on certain mica prospects examined by engineers of the Bureau of Mines were made available to the writer and are incorporated in the present report. Transit surveys and maps of the Avon mica district made by the Bureau of Mines in the course of a mica exploration program during 1943 and 1944 were made available to the writer. Acknowledgment of material used appears on the maps. Production and quality data were given largely by David Keppel, district manager for the Colonial Mica Corporation in Moscow, Idaho. Operating costs were computed by the writer from numerous financial and production records and estimates and are published by permission of the mine owners or operators concerned.

The writer acknowledges with thanks the aid and courtesies extended him in the field by all the operators and prospectors. Especial thanks are due V. A. Christensen and C. J. Montag & Sons, operators of the Muscovite mine; Burton L. Meier, operator of the Last Chance mine; and C. W. Scott, operator of the White Swan mine. S. H. Lorain, district engineer of the Bureau of Mines, Moscow, Idaho, kindly provided the writer with office space and other facilities. Dean A. W. Fahrenwald and Prof. W. W. Staley, of the School of Mines, University of Idaho, generously made available the use of certain surveying and drafting equipment.

PREVIOUS WORK

Practically all the earlier geologic work on pegmatites in Idaho and Montana was done in the Avon district, Latah County, Idaho. D. B. Sterrett, of the Geological Survey, examined this area in 1910, and the mines then existing were described in two publications [2] of the Geological Survey. The results of later work, by A. L. Anderson, are embodied in a report published by the Idaho Bureau of Mines and Geology.[3] In 1942 the area was reexamined and mapped by J. D. Forrester.[4] Brief mention is made by Sterrett [5] of deposits in Montana and other parts of Idaho. The data presented in these publications, especially those of Sterrett, were freely used in the preparation of the present report. Other sources of information are cited in the text.

HISTORY OF MINING

Early mining of pegmatites in Idaho was done almost entirely in the Avon district, Latah County. The Muscovite mine was first opened in 1888 by Woody and Lamb. Later operations were carried on by the Muscovite Mica Co., of Spokane, Wash.; Alexander Munro, of Moscow, Idaho; and the Producers' Mica Co., of Chicago, Ill.[6] At least 920 tons of crude mica were produced from the Muscovite mine before 1942. The Maybe mine, which included the mines now known as the Last Chance and Silver White, and the Levi Anderson mine, now known as the Steelsmith, were opened prior to 1910.[7] The Luella mine belonged to the Western Mica Co. in 1910,[8] and according to local reports was operated to produce scrap mica during and shortly after the first World War. What is now the Olson mine is said to have been worked about 1905. The Bentz claim, now the Doerr property, was located in 1914 and operated for 3 years by the Washington Mica Co., of Spokane. Throughout the Avon district many old prospect pits and abandoned tunnels indicate considerable activity in times past. The early production of the district is unknown, but undoubtedly the Muscovite mine was the largest producer in the early years as well as in the most recent period of activity, which began in 1942.

The war demand for domestic sheet mica led to renewed development and mining during 1942, 1943, 1944, and the early part of 1945. Victor A. Christensen, of Salt Lake City, Utah, manager of Victory Metals, Inc., started rehabilitation of the Muscovite camp and mine in the fall of 1942 and operated the mine, except for surface leases, until December 1944. Mr. Christensen was largely responsible for obtaining the interest of Government agencies in the investigation and development of the district. In 1943 the United States Forest Service built a mine access road which serves most of the mines. The establishment by the Colonial Mica Corporation of a custom-rifting shop and mica purchasing office in Moscow in the fall of 1943 and the subsequent local purchase of sheet mica of the higher qualities at subsidy prices greatly stimulated mica mining in the Avon district. The Doerr and Steelsmith properties were reopened and mined in 1943, and in 1944 the Last Chance, Luella, and a number of other mines and

[2] Sterrett, D. B., Mica in Idaho, New Mexico, and Colorado: U. S. Geol. Survey Bull. 530–L, pp. 377–383, 1913.
Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 86–93, 1923.

[3] Anderson, A. L., Mica deposits of Latah County, Idaho: Idaho Bur. Mines and Geology Pamph. 14, 1923.

[4] Forrester, J. D., Mica and beryl occurrence in eastern Latah County, Idaho: Idaho Bur. Mines and Geology Pamph. 58, 1942.

[5] Sterrett, D. B., op. cit. (Bull. 740), pp. 93, 105.

[6] Sterrett, D. B., op. cit. (Bull. 740), p. 89.

[7] Idem, pp. 89, 92–93.

[8] Idem, p. 87.

prospects were operated. Intermittently during 1943 and 1944 the Bureau of Mines explored deposits by angledozer trenching. Several new discoveries were briefly worked, and small quantities of mica were produced.

A decrease in the price of mica at the end of 1944 caused a curtailment of mining. By February 1945 all the mines in the Avon district except the Last Chance and the Muscovite had closed. The Last Chance closed in March, and in May 1945 only the Muscovite mine was in operation. From the beginning of operations in 1943 to May 1, 1945, more than 1,500,000 pounds of crude book mica was produced in the Avon district, mostly from the Muscovite mine. To April 6, 1945, a total of 98,958.90 pounds of sheet and punch mica, valued at $433.499.66, had been sold.

Outside of the Avon district there was little early mica mining in Idaho. The Vaught prospect, Boise County, reportedly has been intermittently mined for columbite and mica since about 1900. Sterrett[9] mentions mica samples submitted to him from a deposit that appears to correspond to the Mica Queen mine, in Adams County. The Myers mine, in Idaho County, reportedly was first opened around 1920, but the early production was apparently negligible. A small production was obtained from the Mica Queen and Myers properties during 1943 and 1944. Attempts were made to work prospects in other parts of Idaho, but for the most part they met with failure.

Only small quantities of mica have been produced in Montana. The best known properties, including the Montana, Big Chief, and White Swan, are in the Tobacco Root Mountains, Madison County. It is said that the Montana mica mine was first opened about 1905 and mica was produced at that time. The most recent activity in mica mining started about 1941. Intermittent prospecting was done by C. W. Scott; E. Vetter, of Ennis; Ivan Winslow, of Sheridan; Jack Dulea, of Virginia City; and others. In 1943 Scott produced a little mica from the White Swan property. Operations were resumed in 1944 but closed in August. During 1943 and 1944 Ivan Winslow produced some high-quality sheet mica from the Big Chief property, near Sheridan. The total amount of sheet mica sold during 1943 and 1944 by operators in Madison County was less than 1,000 pounds.

GEOLOGIC FEATURES AND ORIGIN OF PEGMATITES

The essential mineral constituents of pegmatite are feldspar and quartz. These minerals may be accompanied by muscovite, beryl, and other rarer valuable minerals, such as columbite-tantalite, cassiterite, scheelite, spodumene, amblygonite, lepidolite, and uranium minerals. Common accessory minerals include black tourmaline or schorl, biotite, garnet, and apatite. Microcline and plagioclase both may be present in the same pegmatite, but the proportions of the two minerals may differ widely from one body to another. Pegmatites are generally distinguished by coarse and irregular texture, although some phases are fine-grained. Feldspar crystals and quartz masses many feet across are not uncommon, and giant crystals of spodumene and beryl, weighing many tons, are well known in South Dakota. Beryl, tourmaline, apatite, garnet, columbite-tantalite, spodumene, and other minerals are ordinarly euhedral, feldspar and muscovite are less commonly so, and quartz is usually anhedral.

Pegmatites are limited to areas of crystalline rocks, especially ancient metamorphic rocks. Most of the pegmatites of Idaho and Montana lie within mica schist or gneiss, but some are enclosed in hornblende gneiss, granodiorite, or crystalline limestone. Both the pegmatites and the crystalline rocks in which they occur were formed at great depths in the crust of the earth. They are exposed at the surface only because erosion has removed many thousands of feet of rock that lay over them when they were formed. Pegmatites have been intruded, injected, or otherwise emplaced in the rocks that enclose them. Their shapes are largely determined by the preexisting structure of the host rock. Thus, tabular bodies may be controlled in form by joints, faults, or foliation surfaces, and pipelike bodies may occupy the centers of pitching folds.

Relatively few pegmatites contain minable quantities of valuable minerals. Although muscovite is a common constituent, an individual pegmatite may contain much or little of it, and that which is present may or may not be of size and quality sufficient to yield sheets suitable for use in the electrical industry. Large perfect mica crystals are very rare, whereas small and imperfect crystals are commonplace. Beryl is generally present only as an accessory mineral in pegmatites containing it. Large rich concentrations of beryl are rare.

Sheet mica and beryl in general are not evenly distributed in pegmatites; some parts of the pegmatite may be rich in one or both minerals, and other parts may be nearly or completely barren. The localization of mica, beryl, and other minerals within a pegmatite is commonly related to the phenomenon known as zoning. Zoned pegmatites contain two or more types of pegmatitic rock, each characterized by a more or less distinct mineral assemblage or texture, which lie in roughly concentric layers about the widest part of the body. Most commonly the central zone, or core, is a tabular or rounded mass of quartz containing other minerals

[9] Sterrett, D. B., op. cit. (Bull. 740), p. 93.

in minor amounts. The core generally crops out more conspicuously than other parts of a pegmatite body. An intermediate zone or several zones ordinarily surround the core and are in turn surrounded by a wall zone, in which commercial amounts of mica and beryl are most likely to be found if they are present at all. Adjoining the contact with wall rock, outside the wall zone, a thin, fine-grained border zone, or selvage, is present. The zones of a pegmatite may be as many as four or five, each containing a distinguishing dominant or rare mineral, or each containing the same minerals in different proportions or different textural relations.

In many mica pegmatites the localization of mica "shoots"—that is, the extent and position of minable mica-bearing rock with relation to the pegmatite as a whole—is related to zoning. Mica deposits lying within zoned pegmatites are classified according to the zone in which they occur.[10] Thus, wall-zone mica deposits lie within the wall zone of a pegmatite, and core-margin deposits adjoin the core. Disseminated deposits are pegmatites in which mica occurs throughout. The localization of beryl and other pegmatite minerals likewise may be related to zoning.

Zones are not necessarily uniform in mineral composition. A given zone, for example, may consist of portions so rich in mica that they can be mined profitably alternating with portions too lean to be worked profitably. The knowledge that sheet mica occurs in the wall zone of a pegmatite is therefore not ordinarily sufficient to permit the detailed planning of development and mining. The position of minable concentrations of commercial minerals within a zone is commonly as important as the location of the mica-bearing zoning itself. Such secondary localization may be related to the keel or trough of a pitching, pipelike pegmatite or to undulations in the walls of the body.

Although the concentric, zonal structure is common in pegmatites, some bodies, particularly small ones, do not have it. Selvages are usually but not always present in bodies that are otherwise homogeneous. In some zoned pegmatites the zoning is strongly developed, in others it is indistinct. Productive mines are generally developed in distinctly zoned pegmatites, for one of the features of zoned pegmatites is the concentration, within relatively small volumes, of one or more minerals. Consistent differences in bulk chemical or mineralogical composition between zoned and homogeneous pegmatites have not, to the writer's knowledge, been proved. Geological Survey work on pegmatites has necessarily been confined chiefly to zoned bodies, which were, or promised to be, productive. Observations on pegmatites of the other class have been incidental and cursory. Zoning seems to be well developed in pegmatites carrying relatively large proportions of lithium, beryllium, or tantalum, and such pegmatites obviously differ considerably in composition from homogeneous bodies consisting almost entirely of feldspar, quartz, and muscovite. Whether homogeneous pegmatites and zoned bodies that have been mined chiefly or entirely for feldspar or mica differ appreciably in composition is a moot question. There seems to be a partial correlation between well-developed zoning and complex composition and large size.

Differences in chemical composition among zoned pegmatites are very marked and form a natural basis of subclassification of these bodies. The differences are probably attributable in part to chemical differences among the magmas or solutions from which the pegmatites were formed. Whether zoning has resulted from fractional crystallization of magma, in place, from the walls of the pegmatite inward, or from the replacement of preexisting homogeneous pegmatite by successive waves of hydrothermal solutions, it seems probable that pegmatite-forming materials have differentiated in depth, especially in those pegmatite regions characterized by wide ranges of composition among zoned pegmatites.

The emplacement of pegmatitic magma may conceivably occur by the simple filling of preexisting openings or by the action of the magma in thrusting apart the walls of relatively small preexisting openings, such as might occur along foliation planes or the axes of folds. The structure of many lenticular, foldform, and pipelike bodies suggests outward thrusting of the walls by the magma. This conclusion is based largely on the absence of extensive wall-rock replacement and on the shapes of the bodies themselves, which do not coincide with the shapes of openings likely to be produced by the processes of faulting, folding, and dynamic metamorphism in general.

Subsidiary replacement processes, which may have acted internally or externally to the body itself, have accompanied the emplacement of some primary pegmatites. Replacement of one pegmatite mineral by another may result from the reactions of residual magma upon the already crystallized parts of the body. Contact metamorphism of the wall rocks of pegmatites, resulting in partial recrystallization of original rock minerals and growth of metacrysts of black tourmaline, garnet, or apatite, may be due to the permeation of the wall rocks by volatile or tenuous liquid products of the differentiation, in place of the pegmatite magma.

[10] The classification and nomenclature of zones used herein was developed during joint discussions among the Geological Survey geologists working on pegmatites in 1942–45.

Some pegmatites probably have been formed in whole or in part by replacement of wall rock. The exact extent to which replacement has acted is ordinarily not determinable because proof rests largely upon the observation of local occurrences in which the process has not run to completion. Geologic features suggestive of the replacement origin of pegmatite include: (1) Replacement of bordering rock by the same minerals as those that chiefly compose the pegmatite itself, (2) extreme irregularity of a pegmatite body, (3) local transgression of the wall rock structure by the pegmatite, without apparent local structural control, and (4) numerous shreds and septa of wall rock included in the pegmatite. Where evidences of primary origin also are present a dual origin may be indicated. Most of the pegmatites of Idaho and Montana are believed to have been formed by crystallization of injected magma, but some of the pegmatites of the Muscovite mine, in Latah County, Idaho, have probably originated largely by replacement of wall rock.

MINERALOGY OF MICA AND BERYL

The commoner kinds of mica are muscovite, biotite, and phlogopite. Numerous rare species exist, but with the exception of lepidolite—the lithia mica—they are not of commercial interest. Muscovite is found in commercial quantities in many parts of the United States. It is a common mineral and a constituent of many igneous, sedimentary, and metamorphic rocks, but pegmatites are the sole source of the crystals from which are obtained flat sheets, usable in the electrical industry. Also, most of the muscovite used ultimately as ground mica is derived from pegmatites.

Muscovite is essentially a silicate of potassium and aluminum. Crystallographically it belongs to the monoclinic system. Its most pronounced physical characteristic is its almost perfect basal cleavage, along which it can be split into thin sheets. Muscovite, like phlogopite and other micas, yields cleavage sheets that are elastic, flexible, and tough. Other advantageous physical properties possessed by muscovite are brilliancy of basal cleavage faces, transparency, comparative softness, and great resistance to the conduction of heat and electricity. These properties make mica useful and valuable in industry.

In thin sheets muscovite is transparent and colorless, but clear sheets one-sixteenth of an inch or more thick may be colorless, gray, amber-colored, red, brown, or green. According to its color in thick sheets it is referred to as "rum," "ruby," "green," or "colorless" mica.

In pegmatites mica is found as variously sized scales and flakes and in rough blocks, or "books." Some books show irregularly developed crystal faces, but the outlines of most books are irregular and ragged. They range from a fraction of an inch to several feet in diameter and in weight from a few ounces to hundreds of pounds. The books do not split perfectly until the outer shell, composed of crushed mica and adhering rock, has been removed by cleaving the book into thick sheets and trimming the edges with a knife. After the tangled edges are removed, further splitting is easy. Sheets less than a thousandth of an inch thick are readily split by hand with a thin, sharp knife.

Many mica books possess physical peculiarities that reduce the amount of sheet mica obtainable. "Rulings" are parallel planes of parting that intersect the basal cleavage at a large angle. Where rulings are closely spaced they divide the book into ribbons, most of which may be too narrow to yield sheet mica. Books with prominent ruling are known as ribbon mica. Books that possess "**A**-structure," or "reeves," are characterized by two sets of minute crenulations that converge to form a pattern resembling the letter **V** on the basal cleavages of the book. This structure may be related to the well-known pressure- or percussion-figures of mica. **A**-structure may permeate the entire book, or, as is common in large books, it may affect only the edges. Likewise the structure may be strongly developed through part of the thickness of a book but weakly developed or absent in the remainder. Strongly reeved mica splits unevenly, and where sheets are obtainable they are faintly wrinkled. "Fishbone," "fish," or "herringbone" mica is similar to **A**-mica except that it possesses a third set of crenulations that bisect the angle formed by the **A**-structure. The relation of the three linear structures resembles that of the spine to the ribs of a fish. "Hairlines" appear to be minute cracks in the laminae of the mica. "Tanglesheet" mica does not split evenly because the laminae are interrupted and nonparallel. Books of "wedge mica" are wedge-shaped, being thick on one edge and tapering toward an opposite edge. Further, books may be warped, bent, curved, or wavy rather than flat, and they may be cracked and broken rather than solid and coherent. The physical imperfections are probably due in part to the conditions during growth of the crystals and in part to disturbances subsequent to growth.

The color of clear sheet mica probably gives very little indication of its useful physical properties, but domestic mica fabricators prefer to buy rum, ruby, or colorless mica rather than green mica. When transparency is a desired quality the color of mica may affect its usefulness.

Sheet mica may be relatively free of structural imperfections but contain stains or inclusions which reduce its commercial value. Clay stains, produced by

the penetration of muddy water between the laminae, are commonly present in mica books near the surface, but at depth clay stains are absent. Vegetation stains may appear in mica books lying at or near the surface. Black stains in mica appear as black dots or spots, or as streaks which in some pieces form a crisscross pattern. Black stains are not caused by surface processes and hence do not necessarily diminish with depth in a deposit. Where black stain is present it does not ordinarily occur in all the books or in all parts of each book. Clear mica may occur in association with black-stained mica. Much black stain is caused by inclusions of magnetite. Where hematite or limonite is present the stain is called "red stain." Red stain ordinarily disappears in depth. Black tourmaline, garnet, quartz, feldspar, and biotite are other common mineral inclusions in mica. The chief objection to them is that they puncture and thus interrupt the continuity of the sheets. Gaseous inclusions in mica, called "air staining," are another common defect. Some mica contains little or no air staining, and other mica contains so many finely dispersed gas inclusions that it is opaque in all but the thinnest sheets and its color is silvery. There are elaborate classifications [11] of sheet mica based on size and on the type and degree of staining present.

Beryl is a silicate of beryllium and aluminum belonging to the hexagonal crystallographic system. In pegmatites beryl most commonly occurs as more or less well-developed hexagonal prisms of widely varying size. Crystals weighing many tons have been taken from mines in South Dakota, but the crystals known to have been recovered from pegmatites in Idaho and Montana have been small—6 inches or less in diameter and less than a foot in length. Beryl most commonly is green, but it may also be white, yellow, pink, or blue. Gem beryl includes emerald, deep green in color, and aquamarine, deep blue in color. To the writer's knowledge neither has been found in Idaho or Montana pegmatites.

The beryllium oxide content of pure beryl ranges from about 10 to 14 percent, but the crystals as found in pegmatites ordinarily contain foreign mineral inclusions such as quartz, plagioclase, tourmaline, and muscovite. The inclusions reduce the value of the crude beryl ore. Some of the mineral impurities usually can be removed by hand cobbing, but the removal of all of them would necessitate crushing and separation of the mineral particles. The value of ordinary beryl, unlike that of sheet-bearing muscovite, is not influenced by the size or perfection of the crystals except insofar as the processes of recovery are affected. Small or fractured crystals are necessarily more costly to recover by hand methods than are large, solid crystals.

[11] Chowdhury, R. R., Handbook of mica, pp. 202–217, Brooklyn, N. Y., Chemical Publishing Co., 1941.

MINING, PREPARATION, AND USES OF MICA AND BERYL

The development and mining of pegmatites for sheet mica and beryl are attended by greater than ordinary mining risks, because of the inherent nature of the deposits. As judged from experience, large extensions of mica-bearing pegmatites in depth or along the strike cannot generally be assumed. Many deposits terminate abruptly. The recognition of the shape and probable size and extensions of a deposit depends on a study of the exposed structure of the pegmatite and the surrounding rocks. The minable parts of a pegmatite are likely to be only a small part of the entire body. The recognition of the relations of mica distribution to zoning of the pegmatite may aid in the planning of development and mining. As a rule the deposit should be followed closely, at least until something is known of its structure.

Small-scale open-pit mining is the most common practice. Underground, many deposits are mined by "gophering" out the mica "shoots" and leaving the barren parts of the pegmatite in place insofar as that is possible. Where the mica-bearing part is large enough, systematic underground methods such as open-stoping, stulling, cutting and filling, square-setting, and combinations of these methods may be used, depending on the local conditions encountered. Blasting should be done with as light a charge as practicable in order not to break or cause exfoliation of the mica books. The larger crystals of mica and beryl may be picked by hand from the broken rock and the waste backfilled; or the broken pegmatite may be removed after hand-picking of the larger crystals and screened or subjected to further hand-picking on the surface.

The crude books picked from the broken rock may profitably be subjected to a rough sorting of the sheet-bearing books from that part of the crude mica that will yield no sheets. The latter, called mine scrap, may be stock-piled for shipment and sale to mica grinders. The crude, sheet-bearing mica is rifted and trimmed to produce sheets of different qualities and grades (sizes). Sheet mica thus prepared is sold to mica fabricators who manufacture the patterns needed in the electrical industry. Additional scrap mica, called factory scrap or bench scrap, is a byproduct of the different stages of preparation and manufacture of

sheet mica. Beryl, like muscovite, is recovered by hand-picking of the broken pegmatite. The crystals are sometimes cobbed to improve the grade before shipping.

The commercial term "sheet mica" ordinarily signifies trimmed sheets of size 1½ by 2 inches and larger. Pieces of crude mica that contain usable areas smaller than 1½ by 2 inches are designated by the collective term, "punch mica," which includes "small punch," "washer," "disc," and "circle" mica. Punch mica may be sold to fabricators in the crude form, or it may be prepared and sold as "small sheet mica."

The uses and value of sheet mica differ with the grade and quality. The grade or size of a piece of sheet mica is determined by the size of the largest rectangle, free of cracks, reeves, and cross grain, that can be cut from the piece, subject to certain specifications of minimum area and width. The minimum allowable thickness of a sheet is 0.007 inch. Table 1 gives the India grading scale for sheet mica. It differs only slightly from the classification established by the American Society for Testing Materials.

TABLE 1.—*India grading scale for sheet mica*

Grade	Minimum width of rectangle (inches)	Minimum and maximum area of rectangle (square inches)
No. 6	¾	1–2½
No. 5½	1	2½–3
No. 5	1	3–6
No. 4	1½	6–10
No. 3	2	10–15
No. 2	2	15–24
No. 1	3	24–36
A–1	4	36–48
Special		48–60

According to the specifications set by the Colonial Mica Corporation during 1942–45, the total area of any piece of sheet mica was not to be greater than two and a half times the area of the largest rectangle that could be cut from the piece. Sheets trimmed on two adjacent sides with no cracks extending from the trimmed sides are designated as "half trim." "Three-quarter trim" sheets are trimmed on all sides with no cracks extending from two adjacent sides and no cracks extending into the pattern. "Full-trim" mica is trimmed on all sides with all cracks, reeves, and cross grain trimmed out.

Domestic mica is qualified either according to a classification established by domestic mica fabricators and used by the Colonial Mica Corporation or according to a classification set up by the American Society for Testing Materials, given in table 2.

TABLE 2.—*Classification of quality of mica adopted by the American Society for Testing Materials* [1]

Classification	Specifications
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, 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 to rigidity and toughness.
Black stained and spotted.	Apt to contain some mineral inclusions consisting of * * * iron oxides.

[1] Quoted from "Standard methods of test for grading and classification of natural mica," A. S. T. M. designation D-351-38, adopted 1938.

The Colonial Mica Corporation purchased sheet mica according to a domestic standard in which the various qualities are designated as No. 1, No. 2, No. 2 inferior, and No. 3. The equivalence between this standard and the standard used by the American Society for Testing Materials, as determined by the Colonial Mica Corporation, is given in the following table:

Equivalence between domestic standard of quality for sheet mica and the standard used by the American Society for Testing Materials

Domestic standard	*A. S. T. M. standard*
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 stained.

Sheet mica 1 by 1 inches and larger of No. 1, No. 2, and No. 2 inferior qualities was purchased at high prices by the Colonial Mica Corporation during the years 1942–44. Mica of No. 3 quality and heavily air-stained mica were not purchased. High-quality sheet mica purchased by the Colonial Mica Corporation was sold to mica fabricators who produced the special patterns used in the manufacture of condensers, electric generators and motors, radio tubes, airplane spark plugs, and other war materials. Sheet mica of No. 3 quality, known also as "electric" mica, is usable in many types of electrical equipment, for instance household appliances such as flatirons, toasters, and stoves.

Scrap mica is ground for use chiefly as a filler in paint, paper, and rubber manufacturing.

Beryl likewise was purchased by the Colonial Mica Corporation as a strategic mineral. It is ground and used in certain kinds of refractory ceramic wares. The metal beryllium is extracted from beryl for use as an alloying element with other metals, chiefly copper. Beryllium alloys have many small specialized uses, particularly where resistance to wear and fatigue is important. Beryllium oxide, sulfate, and other compounds are manufactured for use in chemical laboratories.

MINES AND PROSPECTS IN IDAHO

DISTRIBUTION OF KNOWN DEPOSITS

Pegmatites in nine counties in Idaho—Adams, Boise, Bonner, Boundary, Clearwater, Idaho, Latah, Lemhi, and Valley—were examined in the course of the field work on which the present report is based. Their locations are shown in fig. 1. Mica-bearing pegmatites are reported also in Cassia County.[12] Many of the pegmatites are in west-central Idaho in the metamorphic rocks of the Belt series, of Algonkian age, that border the west side of the Idaho batholith or in the marginal parts of the batholith itself. The pegmatites of the Avon district, Latah County, lie in mica schist and gneiss of the Belt series adjoining part of the Thatuna batholith,[13] a smaller granodiorite mass that crops out in Latah and adjoining counties. The pegmatites in northern Idaho lie in the batholith that underlies most of Boundary and Bonner Counties and in the intruded Belt rocks.

Many of the pegmatites in the Avon district contain mica from which rum-colored sheets, principally of No. 2 and No. 2 inferior qualities, can be cut. Brown to greenish-brown sheet mica, chiefly of No. 2 inferior quality, has been produced from the Myers mine, in Idaho County, and the Mica Queen mine, in Adams County. Mica yielding black-stained sheets of green or greenish-brown color is present in pegmatites on Allison and Lake Creeks, Idaho County. Silvery, air-stained mica is present in pegmatites in the Avon district and on Bobs Creek, Clearwater County.

Beryl has been observed in half a dozen or so pegmatites, but only in the Muscovite mine does it occur in commercial quantities. Columbite has been found in the Vaught prospect, in Boise County.

[12] Anderson, A. L., Geology and mineral resources of eastern Cassia County, Idaho: Idaho Bur. Mines and Geology Bull. 14, p. 159, September 1931.

[13] Tullis, E. L., Contributions to the geology of Latah County, Idaho: Geol. Soc. America Bull., vol. 55, No. 2, p. 143 and pl. 6, February 1944.

PRODUCTION AND RESERVES

The mica production of Idaho from 1943 to May 1, 1945, is given in table 3. Almost all the production came from the Avon district, Latah County. The principal reserves of mica and beryl are shown in table 4. All of the mines referred to are in the Avon district. A number of small deposits in Idaho containing insignificant reserves are not included in the tabulation.

TABLE 4.—*Summary of mica and beryl reserves in Idaho*

Mine	Crude sheet-bearing mica (pounds)		Beryl (tons)	
	Indicated [1]	Inferred [1]	Indicated	Inferred
Muscovite	829, 800	310, 000 to 1, 130, 000	75. 5	155 to 455
Last Chance	82, 600	----------	------	----------
Steelsmith	39, 600	----------	------	----------
Total	952, 000	310, 000 to 1, 130, 000	75. 5	155 to 455

[1] The terms "indicated" and "inferred" are used in conformity with standard Geological Survey usage. Definitions of these terms are as follows:

"Indicated ore is ore for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely spaced, or otherwise inappropriately spaced, to outline the ore completely or to establish its grade throughout.

"Inferred ore is ore for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence."

TABLE 3.—*Idaho mica production by counties, 1943–45*

	Production (pounds)			
	Adams County [1]	Idaho County [2]	Latah County [3]	Total
Mine-cobbed mica	9, 939. 00	(?)	+1, 506, 082. 00	+1, 516, 021. 00
Untrimmed punch	----------	----------	33, 294. 17	33, 294. 17
Sheet mica, 1½ by 2 inches and larger, ¾ trim	3. 62	26. 50	6, 126. 10	6, 156. 22
Sheet mica, 1 by 1 to 1½ by 2 inches, full trim	437. 24	245. 05	41, 894. 90	42, 577. 19
Sheet mica, 1½ by 2 inches and larger, full trim	82. 37	41. 18	17, 670. 73	17, 794. 28
Total prepared mica	523. 23	312. 73	99, 985. 90	100, 821. 86

[1] Production and sales during 1944, Mica Queen mine.

[2] Production and sales during 1943–44, chiefly from the Myers mine, but also from Lolo Creek, Allison Creek, Hidden Fawn, Anderson, and Barham prospects.

[3] Crude-mica production, 1943, 1944, and Jan. 1 to May 1, 1945; figures for sheet and punch mica represent sales between Oct. 1, 1943, and Apr. 2, 1945; all production from the Avon district.

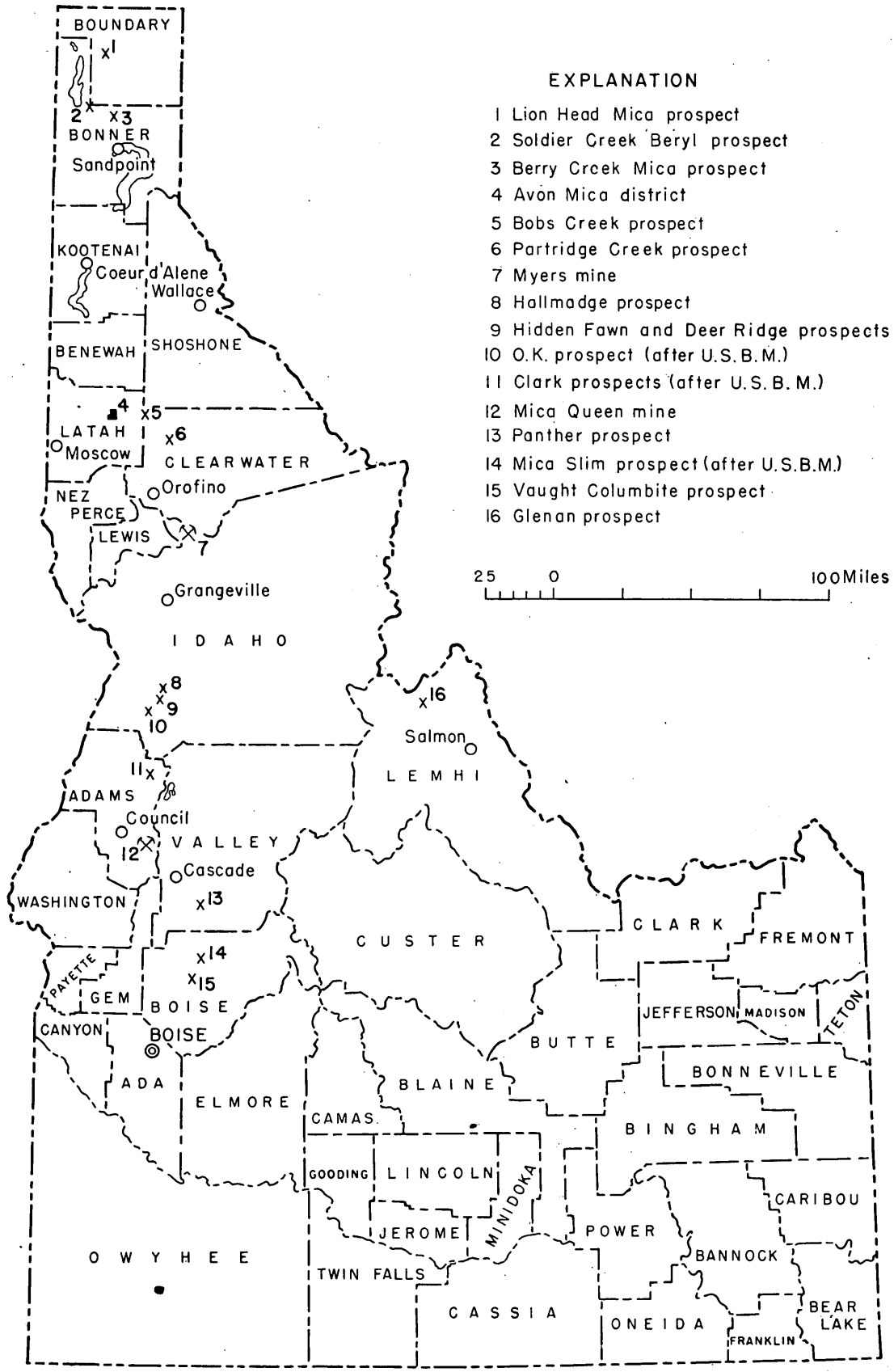

FIGURE 1.—Index map of Idaho showing location of mica, beryl, and columbite mines and prospects.

ADAMS COUNTY

CLARK PROSPECTS

The Clark mica prospects are about 4 miles northeast of New Meadows, Idaho, on Fourmile Creek, a tributary of the Little Salmon River. (See fig. 2.) They were located in 1940 by Fred Clark, of New Meadows. R. M. Gammell,[14] of the Bureau of Mines, examined the prospects in 1943. At that time the workings consisted of several open cuts on two pegmatites. No mica had been produced. The mica books seen by Mr. Gammell were heavily iron-stained.

MICA QUEEN MINE

LOCATION AND ACCESS

The Mica Queen mine is in the NW¼ sec. 8, T. 15 N., R. 2 E., Boise meridian, 10.5 miles southeast of the town of Council (fig. 3). The property lies in the Weiser National Forest. From Council it is reached by driving 5.1 miles south on United States highway No. 95, and 14.2 miles east on the road ascending the valley of the Middle Fork of the Weiser River. The workings lie a few hundred yards northeast of the old Rinehart cabin, which stands near the road. Trails lead from the cabin to the different workings.

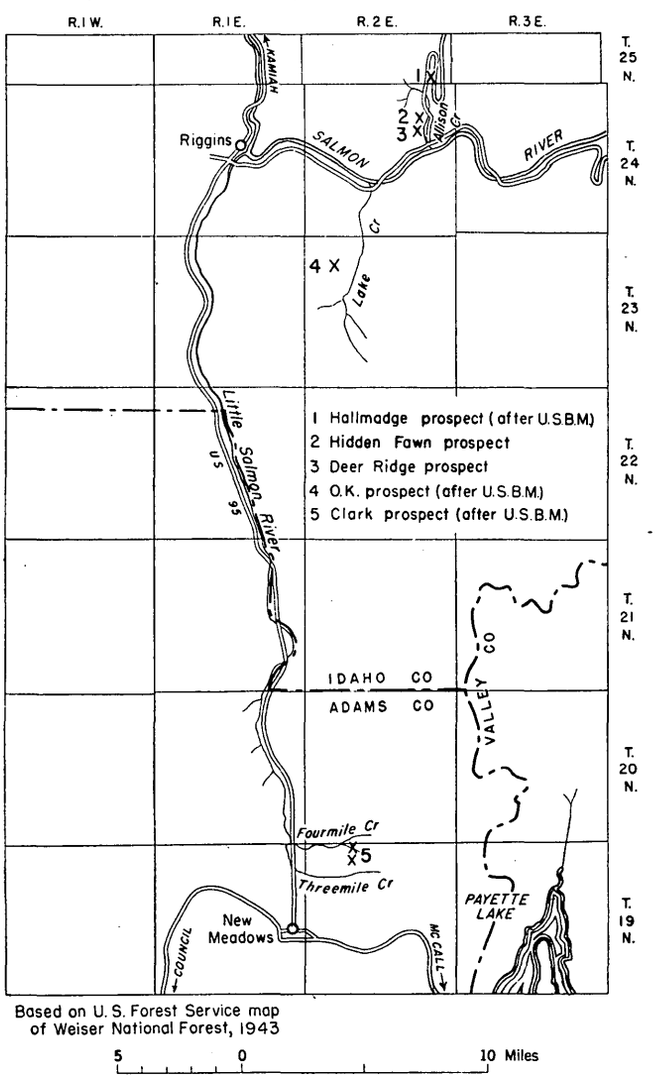

FIGURE 2.—Map showing location of mica prospects, Idaho and Adams Counties, Idaho.

[14] Gammell, R. M., Clark mica deposit, Adams County, Idaho: U. S. Bur. Mines unpublished war minerals mem., April 1945.

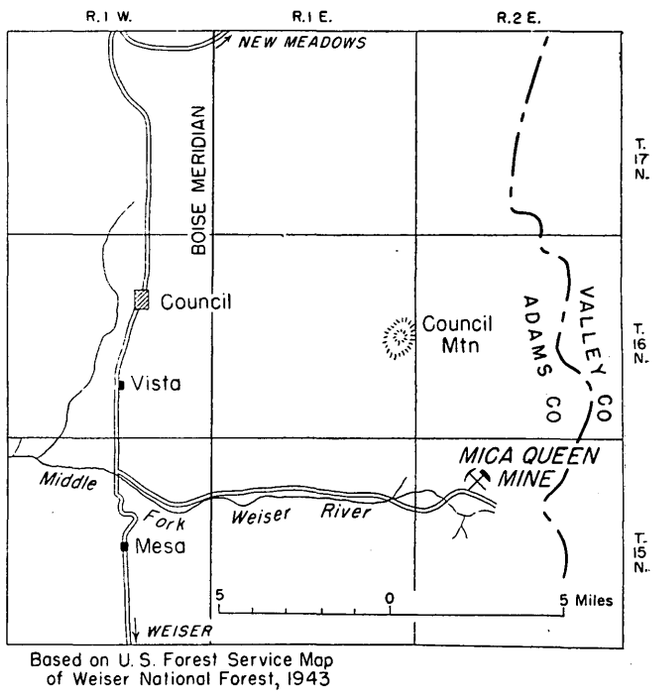

FIGURE 3.—Map showing location of Mica Queen mine, Adams County, Idaho.

HISTORY AND PRODUCTION

The Mica Queen property consists of a single patented claim belonging to A. H. Huntington, of Kerman, Calif. The owner discovered the pegmatites in 1906 and developed them during following years. The property is reported to have produced in 1918 about 200 pounds of sheet mica from a small shaft on the outcrop of one of the pegmatites.

In 1944 the property was leased by Gordon C. Smith, of Boise, Idaho, and was mined from July until December with a crew of two or three men. Crude mica production amounted to 9,939 pounds, which was shipped to the Colonial Mica Corporation, in Moscow, Idaho. A total of 523.23 pounds of sheet mica, including 437.24 pounds of small sheets, 3.62 pounds of large sheets, three-quarter trim, and 82.37 pounds of large sheets, full trim, was sold in 1944. The property was visited by the writer, accompanied by J. L. Johnson, of Council, on September 23, 1943, and again on July 3, 1944, prior to the start of operations.

WORKINGS

The workings consist of four tunnels, a stope, a few small cuts, and a shallow shaft. They lie on a steep forested hillside above the Middle Fork of the Weiser River. All the workings except the stope existed prior to 1943. The upper or No. 1 tunnel is caved at the portal but is said to be about 50 feet long. Tunnel No. 2, a few feet west of the trail leading from the Rinehart cabin to the shaft, likewise is caved. The shaft is open to a depth of 12 feet. It lies in the floor of an old mine building about 350 feet north-northeast of No. 2 tunnel. No. 3 tunnel, 50 feet long, is 20 to 30 feet below the shaft collar. The lower or No. 4 tunnel, 75 feet below tunnel No. 3, is 135 feet long. The shaft and tunnels No. 3 and No. 4 appear to intersect the same pegmatite. An overhand stope reportedly was driven from the lower tunnel in 1944, and the mica produced in that year came from the stope. Tunnels No. 1 and No. 2 are in other pegmatites.

MICA DEPOSITS

The Mica Queen property lies on the south flank of Council Mountain within and near the west edge of the Idaho batholith. The country rocks exposed in the mine workings are gneissic quartz diorite or granodiorite, and coarse biotite-quartz schist. The pegmatites contain plagioclase, quartz, muscovite, microcline, biotite, and garnet.

Above and at the sides of the caved portal of the upper or No. 1 tunnel is exposed a pegmatite 7 to 10 feet thick, striking north and dipping 30° to 40° E. The pegmatite is a mixture of medium-grained quartz and plagioclase with abundant fine scaly muscovite and contains a few mica books. Microcline, biotite, and red garnet are present in minor quantities. The wall rock is gneissic quartz diorite or granodiorite containing scattered small crystals of garnet.

Mica books piled near the portal of tunnel No. 1 are pale brown, clay-stained, and exfoliated by weathering. Most of the books show A-structure, but small sheets of stained quality could be cut from the center parts of some books.

Pegmatite containing muscovite lies in a small dump at the portal of tunnel No. 2.

The pegmatite cropping out near the mine house, on which the shaft was sunk, is 2 to 4 feet thick. It consists of feldspar, quartz, and disseminated books and flakes of muscovite. In the shaft it strikes N. 19° E. and dips steeply to the southeast. The pegmatite lies in mica schist, but granitic rock crops out a few yards to the east.

At the end of No. 3 tunnel, 20 to 30 feet below the outcrop, the pegmatite is 3 to 6 feet thick. The average dip is 75°–85° W. The hanging-wall contact cuts across the foliation of the mica schist at an acute angle. The pegmatite consists of massive white quartz, oligoclase (Ab_{80}), clusters of mica flakes, and books of muscovite in the amount of about 1 percent of the pegmatite. Most of the book mica lies near the hanging wall.

Near its face the lower tunnel penetrates what is apparently the same pegmatite as that showing on the surface and in tunnel No. 3. The body is 4 feet thick, strikes N. 38° E., and dips 72° NW. It is a mixture of oligoclase, white to light-gray quartz, fine scaly muscovite, and book muscovite. Most of the books lie near the hanging-wall border of the pegmatite as a layer 18 to 24 inches thick containing an estimated 10 percent book mica. The wall rock of the pegmatite is coarse biotite-quartz schist, which strikes and dips parallel to the contacts of the pegmatite. Nearer the portal of the tunnel, lenses, veins, and veinlets of quartz and quartz-feldspar pegmatite are exposed. They range from less than 1 inch to 16 inches in width; some cut across the schistosity and others are concordant. Subsequent to the writer's visits to the property a stope reportedly was driven overhand on the pegmatite in No. 4 tunnel and a good recovery of sheet-bearing mica was made.

The muscovite in the pegmatite exposed in tunnels No. 3 and No. 4 is of three kinds: (1) Fine, soft, white, scaly mica dispersed through the pegmatite; (2) books, as large as 5 inches in diameter, of soft light-green mica: some of the books are flat, but most are curved and in part ruled and cracked; a small proportion of the green mica contains sheets; and (3) brown mica having a faint greenish tint. The books range from less than 1 inch to 4 inches in diameter. Much of the mica is flat but ruled and cracked to a slight degree. It is moderately hard and free of stains other than slight, haphazard clay stains. Sheets can be cut from sufficiently large books of this type. The sheet mica purchased by the Colonial Mica Corporation was classified as "green."

The Mica Queen is the most promising mica mine seen by the writer south of Latah County, but it probably could not be worked profitably under conditions comparable to those of the prewar period. Judging from the available exposures, the mica deposits are small and the most promising was mined in 1944.

BOISE COUNTY

MICA SLIM PROSPECT

The Mica Slim prospect, the location of which is shown in figure 4, is in sec. 22, T. 9 N., R. 5 E., Boise meridian, about 6½ miles east of Garden Valley near

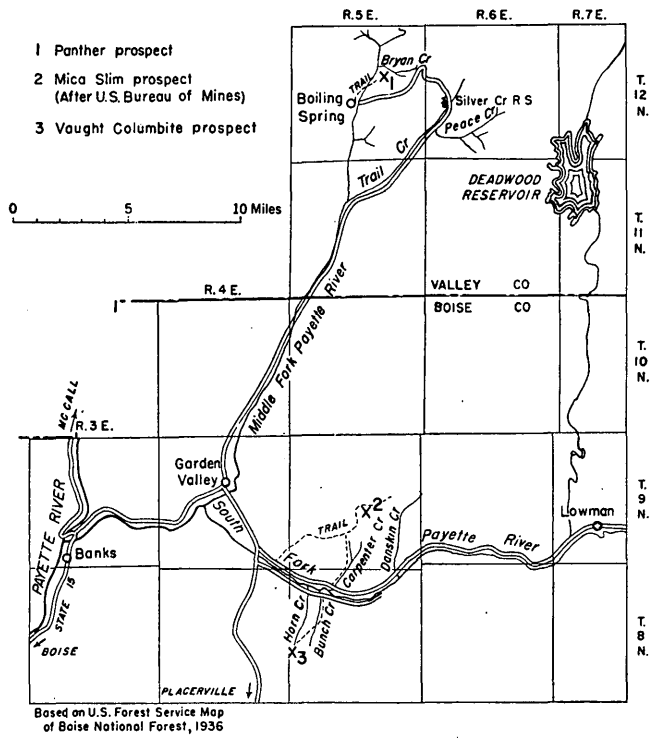

FIGURE 4.—Map showing location of mica and columbite prospects, Boise and Valley Counties, Idaho.

the head of Danskin Creek, a tributary of the South Fork of the Payette River. A trail leading to the prospect starts at the Garden Valley-Lowman road, about 4 miles southeast of Garden Valley. The property consists of two unpatented claims staked by Amos McDonald, of Council, Idaho. It was visited in July 1944 by L. E. Shaffer,[15] examining engineer of the Bureau of Mines in Idaho. The Mica Slim pegmatite is one of many small pegmatites which cut the granodiorite in this area. It is 8 to 12 inches wide and is exposed over a length of 15 feet. An open cut 15 feet long and 5 to 6 feet wide is the only working. The mica books in the pegmatite are small and reeved. Samples of pegmatite taken by Mr. Shaffer were analyzed spectrographically by analysts of the Bureau of Mines. No columbium, tantalum, or beryllium was detected.

VAUGHT COLUMBITE PROSPECT

The Vaught prospect, known also as the Peck prospect, is in sec. 19, T. 8 N., R. 5 E., Boise meridian, in the Boise National Forest, about 11 miles east-southeast of the town of Banks. Its location is shown in figure 4. At the time of the writer's visit on September 24, 1943, the prospect was accessible by way of an old gullied road ascending the valley of Bunch Creek from a point about 7 miles southeast of Garden Valley, on the Grimes Pass road. On the east side of the ridge between Bunch Creek and Horn Creek a trail leads from the old road across the Horn Creek Valley to the prospect, which lies on the west side of Horn Creek at an altitude of 4,200 feet.

The Vaught prospect, or Columbite group as it is called by the owners, comprises eight claims, one of which was known formerly as the Esile Mica claim. The owners are J. K. Vaught, Glen Vaught, and J. G. Vaught, all of Boise, Idaho. Fred T. Peck, of Idaho City, was at one time interested in the property.

The pegmatite exposed on the property is said to have been mined intermittently for columbite and mica since 1900 or thereabouts. Lee Bunch, a miner, is said to have sold some columbite about 1915. During the spring and summer of 1943 some open cuts were dug under the direction of the owners, but at the time of the writer's visit work had ceased. According to J. G. Vaught the total production of columbite has been about 500 pounds, of which 100 pounds was produced by the Vaught brothers. According to correspondence with Fred T. Peck, who submitted specimens for analysis to several laboratories, the mineral is high in columbium and low in tantalum. In July and August 1944 the Bradley Mining Co. performed exploratory work on the pegmatite under a lease and option from the owners. Reportedly, about 4,500 linear feet of angledozer trenches were cut. Pegmatitic material from the trenches was thoroughly panned, but only two pieces of columbite, a quarter of an inch to half an inch across, were recovered.

The pegmatite cuts granodiorite of the Idaho batholith. It crops out prominently over an area 130 by 160 feet, strikes northwest, and appears to dip gently southwest, although no good contact exposures were seen. The body is possibly lenticular. The old workings comprise seven open cuts near the northeast border of the pegmatite and an inaccessible tunnel, said to be more than 100 feet long, a few hundred feet below and southeast of the open cuts. The tunnel is said to lie entirely in granodiorite.

The prominently outcropping core of the pegmatite is composed of massive white quartz containing a few small pockets of muscovite. The southwest part of the wall zone, exposed in a single open cut, appears to be composed mainly of microcline. The northeast part of the wall zone, in which six of the open cuts have been dug, is a mixture of microcline, plagioclase, muscovite, and quartz in varying proportions. Graphic granite and patches of unoriented mica flakes a quarter of an inch to half an inch in diameter are present. In one of the cuts in this zone is exposed a distinct layer, 2 to 3 feet thick, of large muscovite books lying in feldspar

[15] Shaffer, L. E., Mica Slim prospect: U. S. Bur. Mines unpublished summary report of war minerals examination, 1944.

and quartz. The layer lies from 4 to 6 feet from the edge of the quartz core. The books are as much as 16 inches in diameter. The mica is pale yellow where clear, but a crisscross pattern of black-stain is visible in most pieces. A-structure is conspicuous. Columbite was not seen. The columbite that was recovered in the past reportedly lay as small bunches in the wall zone on the northeast side of the pegmatite or in the quartz at the contact of the two zones. The largest mass of columbite found weighed 30 pounds. Part of it is in the possession of Fred T. Peck, of Idaho City.

BONNER COUNTY

BERRY CREEK MICA PROSPECT

The group of pegmatites herein called the Berry Creek mica prospect is on Berry Creek, a tributary of the Pack River, about 3 miles northwest of Colburn. Colburn is situated on United States Highway No. 95 north of Sandpoint. (See fig. 5). The pegmatites crop out on the north side of the valley about half a mile from the Berry Creek road at a point 3 miles from the turn-off north of Colburn. The locality was visited in August 1944 by the writer and Glen Fiegal, of Spokane, Wash., who had discovered the outcrops.

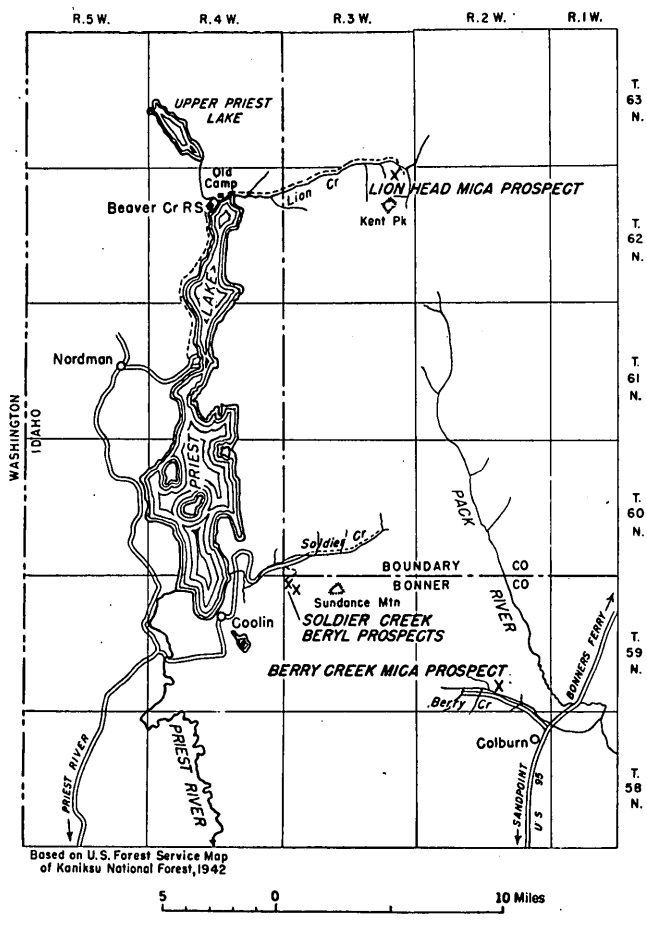

FIGURE 5.—Map showing location of mica and beryl prospects, Boundary and Bonner Counties, Idaho.

The small area inspected is underlain by gneissic quartzite and granitic rock. Several pegmatites, ranging from less than a foot to 4 or 5 feet in width, crop out. They strike N. 80° W. and dip 30° to 40° NE., about parallel to the bedding of the metamorphic rocks. The pegmatites are composed almost entirely of fine- to medium-grained feldspar and quartz. One pegmatite 3½ feet thick consists largely of microcline cut by stringers of milky quartz. A few books of mica lie near the contacts. The largest book seen was 2 by 3 inches. The books are pale brown and free of inclusions but show ruling and cracks. Some of the muscovite is intergrown with biotite, which is partly altered to vermiculite.

SOLDIER CREEK BERYL PROSPECTS

On the west slope of Sundance Mountain, in sec. 6, T. 59 N., R. 3 W., Boise Meridian, about 3½ miles east-northeast of Coolin, two pegmatites were discovered in 1941 by Bert Fry and Jim Carr, of Priest River. Figure 5 shows the location of the prospects. They were explored for beryl, and a single crystal 1½ inches in diameter is reported to have been found. The prospects were visited by the writer in August 1944 in company with Fry and Carr. From Coolin, a resort on the south end of Priest Lake, the prospects are accessible by way of a dirt road running up the valley of Soldier Creek and by a switch-back logging road ascending Sundance Mountain.

The pegmatites are exposed in the road cuts. The lower pegmatite, about 15 feet wide in the road cut, strikes N. 80° W. and dips north. It is traceable for about 200 feet up the hill. The pegmatite is mainly a coarse- to medium-grained mixture of feldspar, chiefly microcline, and white to dark-gray quartz. A few books of mica as much as 2 by 2 inches lie in the dike. The country rock is hornblende-feldspar gneiss.

About a quarter of a mile southeast and several hundred feet higher is a second pegmatite, exposed in the side and bottom of a road cut over a distance of 30 feet. The pegmatite is a mixture of coarse white microcline and dark-gray quartz. Beryl was not seen in either the upper or the lower pegmatite.

BOUNDARY COUNTY

LION HEAD PROSPECT

The Lion Head mica prospect lies in sec. 1 or 2, T. 62 N., R. 3 W., Boise Meridian, on Lion Creek, which flows west into the north end of Priest Lake. Its location is shown in figure 5. A. E. Haynes, of Newport, Wash., discovered mica-bearing pegmatites in this area

in 1928, and in 1944 he located four mining claims. The writer visited the area in August 1944, accompanied by Haynes. The north end of the lake is reached by a trail leading to the Beaver Creek Ranger Station or by boat from one of the numerous resorts on the shores of the lake. From the mouth of Lion Creek a

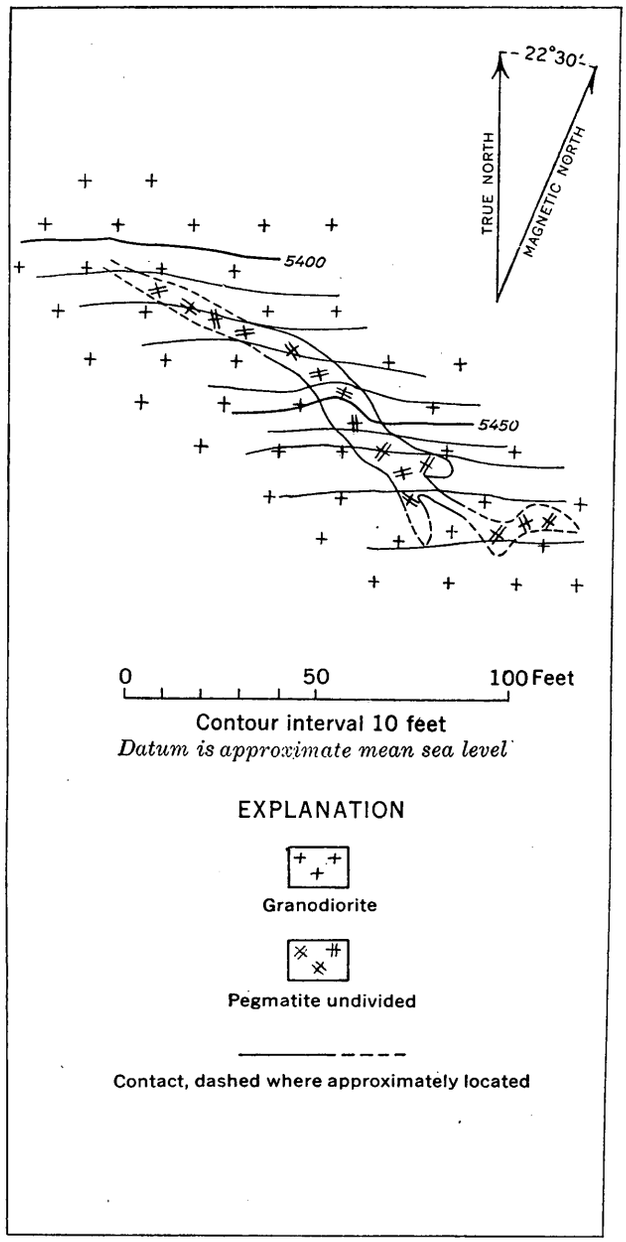

FIGURE 6.—Sketch map of the Lion Head prospect, Boundary County, Idaho.

trail follows the stream for 9 miles to Haynes' camp, situated in the valley at an altitude of about 4,700 feet, or about 2,250 feet above the lake. The main pegmatite is at an altitude of 5,450 feet on the north flank of Kent Peak. It is reached by way of an obscure trail ascending the steep, rocky south wall of the valley. A second pegmatite crops out at an elevation of 5,290 feet on the route to the main outcrop.

The lower ledge is 35 feet long and 1½ to 3 feet wide, striking N. 80° W. and dipping steeply. It is composed chiefly of coarse white quartz and smaller amounts of white feldspar. Books of brownish muscovite 5 inches and less in diameter, partly intergrown with biotite, show over a length of 6 feet. Six mica books were counted. The dike lies in granodiorite.

The main dike, 140 feet in length and 12 feet in maximum width, crops out on a steep granodiorite cliff (fig. 6). It strikes N. 55° W. and dips almost vertically. The walls are irregular. Blunt apophyses of pegmatite branch from the main part of the body. The pegmatite is largely a mixture of coarse white and pink microcline and gray quartz. Biotite, in small part altered to vermiculite, is present. Muscovite books constitute from 2 to 3 percent of the pegmatite throughout a length of 40 feet. Most of the mica occurs with quartz. The books seen were 3 by 3 inches and smaller, but books as large as 6 by 6 inches have been recovered. The mica is pale olive-brown. Most books are reeved, cracked, or partly ruled, and black stain was seen in some pieces. A small proportion of them is flat and free of stains. The pegmatite cannot be mined profitably, even at the high mica prices that prevailed in 1944, because it is small, difficult to reach, and remote from sources of labor and supply.

Both walls of the Lion Creek valley, from Priest Lake to a point 2 miles upstream from the Lion Head prospect, have been prospected by Haynes and his partners, but, apart from the deposits described above, only small stringers and veins of quartz and pegmatite were found, and they lack commercial amounts of mica.

CLEARWATER COUNTY

BOBS CREEK MICA PROSPECT

A mica-bearing pegmatite crops out on Bobs Creek, in T. 41 N., R. 1 E., Boise Meridian, 4½ miles northeast of the town of Bovill. The location of the pegmatite is shown in figure 7. In 1943 local interest in the deposit as a possible source of high-quality mica was aroused, but the mica was tested by Colonial Mica Corporation and classified as of No. 3 quality. Engineers of the Bureau of Mines examined the deposit and reported [16] that mica books as large as 12 by 18 by 4 inches lie in a pegmatite dike 3½ feet wide. It is said that mica constitutes 30 percent of the exposed part of the dike. Mica speci-

[16] U. S. Bur. of Mines, War Minerals Rept., Bobs Creek mica, Clearwater County, Idaho, May 1943.

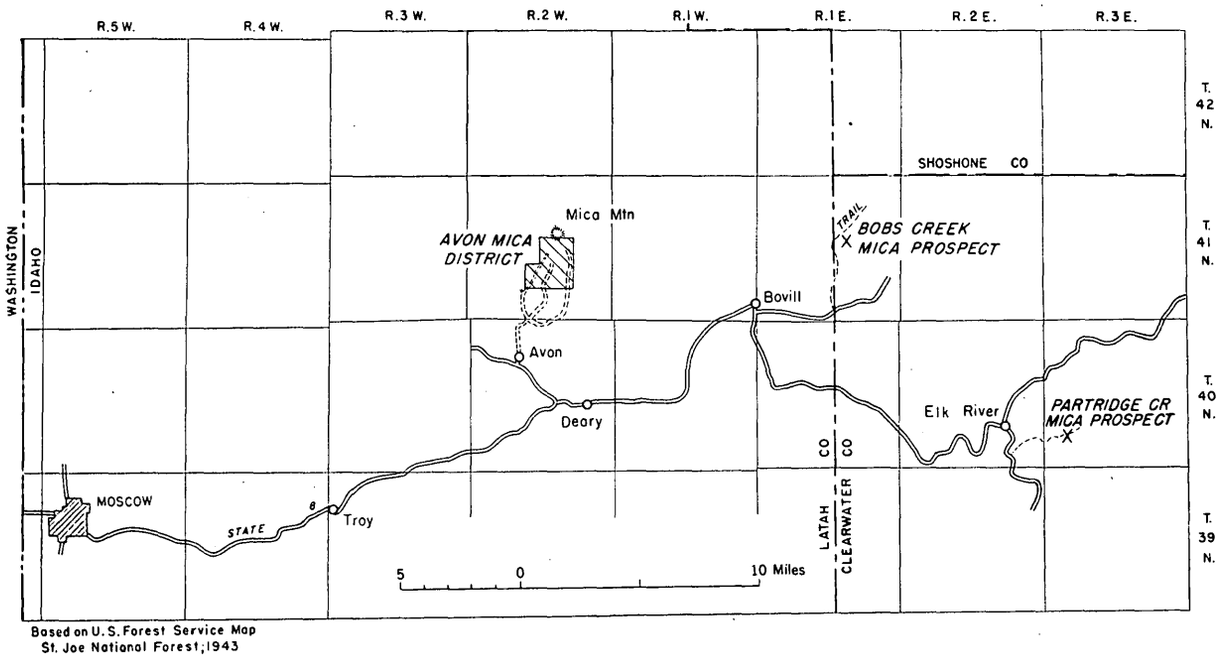

FIGURE 7.—Map showing location of mica deposits, Latah and Clearwater Counties, Idaho.

mens seen by the writer were silvery in color owing to air stain. About 14 pounds of mica were collected by J. W. Melrose, geologist for the Chicago, Milwaukee, St. Paul & Pacific Railroad, and submitted to the Asheville Mica Co., Asheville, N. C., for grading. Fifty-eight percent of the sample was scrap, 25 percent punch, and 17 percent sheet mica in sizes ranging from 2 by 2 inches to 3 by 5 inches.

PARTRIDGE CREEK MICA PROSPECT

An area in which mica-bearing pegmatite is reported to occur was briefly visited in November 1943 by I. G. Sohn, of the Geological Survey, accompanied by C. M. Friend, of Elk River, Idaho. The area lies in the SW¼ sec. 29 and the SE¼ sec. 30, T. 40 N., R. 3 E., Boise Meridian, about 2½ miles east of the town of Elk River, on a northeastward-trending ridge between Partridge Creek and Deep Creek. A logging road and a trail lead from Elk River to the crest of the ridge. The location of the prospect is shown in figure 7.

The bedrock in the area is mica schist cut by numerous pegmatite dikes. Mica flakes more than 3 inches in diameter were observed in the soil at two places along the logging road. A piece of mica seen by the writer was free of staining but small. Mr. Friend claims to have found, about 1925, pieces of mica larger than 6 inches across in pegmatite, but the mica-bearing dike from which the specimen came could not be found in 1943, probably because of the thick overburden and vegetation that mantles the area.

IDAHO COUNTY

HALLMADGE PROSPECT

The Hallmadge mica prospect, owned by Gus Hallmadge, of Whitebird, Idaho, is 8 miles east-northeast of Riggins in the valley of Allison Creek, a small tributary of the Salmon River. (See fig. 2.) The property is reached from Riggins by roads up the Salmon River and Allison Creek. Heavily stained mica books as large as 16 by 16 inches are reported [17] to lie in pegmatite opened by a tunnel 40 feet long.

HIDDEN FAWN AND DEER RIDGE PROSPECTS

The Hidden Fawn and Deer Ridge claims reportedly were located in 1944 by E. S. Barham, E. J. Conine, and other residents of Riggins, Idaho. The claims lie in sec. 11, T. 24., R. 2 E., Boise Meridian, on the west wall of the valley of Allison Creek above the Gus Carlson farm. (See fig. 2.) They are reached by a steep trail from the Allison Creek road. A small pegmatite on the Hidden Fawn claim strikes N. 10° W. It is perhaps 6 to 8 feet thick but poorly exposed. Numerous muscovite books 12 inches across and smaller lie in quartz and feldspar. The mica is greenish brown. Most of the books show A-structure and black specks, but some books contain flat clear areas.

The Deer Ridge prospect is several hundred yards southwest of the Hidden Fawn outcrop. A small branching pegmatite several feet thick is exposed throughout a vertical distance of about 15 feet in the

[17] U. S. Bur. of Mines, War Minerals Mem., Hallmadge mica deposit, Idaho County, Idaho, 1943.

face of a low ledge of mica gneiss. One branch strikes N. 25° W. and another strikes N. 80° E. and dips 65° NW. Small green mica books lie in a matrix of feldspar and quartz. Most of the books are reeved, cracked, and warped, but some contain small areas that are flat and clear. Plagioclase from the Deer Ridge pegmatite was identified as oligoclase (Ab_{82}).

Because of difficult access, small size of the pegmatites, and inferior quality of the mica neither the Hidden Fawn nor the Deer Ridge prospects could be mined profitably, even at the high mica prices that prevailed in 1943–44.

Pegmatites other than those described are said by the owners to lie on and near the claims. R. M. Gammell, of the Bureau of Mines, saw a clear hard mica book 8 by 18 inches in the possession of R. White, of Whitebird, Idaho. The book was said to have come from the valley of Allison Creek.

MYERS MICA MINE

The Myers mica mine is in sec. 20 or 21, T. 34 N., R. 4 E., Boise Meridian, 4 miles northeast of the town of Kamiah, on a farm owned by George Myers. The farming community in the vicinity is known as Woodland. It is reached by automobile through Kamiah, on the Clearwater River. The workings are in a cultivated field a few hundred yards from the Myers farmhouse. Figure 8 shows the location of the mine.

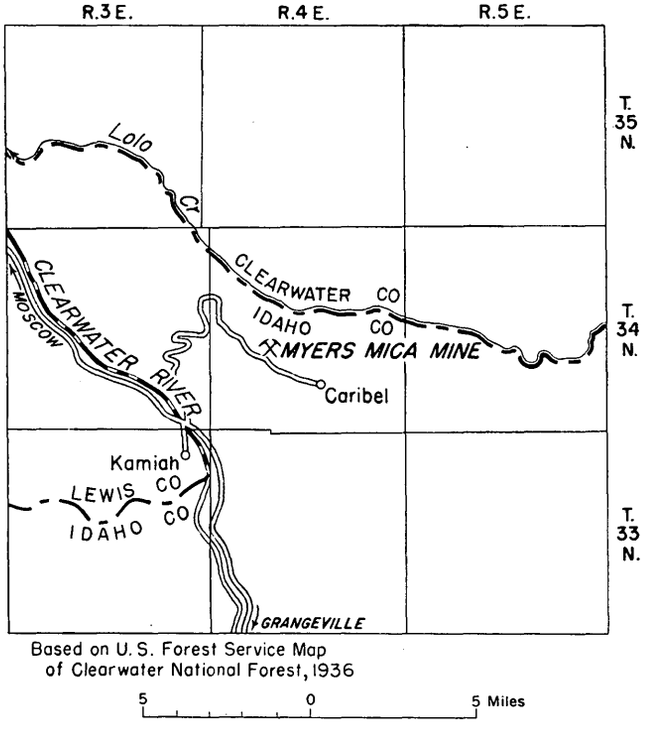

FIGURE 8.—Map showing location of Myers mica mine, Idaho County, Idaho.

The pegmatites were first opened about 1920, when the farm belonged to Ernest Lidke. A shallow shaft was sunk in search of large-sized mica sheets, presumably for use as stove windows, but apparently none were found. No further mining was done until 1943, when Charles F. Anderson and Alex Hines, of Woodland, started an inclined shaft. In August 1944 a lease was taken by Sheldon Bowers, of Moscow, and the mine was operated until November 21 of that year. The writer visited the mine on September 21, 1943, on September 22, 1944, in company with L. R. Page, of the Geological Survey, and again on November 16, 1944.

In 1943 and 1944 the operators of the mine sold 301.06 pounds of sheet mica to the Colonial Mica Corporation. Sales of small sheet amounted to 233.56 pounds; large sheet, three-quarter trim, 26.50 pounds; and large sheet, full trim, 41.00 pounds. The mica was classed as green. A lot of 47.20 pounds of sheet mica, graded and qualified by the Colonial Mica Corporation in Asheville, N. C., contained 0.8 percent of No. 1 quality; 7.6 percent of No. 2; 91.5 percent of No. 2 inferior; and 0.1 percent of No. 3. The sizes ranged from No. 3 to No. 7.

The geology and workings are shown in figure 9. The old workings comprise an open cut, a caved shaft 16 feet deep, and a short drift and crosscut. The new workings, driven on the main pegmatite, include a 50-foot incline and a drift about 25 feet long. The pegmatite in the old workings is a lens 3 to 4 feet thick composed of fine- to medium-grained feldspar and quartz. The lens strikes N. 47° E. and is vertical; its northeast end plunges 45° NE. The main pegmatite is an irregular body, pipelike in part, which plunges N. 13° E. at an angle of 40°. At the surface the pegmatite appears to be about equidimensional in plan, but in the drift at the foot of the incline it is lenslike. Faults, striking N. 60° E. and dipping 50° to 60° SE. cut the pegmatite at the bottom of the incline, but the offset is only a few feet. The pegmatites lie conformably in strongly foliated feldspar-biotite-muscovite gneiss.

The main pegmatite contains a discontinuous core of white to gray massive quartz, in which small quantities of green microcline occur. The quartz is surrounded by plagioclase-quartz pegmatite containing flakes and small curved books of green muscovite. Books of greenish-brown muscovite and biotite occupy shear surfaces in the pegmatite that lie about parallel to the walls. Good books were reported to have been recovered from a wide part of the pegmatite at the foot of the incline. They may have lain adjacent to the small mass of quartz occupying the central part of the pegmatite at this point, but their exact distribution could not be ascertained. Apparently sheet mica was recovered

also from small books lying in shear surfaces. The pegmatite in the back of the drift in the bottom of the mine is highly sheared. Plates of biotite and small broken books and scales of muscovite lie in the shear surfaces. Subsequent to the writer's last visit, the operator reportedly sunk a winze 6 or 8 feet in the floor of the drift but recovered little or no mica.

Few of the books produced from the Myers mine were larger than 4 by 4 inches; most of them were broken and badly wrinkled, and consequently the recovery of sheets was low. The grade of the mined part of the pegmatite is estimated at about 0.5 pound of sheet mica per ton. At the time the mine was closed the showings were poor, and hence the reserves are probably negligible. The total costs of production during the period August 18–November 21, 1944, are shown in table 5. During this period 185.75 pounds of sheet mica were recovered from about 350 tons of pegmatite excavated.

O. K. PROSPECT

The O. K. mica prospect, the location of which is shown in figure 2, is on the west side of the valley of Lake Creek 6 miles southeast of Riggins. It is owned by Fred Clark, of New Meadows, Idaho. Samples of book mica taken by the Bureau of Mines from the prospect were inspected by the writer. Their color is green and greenish brown. Some sheets are clear and others are black-stained. The books were as large as 4 by 5 inches. Cracks and reeves are present, but much of the mica is flat and free-splitting. It would yield sheets of "electric" quality.

LATAH COUNTY (AVON MICA DISTRICT)

LOCATION AND ACCESSIBILITY

The Avon mica district lies in the eastern part of Latah County, in T. 41 N., R. 2 W., Boise Meridian, about 23 miles northeast of Moscow, the county seat. (See fig. 7.) The area is about 2¼ miles long and from 1 to 2 miles wide, comprising sec. 22 and parts of secs. 14, 15, 21, 23, 26, 27, and 28. The arbitrary limits of the district indicated in figure 7 and plate 1 include all the mica mines and prospects in Latah County.

The nearest towns are Avon, lying 3 miles south of the district, and Deary, approximately 5 miles south-southeast. Both towns are on the Washington, Idaho & Montana Railroad, which connects with a branch of the Chicago, Milwaukee, St. Paul & Pacific Railroad at

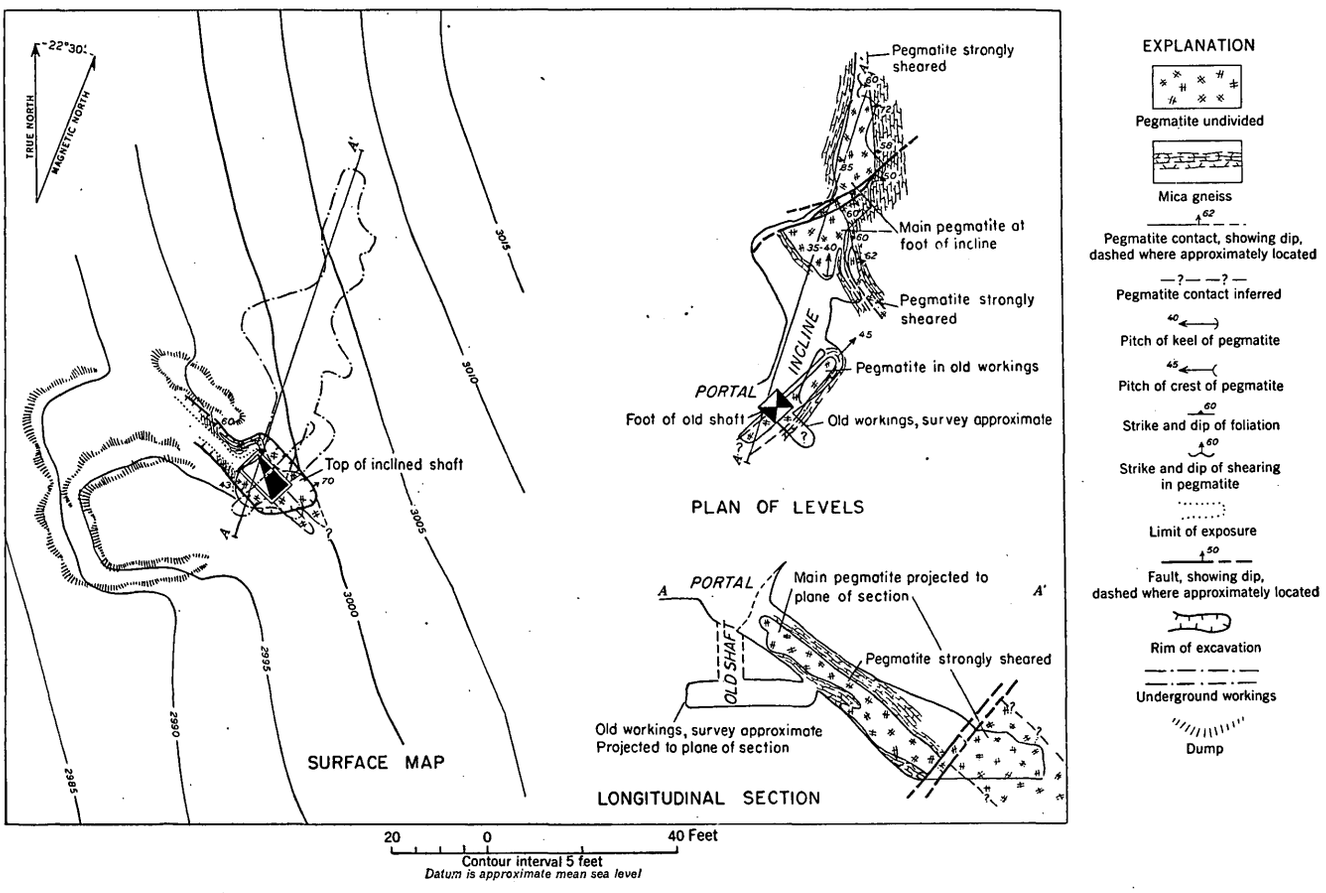

FIGURE 9.—Surface map and underground workings of Myers mine, Idaho County, Idaho.

TABLE 5.—*Costs of production, Myers mine, Aug. 18–Nov. 21, 1944*

Item	Total expense	Percentage of total	Cost per ton of pegmatite mined	Cost per pound of sheet mica produced
Mining:				
Labor	$1, 260. 63	39. 6	$3. 60	$6. 80
Foreman	765. 00	24. 0	2. 18	4. 12
Social security	12. 65	. 4	. 04	. 07
Mine supplies:				
Powder, caps, and fuse	122. 70	------	------	------
Gas, oil, and grease	169. 76	------	------	------
Miscellaneous supplies	243. 25	------	------	------
Total	535. 71	16. 8	1. 53	2. 89
Equipment rental	80. 64	2. 5	. 23	. 43
Total	2, 654. 63	83. 3	7. 58	14. 31
General:				
Royalty	20. 16	------	------	------
Interest on Colonial Mica Corporation loan	13. 68	------	------	------
Transportation (estimated)	100. 00	------	------	------
Total	133. 84	4. 2	. 38	. 72
Rifting and trimming:				
Charges by Colonial Mica Corporation	102. 40	------	------	------
Private shop:				
Labor	146. 62	------	------	------
Social security	1. 46	------	------	------
Rent	80. 00	------	------	------
Utilities	31. 23	------	------	------
Supplies	31. 93	------	------	------
Total	393. 64	12. 5	1. 14	2. 14
Grand total	3, 182. 11	100. 0	9. 10	17. 17

Bovill, 10 miles east of Avon, and with a branch of the Northern Pacific Railway at Palouse, Wash., 40 miles west of Avon. Moscow, the nearest supply center, is 35 miles distant by graveled and surfaced roads.

The mica area is accessible by two dirt roads, which branch from the road leading north from Avon. One road runs north about 6 miles and ends at the Muscovite mine. It was built by the United States Forest Service in 1943 as a mine access road. Most of the mines and prospects in the western part of the district lie close to it or are reached by way of short connecting roads. A second road runs 1 mile east and 3 miles north, up the East Fork of Big Bear Creek to the Lindquist property, whence other prospects in the northeast part of the district are accessible by steep forest trails. Roads to the Doerr property connect with the East Fork road about 2 miles south of the Lindquist property.

TOPOGRAPHY

The Avon district embraces several ridges and valleys in the east part of the Thatuna Hills, which form part of the west front of the Coeur d'Alene Mountains. Within the area altitudes range from about 3,100 feet in the south part to about 4,700 feet on the south and east slopes of Mica Mountain in the north part of the district. The west part of the district is drained by Schwartz Creek and the east part by the East Fork of Big Bear Creek. These streams join north of Avon and flow southward into Big Bear Creek, a tributary of the Potlatch River. Most of the mines and prospects lie along the crest of a long ridge extending south from Mica Mountain. Other workings lie near the head and on the west slope of Schwartz Creek valley, and on the valley slopes of the East Fork of Big Bear Creek. (See pl. 1.) The ridges, branching spurs, and valleys are rounded. In places the slopes are very steep. Bedrock is generally covered with a thick mantle of soil that supports the growth of a dense forest.

GEOLOGY

The bedrock of the Avon district includes mica schist and gneiss, granodiorite, aplite, pegmatite, and basalt. The principal rocks are mica schist and gneiss of the Belt series, which underlie the northern, central, and southwestern parts of the district, and granodiorite of the Thatuna batholith,[18] which occupies the southeastern and east-central parts of the area. The contact between the metamorphic and intrusive rocks follows the East Fork of Big Bear Creek for about a mile. The areal distribution of the rocks is shown in plate 1. Aplite, pegmatite, and basalt intrude the schist and gneiss, and small pegmatites lie in the marginal part of the granodiorite mass. All the mica mines and prospects lie in the metamorphic rocks. Throughout much of the district the bedrock is overlain by a thick mantle of soil, chiefly residual and colluvial but possibly in small part wind-transported. Small quantities of alluvium lie along the stream channels.

The schist and gneiss, resulting from the regional metamorphism of sedimentary strata, are part of the Belt series, of Algonkian age. They are well-foliated, fine- to medium-grained rocks composed largely of quartz, muscovite, and biotite in slightly varying proportions. The beds of schist are gray or silvery-white, depending on the local preponderance of biotite or muscovite. Layers of mica gneiss, of slightly finer grain and less micaceous composition, are interbedded with the schist. The rocks strike about north on the average, and the dominant dip is steep to the west. Although the original bedding is in large part obscured it is probably parallel in general to the schistosity. Schistosity crossing the bedding, however, was observed at a number of points. The rocks are complexly folded. Locally both bedding and schistosity are closely folded along minor axes that trend in many di-

[18] Tullis, E. L., Contributions to the geology of Latah County, Idaho: Geol. Soc. America Bull., vol. 55, No. 2, p. 143 and pl. 6, Feb., 1944.

rections and plunge at moderate to steep angles. The minor folds range in width and amplitude from a few inches to roughly 100 feet. Most of them plunge to the east or southwest, but others plunge to the northeast, northwest, or southeast. Possibly it would appear that the sedimentary rocks, in the course of regional deformation, were first folded isoclinally with development of axial plane foliation and later both foliation and bedding were folded again.

The Thatuna batholith probably should be correlated with the Idaho batholith,[19] of late Jurassic or early Cretaceous age.[20] According to Tullis,[21] the intrusive is chiefly granodiorite but contains small amounts of adamellite, tonalite, and granite. The marginal parts of the batholith on the East Fork of Big Bear Creek contain many small dikes of pegmatite. Heinrich[22] observed that the schist adjoining the contact is changed to a gray massive fine-grained rock containing quartz, biotite, and feldspar with smaller amounts of hornblende and epidote. The contact-metamorphosed rock is cut by numerous small pegmatite dikes.

The introduction of aplite and pegmatite presumably accompanied the intrusion of the Thatuna batholith. Narrow dikes and sheets of aplite cut schist and gneiss in the Doerr and Steelsmith mines. The aplite is a hard white to gray medium-grained rock composed of feldspar, quartz, muscovite, and accessory garnet.

About a hundred pegmatites wider than 1 foot are exposed in outcrops, pits, trenches, and underground workings in the Avon district. The pegmatites are unevenly distributed in the area. Individual bodies lie closely spaced in groups or series, which are separated by relatively broad tracts of metamorphic rock containing few pegmatites other than stringers. The largest bodies, roughly 1,000 feet long and from 20 to 90 feet wide, are exposed on the Fitzgerald property and the Morning Star claim. They are not known to have produced sheet mica. The producing pegmatites range in length from about 30 to 275 feet.

Basalt dikes cut the schist in the Luella, Doerr, and Steelsmith mines. The dikes are probably of the same age as the Miocene[23] basalt flows, which underlie part of the valley lands to the south of the district.

Most of the area is mantled by micaceous soil 1 foot to at least 15 feet in thickness. Most of the soil is residual and colluvial—the product of long-continued weathering of the schist and of downhill creep of the soil blanket. Trains or aprons of pegmatite debris, lying beneath several feet or more of colluvial soil, extend downslope from subsurface ledges of weathered pegmatite. Such float trains are exposed in many exploration trenches. Small areas within the district are covered by what are probably outlying patches of the wind-deposited Palouse formation,[24] which mantles the bedrock in the lower-lying areas to the south.

[19] Idem, p. 153.

[20] Ross, C. P., Mesozoic and Tertiary granitic rocks in Idaho: Jour. Geology, vol. 36, pp. 673–693, 1928.

[21] Tullis, E. L., op. cit., pp. 142–143.

[22] Heinrich, E. W., Some mica-beryl prospects, Avon district, Latah County, Idaho: U. S. Geol. Survey unpublished rept., pp. 5, 6, September 1942.

[23] Tullis, E. L., op. cit., p. 154 and pl. 6.

PEGMATITES

MINERALOGY

The pegmatite minerals that have been recognized in the Avon district include plagioclase, quartz, muscovite, schorl, microcline, beryl, garnet, biotite, apatite, graphite, vivianite, strengite, lithiophyllite, meta-torbernite, autunite, and lollingite.

White to cream-colored plagioclase feldspar is the most abundant mineral. It ranges in composition from sodic oligoclase (Ab_{88}) to albite (Ab_{96}). Cleavelandite, the lamellar variety of albite, is present in several pegmatites. In the upper parts of all pegmatites the plagioclase is granulated by weathering but is not decomposed to clay.

Dark-gray to white quartz is abundant in all the pegmatites as blebs, grains, and stringers, and in some as massive central ribs or cores.

Muscovite, as books and flakes or scales, is of two principal kinds: "Rum mica" and "green mica." They lie in slightly different associations and are greatly different in the average proportion of sheet mica that they contain. Many pegmatites contain books of both kinds of muscovite.

"Rum mica" ranges in color from deep rum to a very pale yellowish rum. Some of it is nearly colorless. Practically all of the sheet mica produced in the Avon district is cut from books of rum-colored mica. Although crude mica of this type commonly embodies such defects as cracks, ruling, warping, and mineral inclusions, yet a certain small proportion of it, ranging from 1.6 to 9.3 percent, according to available figures, is recoverable as sheet mica 1 by 1 inch and larger. In a few mines rum-colored mica is so highly distorted and broken that it yields less that 1 percent of sheets.

"Green mica" includes mica that is light green or light greenish-brown in thin sheets. The crude books are commonly white or gray. Books as large as a foot across have been mined. Practically all are reeved, soft, and broken, and many contain innumerable cracks and hairlines. Most green mica is valuable only as scrap. Rarely can flat sheets be cut from it.

Heavily air-stained, silvery muscovite is present in one of the pegmatites on the Doerr property. It was

[24] Idem, p. 135.

not regarded as of condenser grade by the Colonial Mica Corporation, although it is suitable for many commercial uses.

Schorl, or black tourmaline, as small and large crystals and as crystal aggregates 6 inches or more across, is particularly abundant in the Luella and Last Chance mines and is present in small amount in practically all of the pegmatites examined. Gem tourmaline was not observed.

Microcline is not abundant in the district. White to cream-colored microcline-perthite is present in the Muscovite and Steelsmith mines and in the Carlson lease, and small amounts are probably present in other pegmatites. Green microcline was seen in the open cut at the Avon Mica Co. mine.

Beryl is widely distributed but is found in considerable amounts only in the Muscovite mine, where most of the crystals are too small and too highly fractured to be recovered profitably by hand-picking. Beryl was observed also in the Steelsmith, Olson, Last Chance, and Luella mines. The largest crystal seen was 6 inches in diameter and 9 inches in length. In color the beryl is light green, yellowish green, pale yellow, or nearly white. Many crystals contain central cores of quartz and muscovite.

Small crystals of pink or red garnet and gray-green apatite are present in many pegmatites, especially in one exposed on the Lindquist property. Biotite is uncommon; small amounts of it were seen at the Muscovite, McCornack, and Lucky Jim properties. On the Lucky Jim property biotite lies in joints which cut pegmatite.

Flake graphite, in lumps up to 12 inches across, was found in a pegmatite discovered by the Bureau of Mines about 1,200 feet north of the Witherow lease. According to G. C. Reed, of the Bureau of Mines, the pegmatite is 36 feet in length, 4 feet in maximum width, and contains from 10 to 15 percent graphite.

Vivianite ($Fe_3P_2O_8.8H_2O$) and strengite ($FePO_4.2H_2O$) are present in a pegmatite on the Lindquist property. Vivianite has been found also at the Last Chance mine in association with lithiophyllite ($Li(Mn,Fe)PO_4$) and lollingite ($FeAs_2$). Meta-torbernite, a hydrous phosphate of copper and uranium, and autunite, a hydrous phosphate of calcium and uranium, occur in small amounts at the Last Chance mine.

WALL-ROCK ALTERATION

Crystals of garnet and schorl are present in the wall rocks of nearly all the pegmatites. Many pegmatites are bordered by light-colored, fine- to medium-grained rock composed of plagioclase, quartz, muscovite, and schorl, which has formed by recrystallization of original constitutents of the schist and by partial replacement by pegmatitic material. Plagioclase is most commonly the chief mineral, but locally the altered schist may be quartzose or highly micaeous and schistose. Relict schistosity and bedding are commonly present. At some places in the Muscovite mine the alteration extends 20 feet from pegmatite, although in most mines the altered zone is rarely more than a few inches to a foot wide. Metacrysts of beryl and rum-colored book muscovite are embedded in altered schist in the Muscovite mine.

STRUCTURE

Almost all the pegmatites are conformable to the foliation and bedding of the enclosing schist and gneiss. Dikes are few and commercially unimportant. The following types of pegmatites, based on form and relation to the wall rocks, are distinguishable in the Avon district: Dikes, sheets, and lenses, branching bodies, foldform bodies, and pipelike bodies.

Narrow dikes—tabular bodies that cut across the schistosity—are exposed in the pits and trenches on the Doerr property.

Both lenses and sheets lie parallel to the schistosity. Lenses and sheets differ in that in lenses the ratio of length to thickness is smaller. Most of the pegmatites on the Doerr property appear to be simple concordant lenses. Some of the individual lenses that make up the East and West deposits in the Muscovite mine are highly irregularly in outline, and they transgress the schist at some places. (See pl. 6.) Lenses such as those mined in the Avon Mica Co. mine (fig. 10), the Campbell lease (fig. 11), and the Tonopah north cut on the Steelsmith property (pl. 9), are modified in form by minor but abrupt "rolls," or undulations, in the contacts. The rolls coincide with minor folds in the adjoining schist.

The Central pegmatite in the Muscovite mine and the main pegmatite on the Morning Star claim are branching bodies.

Pegmatites lying in closely folded rocks may be foldform or pipelike bodies. Some of the foldform bodies, such as those in the open pit at the Carlson lease (fig. 12) and in the tunnel of the Olson mine (fig. 17), are concordant pegmatites of approximately uniform thickness that occupy the crests, troughs, and limbs of folds. One of the pegmatites in the Last Chance mine lies conformably in mica schist that has been thrown into a series of small folds. Two sharp anticlinal folds, one of them recumbent, enclose the thickest parts of the pegmatite, which are connected by a relatively thin sheet of pegmatite.

Pipelike pegmatites are those that are conspicuously elongate along a single axis. The axis of plunge is

generally steep and is approximately parallel to the axis of folding of the wall rocks adjacent to the pegmatites. Some pipelike bodies occupy the central parts of folds and conform to the shapes of the folds. Sections normal to the plunge axis may be U-shaped (pl. 9), roughly oval, or nearly triangular. Other pipes, such as the main pegmatite in the Steelsmith mine (pl. 9), do not occupy folds but plunge approximately parallel to minor folds in the adjacent rocks.

Many of the more productive pegmatites are distinctly zoned. One of the bodies in the Last Chance mine consists of five zones: border zone, sheet mica-bearing wall zone, intermediate zone, core-margin zone, and core. The largest pegmatite in the Muscovite mine consists of a core and discontinuous wall and border zones. Most of the pegmatites that are conspicuously zoned contain a core of massive quartz, a wall zone, and a border zone. Others consist only of a feldspar-quartz core and a fine-grained border zone or selvage. Many pegmatites that lack a continuous quartz core contain numerous small masses, or "pods," of quartz in their central parts. Homogeneous or unsegregated bodies are exemplified by the East and West pegmatites in the Muscovite mine. The zoning characteristic of most productive mica pegmatites is lacking in them.

Wall-zone mica deposits include those mined at the Last Chance, Doerr, and Steelsmith mines. Most of the smaller deposits are of the quartz-pod type, in which the book mica occurs in and next to small massive segregations of quartz that lie in the central parts of the pegmatites. Most of the production of the district has come from the East and West pegmatites in the Muscovite mine, which are disseminated deposits.

PRODUCTION

The Avon district includes about 18 mines and prospects. Most of them have produced sheet mica in quantities ranging from a few pounds to thousands of pounds. Only four mines—the Muscovite, Doerr, Steelsmith, and Last Chance—have an appreciable production. Most of the others have been small marginal or submarginal operations. The production of the district by mines, from 1943 to May 1, 1945, is given in table 6.

TABLE 6.—*Mica production, Avon mica district, 1943, 1944, and Jan. 1 to May 1, 1945*

Property	Working place and operator	Mine-cobbed mica (pounds)	Untrimmed punch mica (pounds)	Sheet mica 1½ by 2 inches and larger, ¾ trim (pounds)	Sheet mica 1 by 1 to 1½ by 2 inches, full trim (pounds)	Sheet mica 1½ by 2 inches and larger, full trim (pounds)	Total prepared mica, all classes (pounds)	Total value	Recovery of sheet mica from crude mica[1] (percent)
Doerr	Montag & Eichelberger (Cut No. 2)	[2] 21,625		249.50	1,765.75		2,015.25	$10,076.25	9.30
	Various	(?)			160.31	35.31	195.62	1,244.34	
	Total			249.50	1,926.06	35.31	2,210.87	11,320.59	
Gillis	D. J. Carlson (cut No. 6)	[3] 4,915		43.50	294.06	6.44	344.00	2,076.88	
	D. Gillis (cut No. 6?)	(?)			15.75		15.75	94.50	
	Total			43.50	309.81	6.44	359.75	2,171.38	
Avon Mica Co. mine (Hungry Gut).	Avon Mica Co	[4] 1,680		18.00	66.00		84.00	487.50	
	D. J. Carlson	[4] 2,180	90.50		91.10	48.44	230.04	961.27	
	Bought in block	(?)			5.49	2.13	7.62	49.98	
	Total		90.50	18.00	162.59	50.57	321.66	1,498.75	
Last Chance claim	Wm. Freebury	(?)			2.56		2.56	15.36	
	Burton Meier (cuts 2 and 3, underground, and Witherow lease)	[5] 61,200	3,340.00	79.36	1,147.33	338.23	4,904.92	11,067.98	3.10
	Various	(?)		3.31	1.94		5.25	31.50	
	Bought in block	(?)			102.50	8.44	110.94	682.52	
	Carl Roseberry (cut No. 1)	30,000	574.25		1,048.24	200.28	1,822.77	8,063.96	4.35
	Total		3,914.25	82.67	2,302.57	546.95	6,846.44	19,861.32	
Lucky Jim	Ray Craine	[3] 3,000		1.75	89.55	3.00	94.30	570.43	
Luella	E. A. Campbell	[6] 17,880		5.25	252.31	33.74	291.30	1,815.28	1.6
Maxine No. 1	L. C. Rowland	(?)			10.37	2.19	12.56	79.74	
Maxine No. 2	do	[4] 7,000			164.05	28.47	192.52	1,212.06	
	Bureau of Mines sample	(?)			2.50	.50	3.00	19.00	
	Total				166.55	28.97	195.52	1,231.06	
Lindquist (Munro Mill)	E. R. Lindquist	(?)			12.12	1.12	13.24	81.68	
Muscovite	Surface (C. J. Montag & Sons)	[7] 355,486	3,376.00	1,102.75	10,761.75	3,995.06	19,235.56	104,096.13	4.57
	Dumps (C. J. Montag & Sons)	(?)174,000	2,908.42	339.25	5,342.12	358.37	8,948.16	37,862.29	3.64
	Underground (C. J. Montag & Sons)	[7] 323,775	20,161.00			6,978.31	27,139.31	61,874.78	
	Underground (Victory Mines, Inc.)	[7] 441,702		4,063.25	17,538.25	5,260.68	26,862.18	169,019.19	6.09
	Various	(?)	2,513.50	32.56	802.24	127.24	3,475.54	6,075.02	
	Total	+1,294,963	28,958.92	5,537.81	34,444.36	16,719.66	85,660.75	378,927.41	
Fitzgerald property (Olson mine).	Open pit (A. B. Olson)	[8] 18,000	15.00		702.37	129.55	846.92	5,255.12	4.62
	Underground (Montag & Clayton)	2,000	315.00			39.31	354.81	409.13	
	Total	20,000	330.00		702.37	168.86	1,201.73	5,664.25	

See footnotes at end of table.

TABLE 6—*Mica production, Avon mica district, 1943, 1944, and Jan. 1 to May 1, 1945*—Continued

Property	Working place and operator	Mine-cobbed mica (pounds)	Untrimmed punch mica (pounds)	Sheet mica 1½ by 2 inches and larger, ¾ trim (pounds)	Sheet mica 1 by 1 to 1½ by 2 inches, full trim (pounds)	Sheet mica 1½ by 2 inches and larger, full trim (pounds)	Total prepared mica, all classes (pounds)	Total value	Recovery of sheet mica from crude mica[1] (percent)
Fitzgerald property (Carlson lease).	D. J. Carlson	[3] 5,670			182.50	34.63	217.13	1,372.04	
Silver White	Thatuna Mines	(?)			12.75		12.75	76.50	
Steelsmith	O. L. Gleason	(?)		11.25	10.75		22.00	132.00	
	Upper tunnel mainly (Tonopah Mines)	24,600		172.25	967.68	1.68	1,141.61	6,316.27	4.64
	McDonnell lease (Finley McDonnell)	(?)			63.94	14.37	78.31	498.60	
	Bought in block	(?)			13.00		13.00	78.00	
	Alex Hines	(?)			9.75		9.75	58.50	
	J. D. Murphy (Murphy lease)	(?)			17.56	2.43	19.99	124.80	
	Tonopah north and south cuts (C. C. Weipert).	5,300		4.12	122.06	5.25	131.43	799.08	2.5
	R. Olson	(?)			4.00	.69	4.69	29.52	
	Total	29,900		187.62	1,208.74	24.42	1,420.78	8,036.77	
Campbell lease (Thatuna lease No. 7).	E. A. Campbell	[9] 6,069			112.25	14.87	127.12	792.46	2.1
	Total, Avon district	+1,506,082	33,294.17	6,126.10	41,894.90	17,670.73	98,985.90	433,499.66	
	Total of prepared mica—percent		33.64	6.19	42.32	17.85	100.00		

[1] Calculation of recovery includes an estimated 10 percent of small sheet mica contained in the punch mica.
[2] Excludes about 3,400 pounds of mine scrap.
[3] Doubtful.
[4] Estimated.
[5] Subdivided approximately as follows: Cuts 2 and 3, 29,200 pounds; Witherow lease, 4,000 pounds; underground, Last Chance mine, 28,000 pounds.
[6] Excludes about 12,000 pounds of mine scrap.
[7] Probably accurate within several percent.
[8] Excludes an estimated 4,000–5,000 pounds of mine scrap.
[9] Excludes about 2,000 pounds of mine scrap.

NOTE.—Mine-cobbed mica production is to May 1, 1945, except for Avon Mica Co. mine, mine-cobbed mica production to Dec. 31, 1944. Sheet and punch mica figures are probably complete sales to Apr 2, 1945, excepting: Muscovite mine, 133.05 pounds of sheet sold Custer, S. Dak., Apr. 13–Aug. 12, 1943, and 1,020.75 pounds of punch sold Custer, S. Dak., Feb. 25–Mar. 25, 1945. Figures for punch and sheet mica and dollar value compiled by U. S. Bureau of Mines from records of Colonial Mica Corporation. Mine-cobbed mica figures compiled and estimated by U. S. Geological Survey from various data.

The available data on quality and grade of sheet mica are given in the mine descriptions. Table 7 summarizes the known quality data. The percentages of mica of various qualities in the total prepared mica from each of five mines is recorded.

TABLE 7.—*Quality of sheet mica from principal mines in the Avon district*

Mine	Quality (percent)			
	No. 1	No. 2	No. 2 inferior	No. 3
Muscovite:				
Main pit	3.03	29.70	66.95	0.32
Other pits	5.18	30.06	64.61	.14
Underground	1.02	15.80	82.50	.67
Old dumps	2.81	35.52	61.53	.14
Steelsmith	3.74	43.73	52.22	.31
Doerr	1.34	24.45	71.42	2.80
Luella	5.20	36.80	50.30	7.70
Last Chance	1.61	23.95	73.66	.78

CONDITIONS AFFECTING PROSPECTING AND MINING

The deep soil cover and dense forest make prospecting difficult. Natural outcrops are few throughout the greater part of the Avon district. The mapping of rock formations, including pegmatites, depends largely on exposures in mines, road cuts, and exploration trenches, but a small number of pegmatites, including some of the more productive ones on the Last Chance, Steelsmith, and Muscovite properties, crop out as small quartzose knobs standing only a foot or two above the surrounding surface. The original discoveries were doubtlessly made by testing quartz outcrops and tracing float to its sources.

The district is remote from the chief commercial buying centers for sheet and scrap mica. Consequently, producers must bear greater transportation charges than are borne by producers in districts more favorably situated. During part of the period 1943–45 the Colonial Mica Corporation maintained a buying office in Moscow, and the cost of shipping mica was assumed by the Government. This advantage ended with the conclusion of the Government's domestic mica program.

Beyond the town of Avon access to the district is gained by way of dirt roads which, during parts of the winter and spring, are impassable to all but the most powerful vehicles. The terrain is steep and densely forested, and as a consequence trails and subsidiary roads are relatively expensive to build.

No resident supply of skilled mine labor exists. Miners are imported from the Coeur d'Alene district to the north and from mining districts in central Idaho. Unskilled labor is available locally except during the planting and harvesting seasons.

Timber for mining and construction is abundant on all the properties. Ample water for domestic and mining purposes is obtained from small springs and from underground mine drainage.

AVON MICA CO. MINE

The Avon Mica Co. mine, also known as the Hungry Gut mine, is on State land in the NE¼ sec. 28. Pegmatite was discovered on the present site of the mine

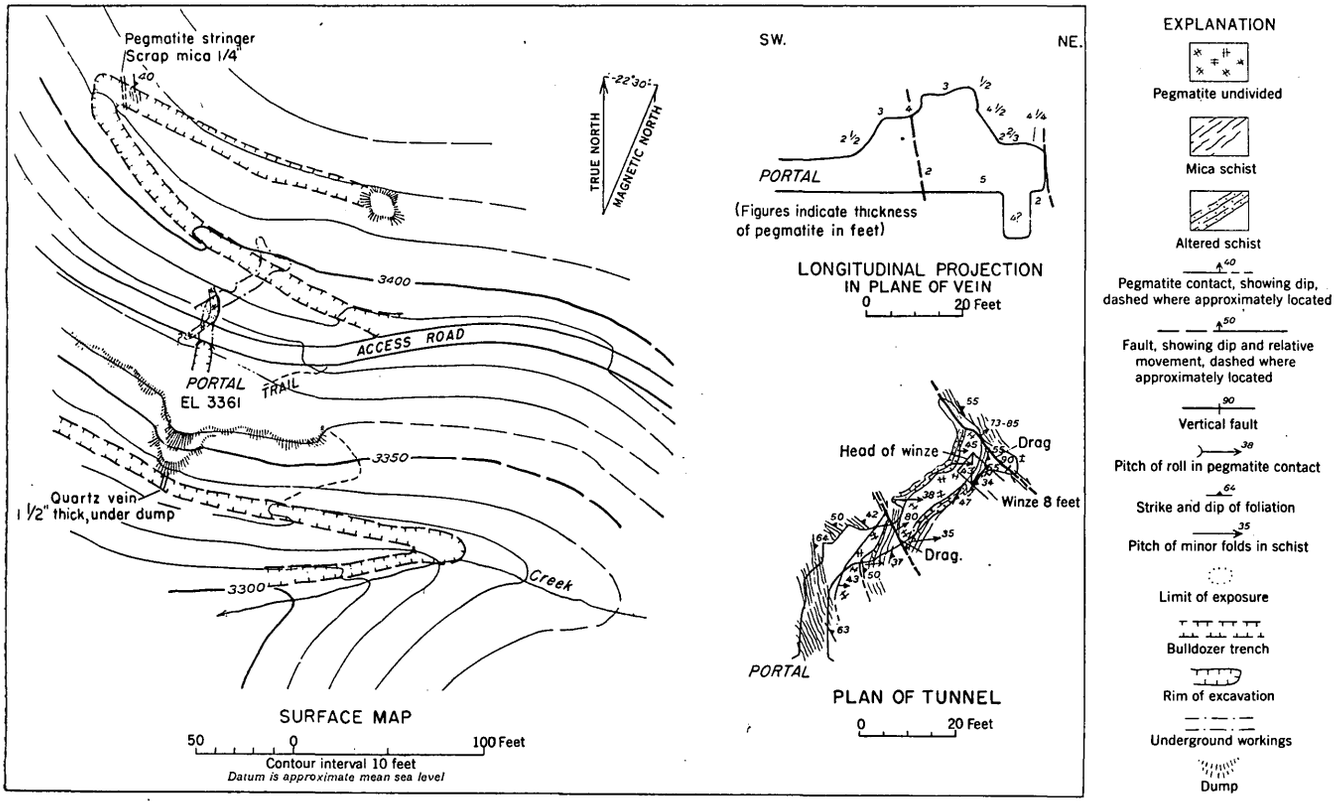

FIGURE 10.—Surface map and underground workings of Avon Mica Co. mine, Latah County, Idaho.

during the building of the access road by the United States Forest Service in 1943. A State lease was obtained by William W. Freebury and E. D. Nieland, of Deary, Idaho, who formed the Avon Mica Co. Small-scale mining was started in the fall of 1943 and continued intermittently during 1944. During part of the time the mine was operated by Dan J. Carlson, of Deary. The workings include a small cut by the side of the access road and a short tunnel, 15 to 20 feet below the road, from which an overhand stope and a shallow winze extend. Almost all of the sheet mica produced came from the underground workings. Figure 10 shows the geology and workings.

The open cut exposes a pegmatite 3 feet thick striking about north and dipping 60° to 70° E. It is composed chiefly of weathered plagioclase and quartz but contains microcline and muscovite in small amounts. The microcline is green, superficially resembling beryl. It occurs as small masses with gray glassy quartz and as tiny stringers one-eighth to a quarter of an inch wide cutting the quartz. Books of light rum-colored mica as much as 3 inches in diameter and scales and small books of soft white muscovite of scrap grade lie in the pegmatite. The rum mica is flat and hard but cracked around the edges of the books. A few black specks were seen in some books, but these are said to be easily removed in trimming.

The tunnel exposes what may be a second pegmatite, which ranges from 1½ to 5 feet in thickness along a length of 37 feet. The body is lenticular or tabular. It strikes N. 40° E. and dips 45° to 55° SE. The footwall contains small rolls which plunge 35° to 43° E. The pegmatite is offset by two reverse faults that strike northwest and dip steeply northeast. The workings end at the northeastern fault, and the offset of the pegmatite is indicated by "drag" material in the fault gouge.

The pegmatite is composed of soft white plagioclase, dark-gray quartz, muscovite, and schorl. Plagioclase makes up 75 percent of it and muscovite about 10 percent. Between a quarter and a third of the mica is hard and rum-colored; the rest is soft and white. The rum-colored mica lies in and next to small pods of quartz, whereas the white mica lies mainly in plagioclase. Most of the rum mica is cracked, curved, and ruled. Reportedly the largest block was found in the bottom of the winze. It was 8 by 12 inches and weighed about 10 pounds. Sheet mica cut from some books was as large as 4 by 4 inches. Only a very small proportion of the white mica is hard and flat enough to yield sheets.

The average grade of the pegmatite exposed underground was estimated to be 0.9 pound of sheet mica, 1 by 1 inch and larger, per ton of pegmatite. The deposit is small, and most of the sheet mica is probably of No. 2 inferior quality. There is little possibility of profitable operation in times of normal mica prices.

CAMPBELL LEASE

The Campbell lease lies in the SW¼ sec. 22 on land belonging to Thatuna Mines. It is accessible by a dirt road branching from the mine access road. Several bodies of pegmatite were uncovered by angledozer stripping done by the Bureau of Mines in the fall of 1943. E. A. Campbell, the operator of the Luella mine, leased the property and in August 1944 started open-pit mining on one of the pegmatites, using a scraper drawn by a gasoline-powered hoisting engine. Work ceased in November 1944. Table 8 gives data concerning costs. Pegmatite was excavated to the amount of 650 tons, from which 6,069 pounds of crude cobbed mica, 2,000 pounds of scrap, and 127.12 pounds of sheet mica worth $79.46 were recovered. A crew of two to three men was employed.

TABLE 8.—*Operating costs of the Campbell lease, Aug. 22–Nov. 1, 1944*[1]

Item	Total expense	Percentage of total	Cost per pound of mine-cobbed mica recovered	Cost per ton of pegmatite mined	Cost per pound sheet of mica produced
Mining:					
Labor	$934. 24	61. 8	$0. 154	$1. 44	$7. 34
Social security and workmen's compensation	25. 58	1. 7	. 004	. 04	. 02
Mining supplies	229. 65	15. 2	. 038	. 35	1. 80
Rental of hoist and compressor	50. 00	3. 3	. 008	. 08	. 39
Total	1, 239. 47	82. 0	. 204	1. 91	9. 73
Rifting and trimming	273. 12	18. 0	. 045	. 42	2. 15
Grand total	1, 512. 59	100. 0	. 249	2. 33	11. 88

[1] To the above operating costs, a small sum representing expense of transportation, royalty, and interest would have to be added to give total cost of production.

The workings, shown in figure 11, are an old tunnel and the open pit excavated by Campbell. Five lenses of pegmatite, striking N. 63° W. to N. 80° E. and dipping to the south, are exposed in the workings and the surrounding stripped area. The pegmatite mined in the open pit is about 120 feet in length and 18 feet in maximum thickness. It strikes N. 70° W., about parallel to the enclosing mica schist. The lenticular form is modified by small steeply plunging rolls in both walls. The pegmatite is divided into a mica-rich border zone up to 12 inches in width, and a central core composed of plagioclase, quartz, sparsely scattered small books and flakes of muscovite, and schorl. Within the core, small mica books lie in medium-grained plagioclase-quartz pegmatite and in small segregations of gray quartz. Almost all of the books are less than 4 inches in diameter, and most of them are curved and cracked. The sheets are colorless to pale rum.

A few yards east of the open pit are several small lenses of plagioclase-quartz pegmatite containing minor amounts of muscovite. No attempt has been made to mine them. The old tunnel exposes a single lens of pegmatite up to 30 feet in width. What is apparently the same body is exposed on the road below the open pit. It strikes N. 65° E. and dips 80° SE. The pegmatite is a mixture of fine- to medium-grained gray quartz, scrap-quality muscovite, mainly of thumbnail size, and soft white plagioclase. The mica schist is strongly tourmalinized at the contacts.

CARLSON LEASE

Extensive trenching by the Bureau of Mines revealed about a dozen small pegmatites on part of an area of State-owned land in sec. 27, held under lease by George Fitzgerald, of Spokane, Wash. One pegmatite appeared to be a favorable prospect, and a sublease on it was obtained by Dan J. Carlson, of Deary, Idaho, who, with Burt Clayton, also of Deary, mined in a small open pit during the fall of 1944.

A map and cross section of the pit are shown in figure 12. The pegmatite is a foldform body, 2 to 6 feet thick, lying conformably in folded muscovite-quartz schist. The pegmatite was estimated to contain 74 percent plagioclase and microcline, 22 percent quartz, 3 percent muscovite, and 1 percent black tourmaline. The bulk of the body is a mixture of medium-grained feldspar and quartz with scattered, small, bent, white to pale-greenish mica books. Small lenticular quartz pods lie in the middle parts of the pegmatite. Most of the mica, both rum-colored and white, is concentrated in and next to the pods. Some pods contain only scrap mica, but others contain a few good books. Rum books up to 6 or 8 inches in diameter were recovered, but they were mostly bent, cracked, ruled, and slightly clay-stained. Most of the mica came from the west end of the pit.

Many other pegmatites exposed in trenches near the open pit appear to be lenses or narrow sheets composed chiefly of albite and quartz. A few small books of good mica were seen in two of them. The chances of profitable mica mining on the Carlson lease are nil.

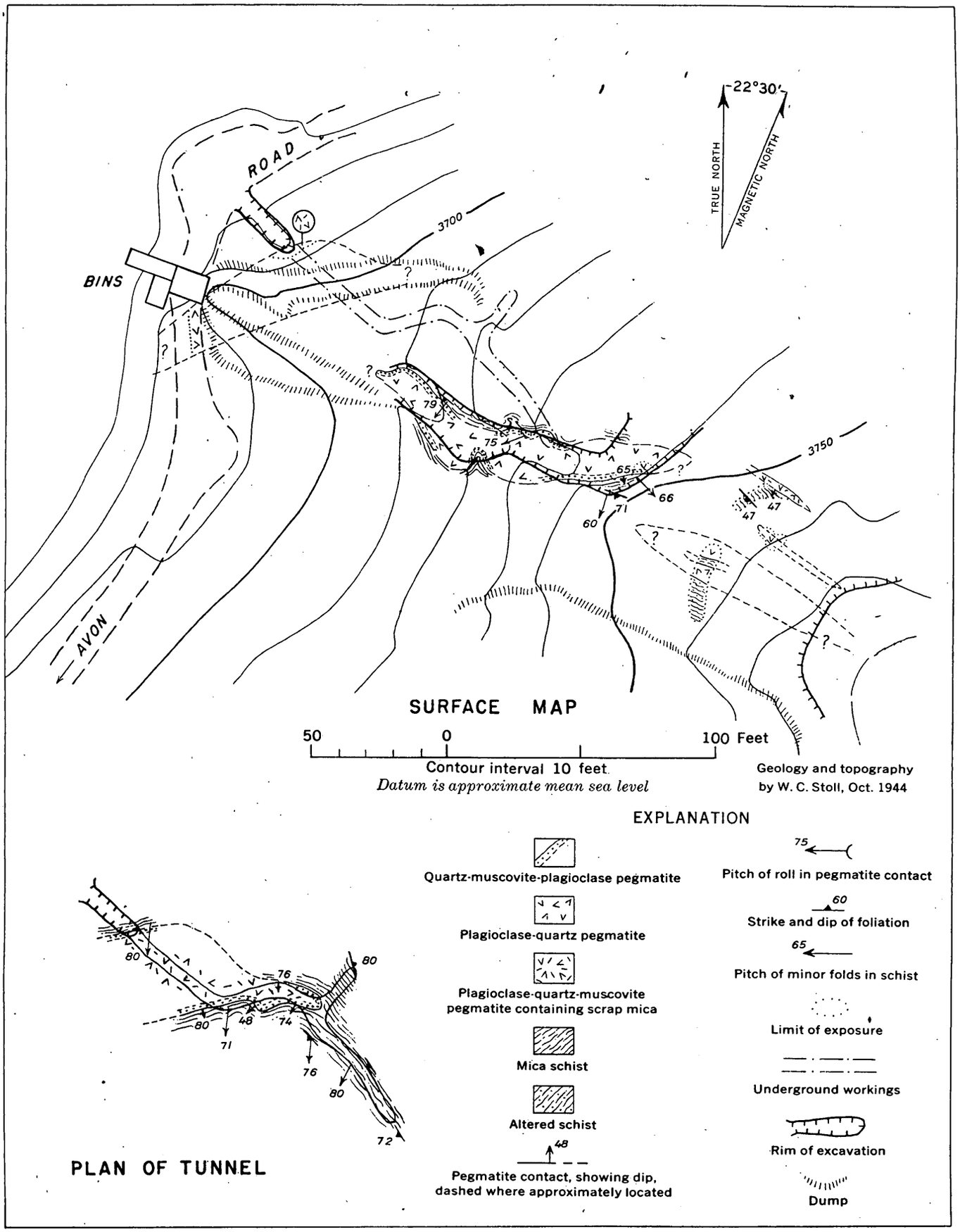

FIGURE 11.—Surface map and plan of tunnel, Campbell lease, Latah County, Idaho.

DOERR PROPERTY AND GILLIS LEASE

LOCATION AND ACCESS

The workings on the Doerr property and the adjoining Gillis lease are about 3,000 feet southeast of the Muscovite mine in the SE¼ sec. 22 at altitudes between 3,530 and 3,800 feet. The properties lie on the crest and flanks of a southeastward-trending spur of the main ridge on which the Muscovite mine is situated. Access is by way of a tractor road from the Muscovite mine, or by either of two dirt roads running north-northwestward from the East Fork of Big Bear Creek. One road follows a valley to the new camp and the lower tunnel, and the other road ascends the spur to the higher workings.

HISTORY, PRODUCTION, AND WORKINGS

The Doerr property was located in 1914 as the Bentz claim and was worked for 3 years by the Washington Mica Co., of which A. H. Bentz, of Spokane, Wash., was president. During the operation, according to

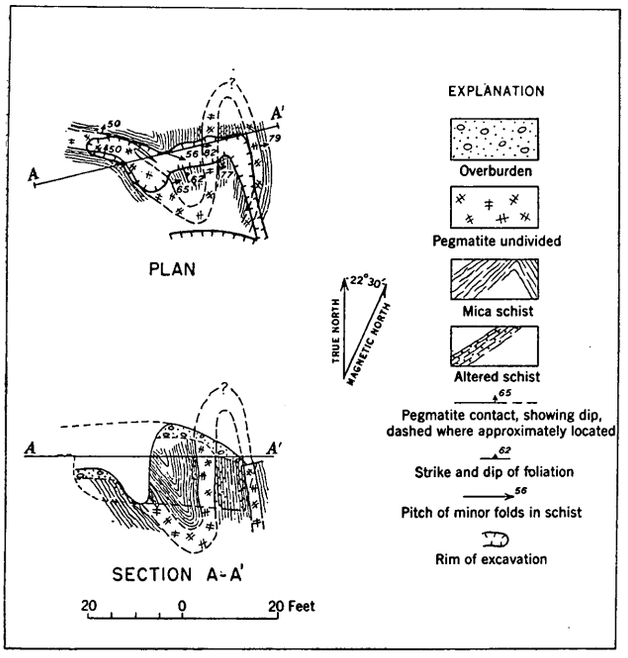

FIGURE 12.—Open pit on Carlson lease.

Bentz, several 40-ton carloads of crude mica were mined and hauled by wagons and sleighs to Avon for rail shipment. The mica reportedly came from stopes in the upper of two tunnels. No mica was produced from the lower tunnel, which was driven after the stoping.

In succeeding years several attempts at operation were made and a little mica is said to have been produced in 1927. Later the Bentz claim was acquired by the present owner, Mrs. Janett Doerr, of Spokane, Wash. In 1943 the Doerr property was leased by Frank Eichelberger, mining engineer of Spokane, and C. J. Montag & Sons, contractors of Portland, Oreg. The land adjoining the Doerr property on the south was leased from the State by Don Gillis of Spokane. The geology and workings of the two properties are shown in plate 2.

In the fall of 1943 C. J. Montag & Sons, using a power shovel and angledozer, dug six open pits on the crest of the ridge. Cut No. 2, the only one from which appreciable amounts of mica were produced, was excavated on the site of an old raise on the outcrop of the same pegmatite that had been mined from the upper tunnel in the early operation. The pegmatite was mined over a strike length of about 65 feet, and the pit was carried to depths of 25 to 55 feet. Old stopes were encountered from place to place, but mica was recovered from the previously unmined parts of the pegmatite. The production from cut No. 2 amounted to 21,625 pounds of mine-cobbed mica, excluding about 3,400 pounds of mine scrap that was sorted out at the mine. Sheet mica 1 by 1 inch and larger in the amount of 2,015 pounds was cut from the crude books. Table 9 gives the results of retrimming, grading, and qualifying 1,390.75 pounds of the sheet mica by Colonial Mica Corporation in Asheville, N. C. The mica was classified as ruby. The weight of sheet mica after retrimming was 1,120.27 pounds. Thins, skimmings, small washer, and scrap amounted to 270.48 pounds.

TABLE 9.—*Quality and grade of total retrimmed sheet mica produced from the Doerr mine*

Grade No.	Quality (percent)				
	No. 1	No. 2	No. 2 inferior	No. 3	Total
1	------	0. 022	0. 018	------	0. 040
2	------	. 090	. 100	------	. 190
3	0. 006	. 080	. 229	------	. 315
4	. 077	. 224	. 723	0. 122	1. 146
5	. 150	4. 508	17. 650	. 422	22. 730
5½	. 132	3. 235	14. 109	. 412	17. 888
6	. 515	11. 425	29. 366	1. 843	43. 149
7	. 462	4. 870	9. 210	------	14. 542
Total	1. 342	24. 454	71. 405	2. 799	100. 000

Cuts No. 3 and No. 4 were made to gain entrance to the old upper tunnel, but it was found to be tightly caved at several places. Cuts Nos. 1, 5, and 6 were dug on small pegmatites previously exposed by stripping. No mica was produced from cuts No. 1 and No. 5, but cut No. 6, on the Gillis lease, was further explored by Dan J. Carlson, of Deary, Idaho, in 1944, and a few hundred pounds of sheet mica are said to have been produced from the cut and from a short drift driven north on the pegmatite exposed in the head of the cut.

Near the north end of the mapped area (pl. 2), the Bureau of Mines in 1943 made about 2,500 feet of angle-dozer trenches in search of mica pegmatite. Trenches were cut also on the Gillis lease, south of the mapped area.

In the winter and spring of 1944 C. J. Montag & Sons drove an extension of the old lower tunnel in an unsuccessful effort to crosscut the pegmatite exposed in cut No. 2.

ROCKS AND STRUCTURE

A series of pegmatites is exposed over a north-south distance of more than 1,200 feet. Most of the pegmatites, including all the larger ones, are lenses that strike northward and dip westward, parallel to the enclosing schist. A few narrow dikes break across the schistosity.

The country rock is gray to silvery-white medium-grained strongly foliated muscovite-biotite-quartz schist interbedded with thin layers of finer-grained harder mica gneiss. The foliation is parallel to the bedding. The rocks strike nearly due north and dip from 50° W. to vertical, the average dip being about 70° W. Large differences from the average strike and dip were observed locally.

Aplite dikes and sills, ranging in thickness from a few inches to 5 feet, are exposed in cut No. 3 and in the lower tunnel. Some of the bodies are cross-jointed from wall to wall. Unlike the pegmatites they are tabular rather than lenticular in form. The aplite is a hard white to gray medium-grained rock composed of feldspar and quartz with scattered scales of muscovite. A few specks of molybdenite (?) and some small light reddish-brown garnets, one-sixteenth of an inch in diameter, were seen in one dike.

Basalt is present as a sill, 7 feet thick, in the lower tunnel.

MICA DEPOSITS

Cut No. 2.—The main mica-bearing lens, in cut No. 2, is exposed only in the face of the cut, beyond which it extends north for an unknown but probably short distance. In the floor of the cut the pegmatite is covered with debris, and the details of its structure and composition over much of its length could not be observed. Reportedly it has been mined above the old, caved upper tunnel, but the limits of the stopes are not exposed. They extend north of the head of the cut and probably lie in the floor as well.

The lens strikes nearly due north and dips 70° to the west, parallel to the foliation of the enclosing schist. The body was mined over a strike length of 65 feet, and it may extend 100 feet or more in total length. Presumably it extends below the upper tunnel but terminates above the lower tunnel, for the extension of the lower tunnel driven in 1944 failed to intersect the body on its projected dip. (See pl. 2, sec. A–A′.) At the head of cut No. 2 the pegmatite is 8 feet thick. It consists of a quartz core 4 feet thick, a wall zone 2 feet thick, and a thin border zone. The wall zone is composed of coarse plagioclase and quartz with scattered books of muscovite from 1 to 2 inches in diameter. Larger books were recovered from other parts of the deposit. The sheet mica is very pale rum, flat, and hard. About 2.5 pounds of it were recovered per ton of pegmatite mined. So far as is known no beryl was recovered during the most recent operation.

Cut No. 6.—The pegmatite is cut No. 6, on the Gillis lease, is exposed at the head of the cut and in a short drift, which was driven about 45 feet north to a point where the pegmatite pinches out. The pegmatite is 3 to 6 feet thick. The south end of the body is not exposed. Small books of mica are sparsely distributed in a matrix of coarse plagioclase and quartz. The average grade of the deposit is probably less than 0.5 pound of sheet mica per ton of pegmatite.

Bureau of Mines trenches.—In the pegmatites exposed in the Bureau of Mines trenches near the north end of the mapped area (pl. 2), book mica is not abundant except in one deposit, which contains silvery mica. Books as large as 6 inches across were seen. The mica is suitable for many electrical uses, but it was not of high enough quality to be bought by the Colonial Mica Corp. The lens containing the mica is partly exposed for a length of 20 feet and a width of 10 feet. It strikes N. 25° E. and dips 60° NW. The content of book mica in the pegmatite may be as high as 5 percent. A second exposure of pegmatite, lying to the north of the first, may be on the same pegmatite, and if so the body is at least 65 feet long.

RESERVES

Reserves of sheet mica-bearing pegmatite exist on the Doerr property, but they are not calculable because the extent of old stoped areas is unknown and the deposits are inadequately exposed. The most promising deposit is the one in cut No. 2. Possibly additional sheet mica might be obtained if the cut were deepened and extended to the north.

FITZGERALD PROPERTY

A part of sec. 27, lying about 3,000 feet S. 17° E. of the northwest corner of the section, on land leased from the State by George Fitzgerald, of Spokane, Wash., was extensively trenched by the Bureau of Mines in 1943. (See pl. 1.) O. H. Gleason and C. Ward, of Lewiston, Idaho, held a sublease on the property at that time. A large pegmatite and several small paral-

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lel pegmatites are partly exposed in old workings and in crosscut trenches above the mine access road on the crest of a ridge extending southwest from the Steelsmith property. The large pegmatite strikes N. 5° E. and probably dips steeply west. Possibly it is more than 900 feet long and as much as 90 feet wide. The body appears to consist largely of weathered, white plagioclase and gray and white quartz, in which flakes and small books of muscovite are irregularly and scantily distributed. Graphic granite was seen at one place. In the old workings, which comprise a tunnel 20 feet long and a small prospect pit lying above the end of the tunnel, medium-grained feldspar-quartz pegmatite containing minor amounts of muscovite is exposed.

LAST CHANCE MINE

LOCATION AND ACCESS

The Last Chance mine is in sec. 22, on the same mineral claim as the Witherow lease, which lies 600 feet to the east. The workings are on a steep slope at the headwaters of a branch of Schwartz Creek at altitudes of 3,600 to 3,660 feet. Access is by way of a dirt road connecting with the mine access road.

HISTORY, WORKINGS, AND PRODUCTION

Old workings existed in 1910. At that time the Last Chance and the nearby Silver White prospect were known as the Maybe mine, or Silver White mine. The Spokane and Eastern Branch of the Seattle First National Bank is one of the trustees of the property. Burton L. Meier, of Deary, obtained a lease in 1944 and started open-pit mining in June in partnership with Don Holtz and J. G. Sullivan. Subsequently, part of the open-pit mining was done by Carl Roseberry, who held a sublease from Meier. In the winter and spring of 1944–45 an old tunnel was partly cleaned out and underground development and mining were carried on. The mine was closed on March 23, 1945.

The workings comprise three open pits, prospect trenches, two tunnels, and stopes. The open pits were excavated by Meier and partners on the sites of old cuts and at points where old stopes reached the surface. Both tunnels are old workings. One was cleaned out and lengthened, but the other remains caved. All the old stopes above the first tunnel are inaccessible. The accessible workings and the geology are shown in plate 3.

An estimated total of 87,200 pounds of mine-cobbed book mica was produced from the Last Chance mine during 1944 and 1945. Of this total, 30,000 pounds came from cut No. 1; 29,200 pounds from cuts Nos. 2 and 3; and 28,000 pounds from the underground workings. The total sheet and punch mica sold was 6,846.44 pounds, valued at $19,861.32. A small part of this came from the Witherow lease. Data on two lots of sheet mica graded and qualified by the Colonial Mica Corporation are given in table 10. The two lots combined weighed 251.0 pounds before trimming, 238.53 pounds after retrimming. Thins, washer, skimmings, and scrap amounted to 12.47 pounds.

TABLE 10.—*Quality and grade of total retrimmed sheet mica produced from the Last Chance mine*

Grade No.	Quality (percent)				
	No. 1	No. 2	No. 2 inferior	No. 3	Total
3	------	------	0. 050	------	0. 050
4	------	------	. 289	0. 259	. 548
5	0. 155	2. 755	5. 260	------	8. 170
5½	. 130	1. 725	7. 055	. 025	8. 935
6	. 855	13. 300	50. 055	. 494	64. 704
7	. 473	6. 170	10. 950	------	17. 593
Total	1. 613	23. 950	73. 659	. 778	100. 000

MICA DEPOSITS

At least five pegmatites are exposed at the surface in an area 100 by 200 feet. The pegmatites lie parallel to the foliation of the enclosing quartz-muscovite-biotite schist. Three are small lenses. The pegmatite exposed in cuts No. 1 and No. 2 and in the underground workings is a foldform body consisting of two thick pipelike parts interconnected by a relatively thin sheet of pegmatite. (See pl. 3.)

Cut No. 1.—The largest pegmatite is exposed over a length of 55 feet in cut No. 1. The average strike is N. 70° W. The body is from 3 to 26 feet thick. The thickest part lies in a sharp recumbent anticlinal fold in the schist. The fold plunges 30° to 40° N. 36° E., and the narrower tabular parts of the pegmatite dip similarly. The contacts lie parallel to the schistosity except at the end of a curving salient wedge of schist that enters the pegmatite where the northwest limb of the fold becomes recumbent.

The position and extent of the four zones into which the pegmatite is divided are shown in plate 3. The border zone is 3 to 6 inches thick. It consists of gray quartz, a little albite and schorl, and abundant muscovite flakes that range from a quarter of an inch to 1 inch in diameter. The flat sides of most of the mica crystals lie approximately at right angles to the wall.

Adjoining the border zone is a wall zone 1 to 4 feet thick, containing abundant books of pale rum-colored sheet-bearing mica lying in a matrix of white albite (Ab_{90}), gray quartz, schorl, and small flakes of muscovite. Most of the mica books lie with their flat sides about perpendicular to the contact, and the schorl crystals have their long axes normal to the contact. The

wall zones contain about 10 percent of book mica by visual estimate.

The intermediate zone, lying between the wall zones and surrounding the central core, is composed of coarse albite (Ab_{93}), masses of schorl, gray quartz, and sparsely disseminated books of pale-green muscovite. Most of the schorl lies in the middle of the zone.

The core of massive white quartz crops out as a small low knob. It lies near the center of the widest part of the pegmatite. A few feet below the outcrop it appears to pinch out.

Some of the books of rum mica recovered from the wall zones were as much as 16 inches in diameter and 6 inches in thickness. Many books were badly cracked and some were warped, but except for small tourmaline and quartz inclusions the mica was clear. Books of light-green mica lying in the intermediate zone were warped, and most were traversed by innumerable cracks and hair lines which give a cloudy, opaque appearance to the mica. Only a very small proportion of the green mica is flat and clear. Although most of it lies in the intermediate zone, some books lie in steep joints that cut across both the intermediate zone and the hanging-wall part of the wall zone.

Cut No. 2.—Pegmatite is not traceable between cuts No. 1 and No. 2 because of overburden, but underground the pegmatite was continuous, at least at the tunnel level. The pegmatite in cut No. 2 follows a second fold that appears to plunge parallel to the fold in cut No. 1. The pegmatite is not well exposed, and some of the structural details are not clear. At its upper contact there is a mica-rich border zone a few inches thick. Underlying this is a wall zone 1 to 2 feet thick containing pale-rum mica similar to that in the wall zones in cut No. 1. The wall zone was estimated to contain 70 percent white albite, 10 percent book mica, 18 percent gray quartz, and 2 percent schorl. The mica books lie with their cleavages normal to the wall. Some are 12 inches across, and most are rather broken or curved. The intermediate zone contains more quartz than the wall zone. It consists of albite and quartz, coarse masses of schorl, and scattered flakes of muscovite. The footwall of the pegmatite is not exposed, nor is a central core, if one exists. Abundant mica reportedly was recovered from the thick part of the pegmatite at the tunnel level, but much of it was broken or punctured by inclusions of tourmaline.

Underground workings.—One of the old tunnels is caved, but the other, which was partly cleaned out, exposes the pegmatite showing in cuts No. 1 and No. 2. In an early operation the thick part of the pegmatite exposed in cut No. 1 was stoped 15 to 25 feet above the tunnel level. The stope is inaccessible. From a point near it, the most recent operators drove a drift southeast on the pegmatite to the fold showing in cut No. 2. The part of this drift that had been driven at the time of examination is shown in plate 3.

The zoning of the pegmatite underground is asymmetric. A mica-bearing wall zone, 1 to 2½ feet thick, lies on the footwall but is absent on the hanging-wall side. The zone contains about 10 percent mica in broken, curved books lying in a matrix of albite, quartz, and a small percentage of schorl. Mica from the wall zone in the southeast drift is pale rum and mostly curved, cracked, and punctured by tourmaline inclusions. The intermediate zone is composed of albite, quartz, fractured masses of schorl as large as 10 by 18 inches, and scattered books of scrap-quality muscovite as much as 3 inches across. The differences between the wall zone and the intermediate zone are not great.

Small quantities of light-green beryl are present. A 4-inch nodule of lithiophyllite, containing a little lollingite and coated with a soft shell of vivianite a quarter of an inch thick, was found in pegmatite in the new drift.

Cut No. 3.—A pipelike body of pegmatite plunging about 55° N. 60° E. is exposed along the steep east wall of cut No. 3. The pipe is nearly bisected by an infolded wedge of schist. The body is similar to that in cut No. 1 except that an additional zone, a "core-margin" zone, partly surrounds the small irregular quartz core. The core-margin zone contains albite, abundant small flakes and books of scrap-grade muscovite, and quartz. Mica pegmatite is said to lie a few yards to the west in the floor of the cut, but its relation to the visible pegmatite is not known.

A specimen of plagioclase from cut No. 3 was Ab_{96}. The pegmatite contains small crystals of gray-green apatite and pink garnet. The largest beryl crystal seen was 4½ inches in diameter. Meta-torbernite occurs as bright green flakes one-eighth of an inch across. It lies on cleavage planes in albite and muscovite, on the crystal faces of schorl, and on fracture surfaces in quartz. Autunite occurs similarly.

The sheet mica-bearing wall zones of the pegmatite were stoped in the early days, and additional mica was recovered in 1944. The old stopes apparently were driven from the tunnel level to the surface. The underground workings in this part of the mine are caved and inaccessible.

RESERVES

The calculable reserves of mica-bearing pegmatite are in the wall zone of the pegmatite exposed in cuts No. 1 and No. 2 and in the underground workings. Data concerning reserves are summarized in table 11.

TABLE 11.—*Indicated reserves in the Last Chance mine*

Location	Strike length (feet)	Average thickness (feet)	Dip length (feet)	Mica-bearing pegmatite (tons)	Crude book mica	
					Percent	Tons
Between cut No. 1 and tunnel level	[1] 42. 5	2	40	[2] 360	10	36
Between cut No. 2 and tunnel level	[3] 17	2	50	136	10	13. 6
Below tunnel level	[4] 60	2	[5] 20	192	10	19. 2
Total				688		68. 8

[1] Length on footwall side, 45 feet; on hanging-wall side, 40 feet.
[2] Assuming one-third of tonnage to have been removed by previous mining.
[3] Wall zone on hanging-wall side only.
[4] Wall zone on footwall side only.
[5] Dip length assumed.

Mining of the wall zones probably would entail the breaking of at least twice the tonnage of barren pegmatite. If 40 percent of the crude mica is discarded as mine scrap, the quantity available for rifting would be 41.3 tons. Available production data indicate that 0.7 percent sheet mica, 1½ by 2 inches and larger and 16 percent punch, containing 20 percent of small sheets, can be recovered from the crude mica saved for rifting. The indicated reserves are thus 579 pounds of sheet mica and 13,200 pounds of punch. Additional reserves might be developed by opening the caved workings beneath cut No. 3 and by extending the tunnel farther north under cut no. 1. The Last Chance Mine can be worked profitably during times of high mica prices but probably not at mica prices that ordinarily prevail in peacetime.

LINDQUIST PROSPECT

The Lindquist prospect, known formerly as the Munro Mill prospect or the Avon prospect, is in sec. 15 near the head of the East Fork of Big Bear Creek. A rough dirt road, which branches from the mine access road a couple of miles north of Avon and follows the creek for about 4 miles, leads to the property. J. H. Nesbit, of Avon, worked the prospect about 1923, but no mica is known to have been produced. The property, including two buildings, was acquired in 1944 by E. R. Lindquist. A little mining and development was done by the owner during the summer and fall of 1944, but only a few pounds of sheet mica were produced.

Workings lie on both sides of the valley. The workings on the east slope comprise the north cut, a second cut and a tunnel situated near the road, and a small open cut on the trail leading from the road to the north cut. The workings and geology on the east side of the creek are shown in figure 13. The south cut is on the west slope of the valley, about 900 feet south of the tunnel portal. On both sides of the creek are numerous angledozer trenches cut by the Bureau of Mines during a mica exploration project.

The north cut is in the center of a pegmatite the contact of which is exposed only at the bottom of the cut. The body is probably a thick, short lens striking northeast and dipping about 50° NW., parallel to the foliation of the enclosing mica schist. The pegmatite minerals include plagioclase, quartz muscovite, schorl, garnet, apatite, vivianite, and strengite. The pegmatite is composed mainly of coarse white plagioclase. Blebs and veinlets of gray quartz lie in the plagioclase. A core of massive white quartz makes up a small part of the body. Gray-green apatite is locally abundant and forms granular aggregates with dark-gray quartz, minor amounts of feldspar, and fine muscovite. Vivianite and strengite occur as irregular masses up to several inches in diameter in association with mixtures of fine-grained muscovite and quartz. The mica books are as large as several inches in diameter, white to yellowish in color, curved, cracked, and ruled. Many are intensely corrugated. Very little sheet mica could be cut from them.

In the cut at the mouth of the tunnel two pegmatites, each 2 to 6 feet thick, are exposed. They strike N. 30° to 50° E. and dip 50° to 60° NW. The enclosing rock is black to silvery muscovite-biotite-quartz schist which at the borders of one of the pegmatites is highly altered over a width of 12 inches. The foliation of the schist lies about parallel to the contacts. The pegmatites contain quartz, feldspar, muscovite, and schorl. One of them is in part composed of massive white quartz; the remainder is an intergrowth of feldspar, quartz, muscovite, and schorl. Muscovite is abundant in both pegmatites, but it is small and of poor quality. Many slickensides are present in the pegmatites and the adjacent schist.

The tunnel driven by Lindquist extends about 95 feet north. (See fig. 13.) At one place short crosscuts extend a few feet east and west of the tunnel. Four lenses of pegmatite, ranging from 4 to perhaps 20 feet in length and from 2 to 4 feet in thickness, are exposed in the tunnel. They strike north and dip 60° to 80° W., about parallel to schistosity. Two of the lenses are coarse gray quartz with thin selvages of muscovite and plagioclase. The others are medium-grained aggregates of albite, gray quartz, and muscovite. The schist and several of the pegmatites show strong shearing. None of the pegmatites contain sheet mica.

A small open cut beside the trail leading from the road to the north cut exposes feldspar-quartz pegmatite for a width of 3 feet. A little muscovite is pres-

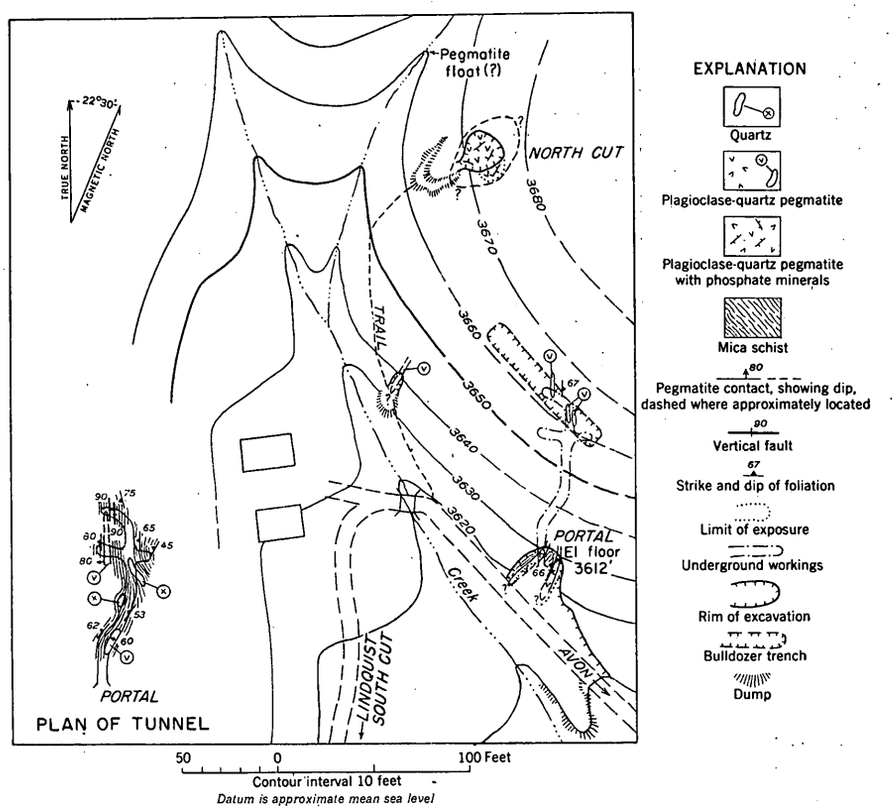

FIGURE 13.—Surface and tunnel maps of Lindquist prospect, Latah County, Idaho.

ent. The exposure appears to be part of a narrow northeastward-striking lens.

Numerous bulldozer trenches cut by the Bureau of Mines have exposed several small pegmatites directly above the north end of the tunnel, and several larger pegmatites were partly uncovered on the west side of the valley. In one of the bodies on the west side of the valley Lindquist excavated a small pit, the South cut. The pegmatite exposed in the pit is about 18 feet thick. The length is not known, but it may be as much as 100 feet. The body strikes N. 10° E. and dips 40° to 60° W. A quartz core 1 to 3 feet thick occupies the center part of the pegmatite in the cut. On either side of the core the pegmatite is an aggregate of highly weathered plagioclase, muscovite, and quartz. Rum mica in small amounts was reportedly recovered from a body of quartz 6 inches thick lying near the hanging wall, but all the mica seen by the writer was white to pale brownish-green in color, and cracked, warped, ruled, and reeved. Other pegmatites exposed in the trenches on the west side of the valley trend in northerly directions and dip west at moderate to steep angles. They are similar in composition to the pegmatite exposed in the South cut.

No good mica deposits are exposed on the Lindquist property. Only insignificant quantities of sheet mica could be produced from the known pegmatites.

LUCKY JIM PROSPECT

The Lucky Jim prospect, known formerly as the J. H. Nesbit prospect, lies in sec. 14 at altitudes of 4,168 to 4,225 feet. The prospect is reached by a steep forest trail that starts at the Lindquist property and ascends the west slope of a steep ridge to the top, on which the workings are situated. The difference in elevation between the Lindquist tunnel and the Lucky Jim tunnel is 556 feet.

In the winter of 1943–44 Fred Lunsford and Ray Craine, of Avon, produced a few pounds of sheet mica from the tunnel. The Bureau of Mines stripped and trenched the surface during the summer of 1944. The old workings include the tunnel, 183 feet long, and a caved shaft. Bulldozer trenches lie between the tunnel and the shaft, and the area surrounding the shaft is stripped. The workings and geology are shown in figure 14.

Apparently two pegmatite lenses and several smaller parallel bodies are exposed at the surface. The southern lens extends below the tunnel. The northern pegmatite does not show in the tunnel and presumably terminates above it. The northern pegmatite, on which the old shaft is situated, is exposed at the surface over a length of 80 feet and is 2 to 14 feet thick. The strike is N. 10°–34° E., and the dip is 40° NW., approximately

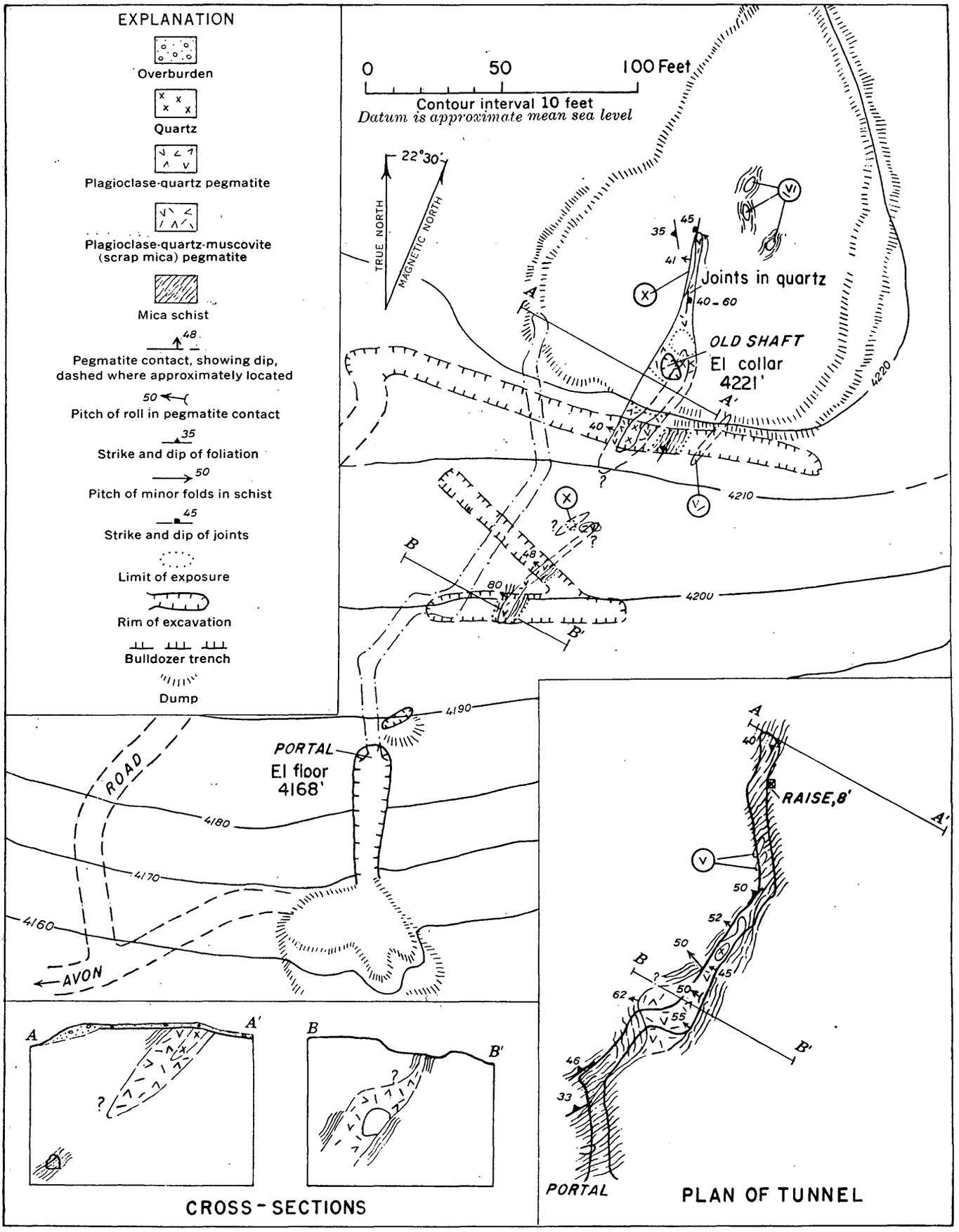

FIGURE 14.—Surface and tunnel maps, and cross sections of Lucky Jim prospect, Latah County, Idaho.

parallel to the foliation of the enclosing quartz-muscovite-biotite schist. The pegmatite consists of a core of white quartz and a feldspathic wall zone containing scrap mica. The quartz occupies a central position for the most part, but near the north end of the pegmatite quartz lies next to the hanging wall. At that place the quartz is cut by two sets of joints. One set of joints strikes N. 12° E. and dips 45° NW., about parallel to the local strike and dip of the pegmatite; the other set strikes about N. 12° E. and dips 40° to 60° SE. Both sets of joint surfaces are in part coated with flakes of soft black biotite and scales of muscovite. The wall zone, composed chiefly of white plagioclase, contains abundant but irregularly disseminated flakes and books of muscovite, blebs of gray quartz, and minor amounts of fine-grained apatite and schorl. Mica books as large as 5 inches in diameter were seen. The mica is nearly colorless and slightly clay-stained. Most of it is cracked, ruled, and reeved. A few books contain areas 1 by 1 inch that are flat and perfectly clear.

The southern pegmatite is narrow and poorly exposed at the surface. It appears to be the same body as that showing in the tunnel below. In the tunnel the pegmatite is exposed for more than 85 feet and ranges from less than a foot to possibly 18 to 20 feet in thickness. The body strikes N. 40° E. and dips 50° to 62° NW. It is almost entirely a medium-grained mixture of plagioclase, muscovite, and quartz. Muscovite constitutes 20 to 40 percent of the pegmatite but is too small and too badly flawed to yield sheets except locally. Several pods of quartz, as long as 7 feet and from a few inches to 2 feet wide, contain small amounts of flat mica that would yield sheets as large as 2 by 2 inches.

LUELLA MINE

LOCATION, HISTORY, AND PRODUCTION

The Luella mine is in sec. 21 near the west edge of the Avon mica district. It is accessible by a dirt road running north from the mine access road. The Luella is an old mine that was worked rather extensively at one time. The Western Mica Co. owned the mine in 1910, and, according to local reports, it was worked to produce scrap mica during and shortly after the First World War. Subsequently the mine lay idle until 1943, when the war demand for domestic muscovite caused renewed interest. In the fall of 1943, E. A. Campbell, of Lewiston, Idaho, obtained a 5-year lease from the State of Idaho and built a camp near the lower portal of the mine. Small-scale mining, both open pit and underground, was carried on by Campbell during parts of 1943 and 1944.

The early production is unknown. During 1943 and 1944 Campbell reportedly produced 17,880 pounds of mine-cobbed mica plus an additional 12,000 pounds of mine scrap. Sheet mica that was sold amounted to 291.30 pounds, of which 87 percent was small sheet and 13 percent large sheet. The gross value of the sheet mica was $1,815.28. The mica was classed as ruby. The only available quality data refer to a lot of 66.75 pounds of sheets that were retrimmed, graded, and qualified by Colonial Mica Corporation in Asheville, N. C. A total of 63.38 pounds of full-trim sheets was recovered. Five and two-tenths percent was No. 1 quality, 36.8 percent No. 2, 50.3 percent No. 2 inferior, and 7.7 percent No. 3 quality. The grades ranged from No. 7 to No. 4.

WORKINGS

The surface workings comprise old open cuts with a connecting short caved drift, and the main pit worked by Campbell. Underground, the mine has been worked on three levels: The upper level, the lower level, and a middle level. A large room, the roof of which is 26 feet above the floor, is the only stope on the upper level. Stope No. 2 connects the lower and middle levels, and an inaccessible raise connects the latter with the upper level. Stope No. 1 extends 30 feet above the lower level. All the stopes are old. The mica produced by Campbell came from the main pit and the middle level. The geology and workings are shown in plate 4.

ROCKS AND STRUCTURE

Mica gneiss and schist.—Medium-grained gray mica gneiss, composed of quartz, muscovite, biotite, and scattered small pink garnets, is the chief country rock. Mica schist is present in the west end of the upper and lower levels, where it is interbedded with gneiss. The schist is similar to the gneiss, but the mica in the schist is coarser and slightly more abundant. East and west of the intensely folded rocks that contain the pegmatites the schist and gneiss trend rather uniformly north-northwest.

The original bedding is marked by narrow mica-rich and quartz-rich bands and by small differences of grain size between adjacent layers. The foliation at most places appears to be parallel to bedding, but locally it cuts across bedding. In part of the mine parallel bedding and foliation are closely folded on steep axes. Minor crenulations in the gneiss and schist plunge in many directions, as do the larger folds. Fracture cleavage, parallel to the axial planes of minor folds, transects the folded foliation surfaces. Some fracture-cleavage surfaces are coated with flakes of muscovite.

Pegmatites.—More than a dozen small pegmatites, enclosed in mica gneiss and schist, are exposed in the workings. All lie within a block 200 feet square and 175 feet or more deep. Most of the pegmatites are pipelike bodies that show a wide range of direction and dip of plunge. The rest are tabular or lenticular bodies that strike in northerly directions and dip east or west at high angles. The pipelike pegmatites occupy the centers of tight plunging folds in gneiss. The bedding and foliation of the gneiss wrap around the bodies and are parallel to the curving contact surfaces of the pegmatites. Some of the pegmatites locally cut across bedding or schistosity, but in general they are conformable. The pipelike bodies appear to be elongate and tapering along their steeply plunging axes. Most are heart-shaped or oval in cross section or plan, but others are wholly irregular. Some of them are interconnected by thin "bridges" or "links" of pegmatite. Adjacent bodies may be in contact or separated by only a few inches of gneiss.

The pegmatites are, chiefly, mixtures of coarse- to medium-grained plagioclase, quartz, schorl, and muscovite. Most are highly feldspathic, but some are locally quartzose. Zoning is evinced by a small quartz core in one pegmatite and by narrow border zones rich in scrap-grade muscovite.

Plagioclase from the open pit was identified as sodic oligoclase (Ab_{88}). Plagioclase from two pegmatites on the upper level was identified as albite, Ab_{92} and Ab_{94}. White cleavelandite is abundant in some of the pegmatites on the upper level. An irregular small core of semitranslucent white to gray massive quartz occupies the central part of the largest pegmatite in the main pit. In others quartz is intergrown in varying amounts with the feldspar. Black tourmaline is present in all the pegmatites as small or large fractured crystal aggregates lying both in the middle parts and near the walls. The tourmaline masses are cut by veinlets of muscovite, quartz, and plagioclase. One pegmatite on the upper level contains a mass of tourmaline 6 feet long and 1½ feet wide.

Muscovite occurs as individual books and bunches of small books and flakes, disseminated in the pegmatites. Although many of the pegmatites contain an abundance of small books and flakes of scrap quality, sheet-bearing mica is relatively scarce. Some of the mica is clay-stained. Black-stain is absent, but the great majority of the books are ruled, warped, and cracked. These defects and the average small size of the books make the proportion of sheet mica contained in the mine-run mica inordinately low. Some fairly good rum-colored books up to 12 inches in diameter were mined in the open pit. They contained many cracks and hairlines but yielded sheets. The books taken from the middle level were pale rum in color and similarly warped and cracked, but a small amount of sheet mica was cut from them.

Several crystals of yellowish-green beryl were found near the hanging wall of the largest of three pegmatites exposed in the open pit. The biggest crystal seen was 8 inches in length and 3½ inches in diameter.

Basalt dikes, joints, and faults.—Basalt dikes are present in the west part of the upper and lower levels.

Joints, most of which strike from north-northwest to west-northwest and dip gently south, cut the mica gneiss throughout the mine. Some of the open joints contain a little iron-bearing carbonate and quartz.

A few small faults were seen in the lower and middle levels. Two of the faults show offsets of 2 inches to several feet. Along a third fault normal movement was indicated by bending of the schistosity.

ECONOMIC POSSIBILITIES

The average recovery of sheets from the crude mica is too low to permit profitable mining for sheet mica at ordinary prices. Further, the pegmatites are not rich even in scrap mica. Some pegmatites may contain as much as 10 percent total mica, including rich spots that may run 25 percent, but the average of all the pegmatites does not exceed 5 percent by visual estimates. The small size and irregular shape of the deposits, the necessity for mining most of them by underground methods, and the remoteness of the mine from scrap-grinding mills make it improbable that the Luella mine could be profitably worked for scrap mica.

MAXINE NO. 2 MINE

The Maxine No. 2 mine is in sec. 27 within 150 feet of the corner common to secs. 21, 22, 27, and 28. Pegmatite was found by the Bureau of Mines during construction of a road between the mine access road and the Last Chance, Campbell, and other mines in the near vicinity. The discovery was made on State land leased by Wilbur D. Henry. In October 1944 Lester C. Rowland, of Deary, Idaho, obtained a sublease on the property and started open-pit mining with a small hoist-driven scraper. According to the operator, about 7,000 pounds of crude mica was produced. The operation was closed in November 1944. A total of 195.52 pounds of sheet mica, valued at $1,231.06, was sold to the Colonial Mica Corporation in 1944 and 1945. A map of the workings is shown in figure 15.

The pegmatite is poorly exposed in the exploration trenches and open pit. Apparently it is a curving body ranging in width from 6 to possibly 20 feet. The part exposed in the pit is composed chiefly of soft, weathered, white albite mixed with smaller amounts of gray

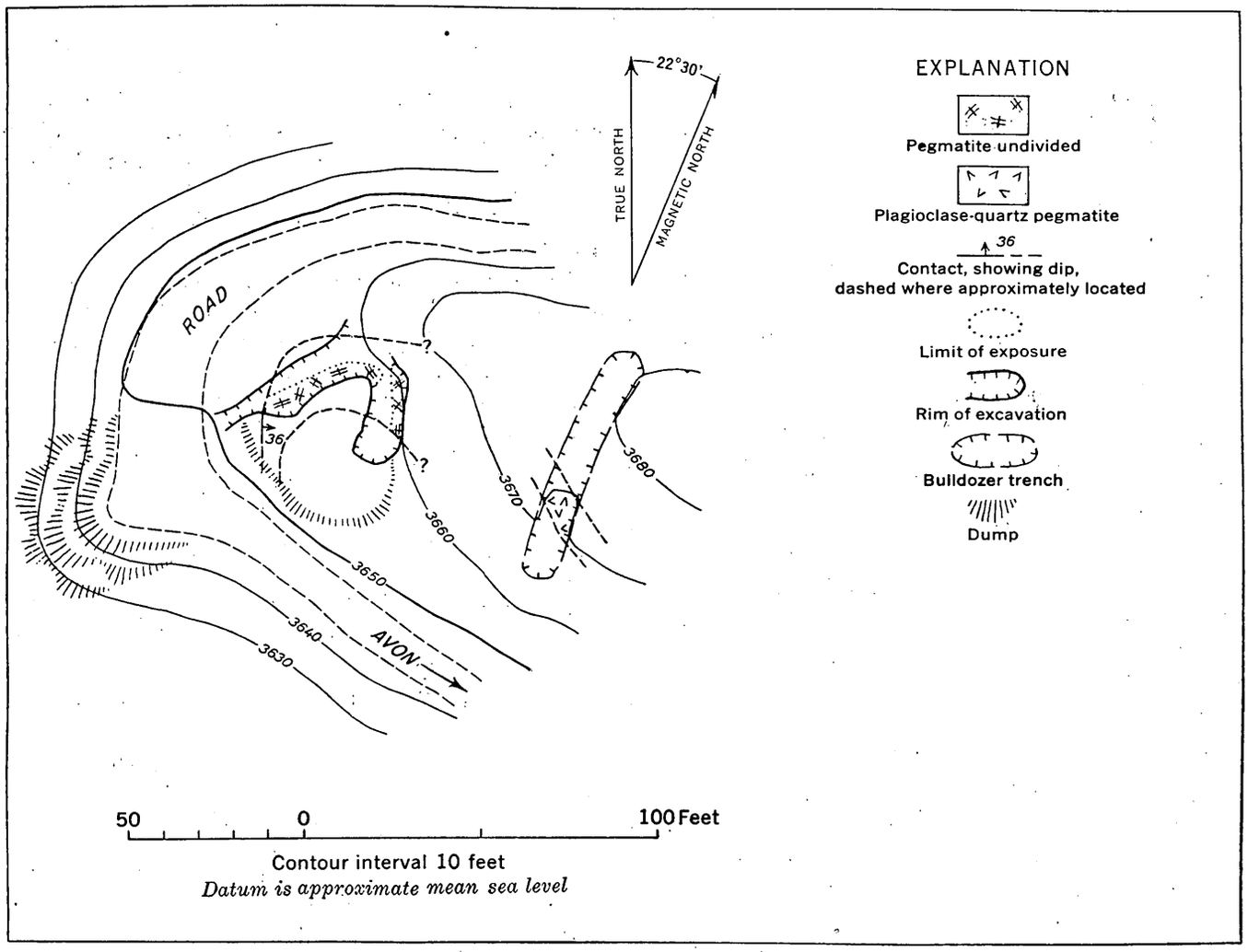

FIGURE 15.—Surface map of Maxine No. 2 mine, Latah County, Idaho.

quartz. Large and small pale-rum mica books are associated with pods of dark-gray quartz lying in the feldspathic pegmatite. Some of the pods are several feet long. Much of the mica is clay-stained but quite free of inclusions. According to Rowland, the largest book recovered weighed 9½ pounds and was 10 inches across. A second type of muscovite, soft and white, was not saved during the operation. It is usable only as scrap. Small additional quantities of sheet mica could be obtained from the pegmatite, but the exposures are not good enough to indicate the size of reserves.

McCORNACK PROPERTY

The McCornack property, owned by Mrs. Mary F. McCornack, of Seattle, Wash., is in sec. 28, in the southwest part of the Avon district. The workings include a few old pits at the crest of a knoll and an old tunnel, 165 feet long, on the south side of the knoll. A map of the tunnel is shown in figure 16. During the autumn of 1944 the Bureau of Mines excavated more than a thousand linear feet of trenches on the McCornack property and partly exposed what may be a large pegmatite or a group of pegmatites. Small showings of muscovite in association with quartz were seen, but the pegmatite is not rich in mica. The tunnel exposes a series of sheets, stringers, and plunging lenses of fine- to medium-grained plagioclase-quartz-muscovite-biotite pegmatite interlayered with bands of mica schist. The muscovite books are too small and too poor a quality to yield much sheet mica.

MORNING STAR CLAIM

The Morning Star claim, in sec. 15, is about a mile north of the Muscovite mine near the top of the steep east slope of the ridge that extends from Mica Mountain southward through the Avon district. Between the Muscovite and the Morning Star are the old Atlas and Violet claims, which were taken up by Alexander Munro

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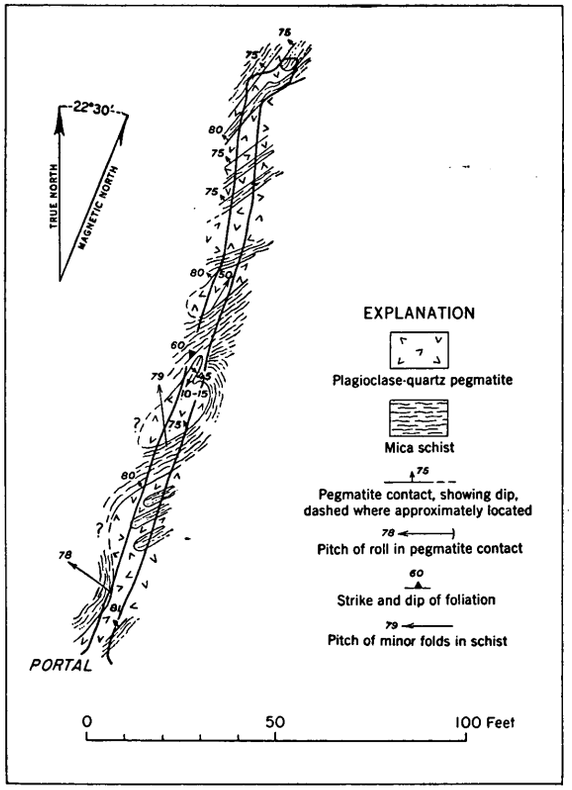


FIGURE 16.—Plan of tunnel, McCornack property, Latah County, Idaho.

prior to 1910.[25] The Morning Star claim is reached by way of an obscure trail following the crest of the ridge from the Muscovite mine or by a steep trail that ascends the east slope of the ridge from the Lindquist property. The underground workings on the Morning Star claim are rather extensive, but no production of commercial mica is known. In 1942 the property was held by Victory Metals, Inc., of Salt Lake City, Utah. It was visited by E. W. Heinrich,[26] of the Geological Survey, in September 1942, and the following description is abstracted from his report.

The workings comprise a small open cut near the top of the ridge; a 100-foot tunnel about 40 feet below the open cut, and a second tunnel, 880 feet long, situated 400 feet down the slope from the upper tunnel.[27] Several pegmatites are exposed on the claim. The main pegmatite crops out here and there over a length of 1,000 feet along the crest of the ridge. Near the north limit of the outcrop the pegmatite has numerous branches and offshoots.

The country rock is a gray fine-grained muscovite schist, which in places contains numerous small garnets and patches of muscovite flakes much coarser than those in the matrix of the schist. The strike of the schistosity ranges from N. 55° E. to N. 5° E., and the dip is 65° NW. At the north end of the claim, on the crest of the mountain, the schistosity strikes N. 5° E. and dips 70° NW., but the bedding strikes N. 75° E. and dips 70° NW.

The main pegmatite is conformable to the foliation of the wall rock, although several branches transgress the foliation. The body, from 10 to 20 feet thick, strikes about N. 10° E. and dips 70° NW. About 800 feet northeast of the workings it forks; one branch extends N. 40° E. and the other, N. 15° W. A second pegmatite, 40 feet to the east, is 5 feet wide; it strikes N. 20° E. and dips 45° NW. About 50 feet southeast of the north limit of the outcrop of the main pegmatite is a third pegmatite, 10 feet wide, which strikes N. 35° E. and dips 75° NW.

The open cut exposes two branches of a pegmatite, each a foot thick. They strike N. 5° E. and dip 50° NW. concordantly with the schistosity except at the junction, where the upper branch curves sharply across the schistosity.

The upper tunnel cuts across three pegmatites. One body, exposed at a place 4 feet from the face, may be the same as the one showing in the open cut. At a place 65 feet from the portal the main pegmatite is exposed over a width of 15 feet. It strikes N. 10° E. and dips 55° NW. An irregular body, exposed 15 feet from the portal, pinches out a foot above the floor of the tunnel. Near the end of the long lower tunnel a pegmatite 4 to 5 feet thick is exposed.

The pegmatites consist of quartz, feldspar, muscovite, garnet, and schorl. An intergrowth of quartz and feldspar with scattered flakes of muscovite forms the bulk of all but the smaller deposits, which contain only small amounts of quartz. The borders of the pegmatites are richer in pearly muscovite, garnet, and schorl than are the interior parts. Tourmaline crystals as long as 6 inches were observed. Yellow to pearly mica in books 4 inches in diameter and smaller is disseminated in most of the pegmatites. Most of the mica is in flakes half an inch or less in diameter. The books are ruled, crumpled, and intergrown at various angles. Practically no mica of sheet or punch quality was seen.

MUSCOVITE MINE

LOCATION AND WORKINGS

The Muscovite mine is near the center of sec. 22 on and near the crest of a long wooded ridge that extends southward from Mica Mountain. The access road from

[25] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, fig. 16, pp. 88, 92, 1923.

[26] Heinrich, E. W., Some mica-beryl prospects, Avon district, Latah County, Idaho: U. S. Geol. Survey unpublished rept., pp. 6, 7, September 1942.

[27] Forrester, J. D., Mica and beryl occurrence in eastern Latah County, Idaho: Idaho Bur. Mines and Geology Pamph. 58, 1942. (Maps of the upper and lower tunnels are shown.)

Avon ends at the mine. The workings lie on a patented mining claim and extend from altitude 4,181 feet, at the portal of the lower adit, to about 4,460 feet, at the crest of the knoll on which the pegmatites crop out. The location of the mine is shown in plate 1.

The mine workings and the surface geology are shown in plate 5, and the workings and geology underground are shown in plates 6 and 7. The workings comprise five levels, stopes, raises, and three open pits. The lowest, or No. 5, level includes 1,218 feet of crosscuts and drifts. Four stopes, Nos. 1, 2, 3, and 4, extend upward from the No. 5 level. Most of the No. 4 level is caved, but the north part is accessible through raise No. 4 starting at the No. 5 level. As indicated by old surveys, the No. 4 level includes at least 630 feet of drifts and crosscuts. Old filled stopes of unknown extent lie above the drift. A shaft is said to descend some 25 feet from the No. 4 level to a sublevel, most of which is inaccessible. The sublevel is probably about 230 feet long. The old No. 3 level has been almost entirely obliterated by open-pit mining. The east tunnel is caved and inaccessible. Judging from old descriptions, it is perhaps about 400 feet long.

The main open pit, on the south side of the knoll, is 300 feet in length, 120 feet in width and 120 feet in maximum depth. The Montag No. 1 pit is 120 feet long and 20 feet deep. Pit No. 3, an old excavation at the crest of the knoll, is 55 feet long, 40 feet wide, and 20 feet deep.

All the levels were driven before 1942. During 1943–45 the No. 5 level was extended about 190 feet, four stopes were driven overhand from it, and raise No. 4 was driven to connect the No. 5 with the No. 4 level and the sublevel. Most of the main pit and the Montag No. 1 pit were dug in 1944.

HISTORY AND PRODUCTION

The Muscovite mine is the largest mica producer in Idaho and one of the largest producers in the United States. It was first worked in 1888 by Woody and Lamb.[28] Later it was worked intermittently, first by the Muscovite Mica Co., of Spokane, Wash., and subsequently by Alexander Munro, of Moscow, Idaho and the Producers Mica Co., of Chicago, Ill. During the period 1910–18 several carloads of crude mica are said to have been shipped each year. Between 1918 and 1942 several attempts were made to work the mine, and a few tons of beryl are said to have been produced. According to Anderson,[29] 800 tons of crude book mica yielding 5 percent sheets were produced before 1910. In 1918, according to Ray W. Craine, of Avon, about 120 tons were shipped. The total production to 1942 is thus at least 920 tons of crude mica.

In 1942 the mine and adjacent ground were leased by Victory Metals, Inc., later called Victory Mines, Inc. During parts of 1942 and 1943 preliminary work was done under the direction of the resident manager, Mr. Victor A. Christensen, of Salt Lake City, Utah. About October 15, 1943, mining was started on the No. 5 level in stope No. 1 and later in stope No. 2. A development program directed by Mr. Christensen opened mica-rich pegmatite in the north end of the No. 5 level. Stope No. 3 was started on this deposit and mined from April to October 1944. Subsequently, stope No. 2 was again mined. In 1945 the underground operations were carried on by C. J. Montag & Sons, contractors, of Portland, Oreg., who obtained a lease following the withdrawal of Victory Mines, Inc. Stope No. 4 was started in February and mining was in progress in May 1945. Concurrently with underground mining, C. J. Montag & Sons mined the surface showings by open-pit methods. Montag No. 1 pit was stripped and mined from November 1943 to February 1944. Mining in the main pit was started in April and continued until the end of September 1944 (pl. 8, *A*). Following completion of mining in the main pit, part of the crest of the knoll near pit No. 3 was stripped and mined. Surface work was discontinued in December 1944 but resumed intermittently during early 1945.

Old mine dumps were reworked by screening and hand-picking of mica during the spring and summer of 1944. A large recovery of book mica was made, but the amount of beryl saved was small, partly because of the fineness and fragility of the beryl fragments.

The mica production of the Muscovite mine from October 1943 to May 1, 1945, is shown in table 12. The recovery of sheet mica ranged from 3.2 to 7.5 percent, differing rather widely among different working places. The recovery figures reflect the efficiency of rifting and trimming as well as the quality of the crude mica.

SUMMARY OF GEOLOGY

The pegmatites of the Muscovite mine comprise three major bodies, the East, Central, and West pegmatites, and numerous small lenses. They are concordantly enclosed in quartz-mica schist, which, except locally, strikes to the north and dips 50° to 70° W. The schist adjacent to pegmatite is highly altered. The major pegmatites are closely spaced and roughly parallel. The Central pegmatite is a branching body composed of fine-grained border zones, wall zones containing sheet muscovite, and a central core of albite and quartz.

[28] Sterrett, D. B., op. cit. (Bull. 740), p. 89.

[29] Anderson, A. L., Mica deposits of Latah County, Idaho: Idaho Bur. Mines and Geology Pamph. 14, p. 8, 1923.

TABLE 12.—*Mica production, Muscovite mine, October 1943 to May 1, 1945*

[Figures are close approximations]

No.	Working place	Mine-cobbed mica (pounds)	Untrimmed punch mica (pounds)	Sheet mica 1½ by 2 inches and larger, ¾-trim (pounds)	Sheet mica 1 by 1 to 1½ by 2 inches, full trim (pounds)	Sheet mica 1½ by 2 inches and larger, full trim (pounds)	Total prepared mica, all classes (pounds)	Recovery of sheet mica from crude mica [1] (percent)
1	Main open pit	255, 520						
2	Surface workings near pit No. 3	88, 000						
	Total, 1 and 2	343, 520	3, 376. 00	984. 50	10, 314. 25	3, 995. 06	18, 669. 81	4. 55
3	Montag No. 1 pit	11, 966		118. 25	447. 50		565. 75	4. 7
4	Mine dumps	(?) 174, 000	2, 908. 42	339. 25	5, 342. 12	358. 37	8, 948. 16	3. 64
5	Stopes 1 and 2 [2]	88, 927		250. 75	3, 359. 00		3, 609. 75	4. 1
6	North drift [3]	10, 000		210. 00	490. 00		700. 00	
7	Stope No. 2 [4]	75, 650			2, 093. 35	319. 00	2, 412. 35	3. 2
8	Stope No. 3	265, 000		3, 602. 50	11, 354. 65	4, 941. 68	19, 898. 83	7. 5
9	Raises	2, 125			241. 25		241. 25	
10	Stope No. 4	317, 775						
11	Sublevel above stope No. 3	6, 000						
	Total, 10 and 11	323, 775	20, 161. 00			6, 978. 31	27, 139. 31	
12	Various	(?)	2, 513. 50	32. 56	802. 24	127. 24	3, 475. 54	
	Grand total	[5] 1, 294, 963+	28, 958. 92	5, 537. 81	34, 444. 36	16, 719. 66	85, 660. 75	

[1] Calculation of recovery includes an estimated 10 percent of small sheet mica contained in the punch mica.
[2] Production to May 1, 1944.
[3] Rough estimate.
[4] Production May 1, 1944, to May 1, 1945.
[5] Probably accurate within several percent.

NOTE.—Figures excluded from above table are 133.05 pounds of sheet and 1,020.75 pounds of punch sold at Custer, S. Dak. Mine-cobbed mica figures to May 1, 1945; sheet and punch figures are sales to Apr. 2, 1945.

The East and West pegmatites are a series of closely spaced lenses complexly interlayered with schist. They contain sheet muscovite and beryl throughout their known extent.

MICA SCHIST

The unaltered country rock is chiefly gray well-foliated fine- to medium-grained quartz-muscovite-biotite schist, which locally contains small feldspar crystals or garnet-rich bands. Some schist layers contain more abundant coarser muscovite and are silvery in color.

The foliation strikes generally between N. 15° E. and N. 15° W. and dips west at angles of 50° to 70°. Generally, bedding strikes and dips are about parallel to schistosity, but locally bedding and schistosity are divergent. In the Montag No. 1 pit the west branch of the Central pegmatite and the foliation of the enclosing schist curve from north to west and dip steeply southwest and south. The curvature shows a relatively large fold.

Bedding and schistosity are both closely folded. Most of the minor folds plunge west, southwest, or south at angles of 40° to 65°. In stope No. 4, wrinkles in the westward-dipping schistosity plunge 62° N. 15° W. Isoclinal folds in the altered schist were observed at many places. They trend slightly east or west of north and plunge 10° to 20° north or south. They are overturned to the east and locally are transected by pegmatite bodies.

ALTERED SCHIST

The schist adjoining pegmatite is strongly altered for widths of a few inches to 20 feet. Less intensely altered rock, marked chiefly by tourmalinization, extends as much as 30 feet from pegmatite.

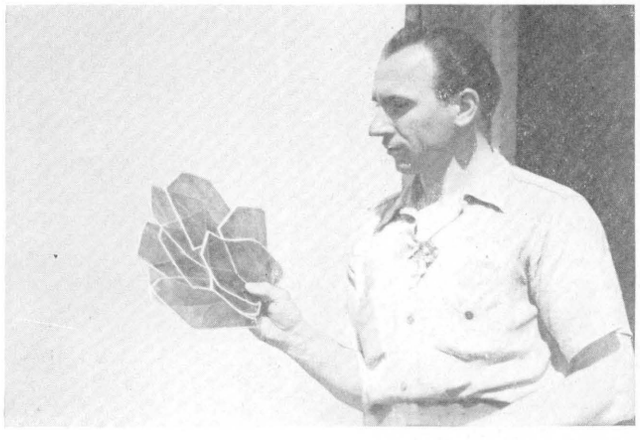
The highly altered schist is a light-colored medium-grained to schistose rock composed of 65 percent plagioclase, 20 percent quartz, 10 percent muscovite, and 5 percent schorl, neglecting minor constituents such as beryl, apatite, and oxide stains. The average grain size is 1 to 4 millimeters, but in places larger crystals occur.

Where close to pegmatite, beryl occurs as anhedral grains half an inch or less across and as light-green euhedral crystals as much as 4 inches in diameter. Small gray-green apatite crystals and crystals of black tourmaline as much as 2 inches across are locally present. Books of rum-colored muscovite, similar in all respects to those lying in pegmatite, are embedded in the altered schist.

EAST PEGMATITE

Most of the mica produced from the Muscovite mine has come from the East pegmatite. It has been mined in the main open pit, in old stopes of unknown extent lying above the No. 4 level, and in stopes No. 3 and No. 4, above the No. 5 level. The East pegmatite strikes from N. 12° W. to N. 22° E. and dips 63° W. on the

A MINING IN THE MAIN OPEN PIT OF THE MUSCOVITE MINE.



B SPECIMENS OF SHEET MICA.

VIEW OF MUSCOVITE MINE SURFACE WORKINGS, AND SPECIMENS OF SHEET MICA.

average. It extends from the surface down to and below the No. 5 level, a maximum known dip of 280 feet, and ranges from less than a foot to 15 feet in thickness. On the surface the pegmatite is partly exposed over a strike length of 260 feet; it may not be continuous over this length. On the No. 4 level, now mostly inaccessible, it is 4 to 6 feet thick [30] and is probably about 250 feet long. On the No. 5 level the East pegmatite is exposed at the foot of stopes No. 3 and No. 4 over strike lengths of 75 feet and 80 feet respectively, but is not continuous between the two stopes.

The East pegmatite lies in the footwall of the Central body but extends farther to the south than the latter. Where the two overlap they are separated by 1 foot to 20 feet of schist. The East pegmatite is parallel to the West pegmatite and underlies it by 15 to 40 feet.

The East pegmatite is a series of individual closely spaced pegmatite bodies of widely different size and of tabular, lenticular, or complex shape, which are separated by irregular horses and narrow septa of altered schist. The individual pegmatite bodies and the bordering altered schist form a narrow, tabular, mineralized layer lying conformably with the foliation of the enclosing unaltered mica schist.

The pegmatite is an aggregate of medium- to coarse-grained albite (Ab_{95}), quartz, muscovite, microcline-perthite, beryl, and minor quantities of black tourmaline and apatite. Albite is the chief mineral, but locally quartz is predominant. Muscovite occurs throughout and forms a considerable, although varying, portion of the pegmatite. Most of the muscovite books are less than 4 inches across, but crystals a foot or more in diameter have been recovered. Pale-gray microcline-perthite occurs as blocky masses several feet across. Beryl, like muscovite, occurs throughout the pegmatite, but the beryl content varies widely. The crystals are small and highly fractured.

No zoning was observed in the East pegmatite and even selvages are absent, although the mineralogical composition of the pegmatite varies from place to place along the strike and dip. At many places the contacts are highly irregular or gradational. Long, narrow septa and shreds of altered schist lie within the pegmatite, and streaks and knots of pegmatite lie in the altered schist.

CENTRAL PEGMATITE

Extent and structure.—The Central pegmatite is exposed in the open pits and underground on the No. 4 and No. 5 levels and in raise No. 4. Presumably, the east tunnel intersects the Central pegmatite, but this could not be determined because the workings are inaccessible. Seemingly the body has been mined from the surface, to a small extent in stope No. 3 and raise No. 4, and probably in the east tunnel.

On the surface (pl. 5) the Central pegmatite is made up of three divergent branches. The east branch is about 265 feet long and 35 feet thick. Including the east and middle branches, the pegmatite is about 50 feet thick at one place. The east branch strikes N. 15° E. near the south end and N. 38° W. near the north end. It dips 65° W. The middle branch, an offshoot of the east branch, is 70 feet long and as much as 24 feet thick. It strikes due north and dips parallel to the east branch, with which it is probably joined a few yards below the surface. The west branch, diverging from the middle member, curves to the northwest and west and dips steeply southwest and south. Its strike length is more than 100 feet, and the average thickness is about 10 feet. The west branch has been exposed only at the surface, and the relations of the three branches underground are unknown.

Except for local discordance the branches are parallel to the foliation of the adjoining schist, but the pegmatite as a whole appears transgressive. The curvature of the west branch and the local strike and dip of the schistosity suggest that the body occupies part of the east limb and the trough of a southwestward-plunging, synclinal fold, overturned to the east.

The Central pegmatite contains three zones: A core of albite-quartz pegmatite, a wall zone of quartz-albite-muscovite-beryl pegmatite, and a narrow border zone. The wall zone and border zone form discontinuous outer shells surrounding the core.

Albite-quartz pegmatite.—The core of albite-quartz pegmatite constitutes more than 95 percent of the Central body. It consists on the average of about 75 percent albite and 25 percent gray to white quartz, neglecting lesser constituents. The albite is partly granular and partly cleavelandite (Ab_{95}). Quartz occurs as small irregular masses and blebs 2 inches or less across, intergrown with and irregularly distributed in the albite, and as veins and veinlets cutting albite. At one place veinlets of cleavelandite appear to cut white quartz. Tiny scales of muscovite are scantily and irregularly dispersed in the zone. Black tourmaline and scattered books of soft greenish-gray scrap muscovite as much as 8 inches in diameter are present. The albite-quartz zone is not of uniform composition. Locally quartz constitutes 75 percent of the pegmatite, and in other places the zone consists solely of coarse cleavelandite.

Quartz-albite-muscovite-beryl pegmatite.—The wall zone consists mainly of quartz, albite, muscovite, and beryl but also contains microcline-perthite, black tourmaline, apatite, and garnet. The zone is commonly

[30] Sterrett, D. B., op. cit. (Bull. 740), p. 91.

not more than a foot or two thick and in many places is absent or marked for distances of many yards by scattered small rum-colored books of muscovite. In other places the wall zone is as much as 5 feet thick. Green to yellow beryl and rum-colored muscovite are particularly abundant where the zone is wide, and rich in quartz. Blocks of altered schist lie in the wall zone. The boundaries between the wall zone and the albite-quartz core are irregular and in places indistinct.

Border zone.—In a few contact exposures a fine-grained border zone lies between the wall zone and the altered schist or, where the wall zone is absent, between the core and the schist. At most exposures a border zone was not observed. Where present it is from 1 to 6 inches thick and ordinarily contains abundant fine muscovite. At other places it is marked only by a slight diminution of grain size. The border zone does not constitute a mappable unit.

WEST PEGMATITE

The West pegmatite is exposed in the main pit and in stopes No. 1 and No. 2 above the No. 5 level. An inaccessible raise follows the deposit from the head of stope No. 2 to the floor of the main pit. Sterrett [31] noted this pegmatite in 1910 in a short crosscut driven west from the No. 4 level. The pegmatite strikes N. 5° W. to N. 11° W. and dips 63° SW. In the floor of the main pit it is about 80 feet long, but small lenses in the hanging wall of the Central pegmatite in the north end of the main pit may be a northward extension of the body. On the No. 5 level the pegmatite is 129 feet long but is cut off by a fault at its southernmost exposure. It ranges from less than a foot to about 13 feet in thickness. Mineralogically and structurally the West pegmatite is similar to the East pegmatite but contains less sheet mica and more beryl. At one place in stope No. 1 the West pegmatite contains a core of quartz 1 foot thick.

BASALT

A basalt dike about 8 feet thick, striking northwestward and dipping 75° to the northeast, cuts the schist in the No. 5 adit 130 feet from the portal.

FAULTS

Numerous small postmineral faults, running both parallel to and across schist and pegmatite, were mapped on No. 5 level. Overburden and rock weathering make detection of faults more difficult at the surface. With few exceptions the faults are merely narrow seams of gouge along which little movement has taken place.

[31] Sterrett, D. B., op. cit. (Bull. 740), fig. 17, pp. 90, 91.

By permitting seepage of surface water, faults have contributed to the deep weathering and softening of the pegmatites, especially the West pegmatite. Post-mineralization faulting in the pegmatite has crumpled and broken many mica books, which consequently yield a lower proportion of sheet mica. Strike faults have caused caving of the hanging walls of inadequately supported stopes. Where they are closely spaced the shattered nature of the ground makes close timbering or spiling of drifts necessary.

MICA AND BERYL DEPOSITS

MAIN OPEN PIT

The main open pit was excavated with power shovel and bulldozers by C. J. Montag & Sons from April through September 1944. An old glory hole, a smaller cut, and part of the old No. 3 level were obliterated in the process of mining. Old filled stopes that had been driven overhand from the No. 3 level on the East pegmatite during earlier operations were encountered in excavating the pit. Some of the old stope fill carried considerable amounts of good book mica that had been neglected by the earlier miners, and this mica was recovered in addition to that mined from new ground.

The East, Central, and West pegmatites and a few small lenses are exposed in the pit. The East deposit was mined over a length of 150 feet and averaged between 5 and 6 feet in thickness. The average strike is N. 2° E. and the dip, 57°–65° W. It appears to be continuous with an old filled stope lying east of the Central pegmatite, but exposures are so poor that this supposition cannot be verified.

Muscovite books as much as 8 inches across are irregularly distributed in the East pegmatite. The richest concentrations occur where gray quartz is abundant. The books are rum-colored, clear, and flat to slightly wavy. Most of them show numerous small cracks, and some are ruled and slightly reeved on the outside. Beryl likewise is more abundant in the quartz-rich parts of the pegmatite. The crystals are light green, and a few are clear, although closely fractured. They are as much as 3 inches in diameter but most are an inch or less across. Commonly, the crystal form is well-developed. Many of the crystals are traversed by tiny veinlets of gray quartz, some of which follow the rough basal cleavage. The larger crystals especially contain central cores of coarse gray quartz and muscovite.

The south end of the Central pegmatite is exposed on the north wall of the pit, and its blunt lower termination is visible in the same exposure, but farther north the pegmatite extends to and below the No. 5 level.

The West pegmatite was never fully exposed during the writer's visits. It was mined along the strike for

a length of about 80 feet. The mica in the West pegmatite is more broken than that in the East body.

To May 1, 1945, the main pit had produced about 255,000 pounds of crude mica, of which possibly 190,000 pounds came from the East pegmatite, 44,000 pounds from the West pegmatite, and 21,000 pounds from the Central pegmatite. The East deposit carried about 2.5 percent book mica, which yielded roughly 4.5 percent of small and large sheet mica (pl. 8, *B*). About 30 percent of the sheets were 1½ by 2 inches and larger. Beryl production was 374.5 pounds, but most of the beryl mined was probably lost. Assay of the beryl ore, which included a certain proportion of impurities, was 10.10 percent BeO.

Operating data and costs for the main period of operation, April 15 to September 30, 1944, are given in table 13. During the operation 64,796 tons of material—5,590 tons of overburden, 5,236 tons of pegmatite, and the remainder schist—were excavated, and 234,000 pounds of crude mica were recovered. From this 8,365.25 pounds of sheet mica were trimmed as of December 31, 1944. Labor amounted to 2,272.5 man-hours. Data concerning grade and quality of the sheet mica produced from the main pit are given in table 14.

TABLE 13.—*Operating costs for the main open pit, Muscovite mine, Apr. 15 to Sept. 30, 1944* [1]

Item	Total expense	Percent of total	Cost per cubic yard excavated	Cost per ton excavated	Cost per ton of pegmatite mined	Cost per pound of crude mica recovered	Cost per pound of sheet mica sold up to Dec. 31, 1944
Stripping and mining:							
Equipment expense: [2]							
R. D.-6 tractor	$1, 514. 25						
105 compressor	216. 00						
P & H ¾-yd. shovel	5, 162. 11						
H. D.-7 tractor	468. 00						
GMC pick-up truck	750. 00						
Jackhammer, hose, steel, and other equipment	480. 00						
D-7 bulldozer	8, 770. 50						
International truck	378. 00						
Total	17, 738. 86	52. 6	$0. 59	$0. 27	$3. 40	$0. 076	$2. 12
Labor [3]	2, 531. 32	7. 5	. 08	. 04	. 48	. 011	. 30
Taxes and insurance	299. 63	. 9	. 01	. 01	. 06	. 001	. 04
Supplies:							
Powder	713. 55						
Caps	48. 21						
Gas and oil	103. 60						
Total	865. 36	2. 6	. 03	. 01	. 17	. 004	. 10
Supervision and overhead	1, 500. 00	4. 4	. 06	. 02	. 28	. 006	. 18
Camp expense	432. 66	1. 3	. 01	. 01	. 08	. 002	. 05
Rifting and trimming:							
Labor, taxes, and insurance	9, 203. 24						
Rent, equipment, and miscellaneous expense	928. 67						
Supervision	250. 00						
Total	10, 381. 91	30. 7	. 35	. 16	1. 98	. 044	1. 24
Grand total	33, 749. 68	100. 0	1. 13	. 52	6. 45	. 144	[4] 4. 03

[1] Add $6,000 estimated as administrative and general overhead expense to give total production cost.

[2] Equipment rates and total hours are as follows: R. D.-6 tractor, $6.50 per hr., 234.5 hrs.; 105 compressor, $36 per mo., 6 months (charged); P & H ¾-yd. shovel, $10.42 per hr., 495.5 hrs.; H. D.-7 tractor, $6.50 hr., 77 hrs.; GMC pick-up truck, $125 per mo., 6 months (charged); Jackhammer, hose, steel, and other equipment, $80 per mo., 6 months (charged); D-7 bulldozer, $9 per hr., 974.5 hrs.; International truck, $3.50 per hr., 108 hrs. The above-mentioned rates are the ones chargeable by contractors in Portland, Oreg., for rental of their equipment. The rates include wage of operator, fuel and other supplies, depreciation, repair expense, and a certain profit to the owner, probably between $1 and $2 per hour.

[3] Wages of machine operators included in the equipment rates are not included in the cost of labor given above.

[4] The final cost per pound of sheet mica is somewhat less than shown, since there was about 13½ tons of crude mica still on hand at time calculation was made.

PIT NO. 3

Pit No. 3 was dug many years ago. It lies mainly in the east branch of the Central pegmatite but exposes part of the middle branch as well. An old stope on the hanging-wall zone of the east branch lies a few feet below the pit floor. Within the pit the exposures are chiefly cleavelandite-quartz pegmatite. Scattered books of soft mica, white to green in color, lie in the cleavelandite. A more quartzose part of the pegmatite forms a small resistant knob at the crest of the knoll, on the east side of the pit.

Northwest of pit No. 3 part of the east branch was uncovered by trenching done by the Bureau of Mines. One trench 30 feet north of the pit exposes pegmatite

TABLE 14.—*Quality and grade of total retrimmed sheet mica produced from the main open pit, Muscovite mine* [1]

Grade No.	Quality (percent)				
	No. 1	No. 2	No. 2 inferior	No. 3	Total
1–A	-------	0. 007	0. 016	-------	0. 023
1	-------	. 035	. 059	-------	. 094
2	0. 003	. 125	. 507	-------	. 635
3	. 021	. 320	. 982	0. 004	1. 327
4	. 190	1. 008	3. 630	. 025	4. 853
5	. 575	5. 250	11. 950	. 060	17. 835
5½	. 292	3. 140	6. 690	. 018	10. 140
6	1. 845	16. 300	36. 200	. 209	54. 554
7	. 109	3. 510	6. 920	-------	10. 539
Total	3. 035	29. 695	66. 954	. 316	100. 000

[1] Data for 6 lots of sheet mica retrimmed at Asheville, N. C., by Colonial Mica Corporation. The mica was classified as ruby. The lots had a total weight of 4,728.13 pounds before retrimming, 4,337.25 pounds after retrimming. Scrap, washer thins, and skimmings amounted to 390.88 pounds.

for a width of about 26 feet. Except for narrow and indistinct wall zones the pegmatite is composed of coarse cleavelandite and quartz containing a little soft greenish mica. The most northerly part of the pegmatite was not examined by the writer, but according to the engineer of the Bureau of Mines who supervised the trenching of the deposit the pegmatite there is composed almost entirely of massive gray quartz with but little, if any, feldspar or mica.

MONTAG NO. 1 PIT

Parts of the middle and west branches of the Central pegmatite were uncovered by bulldozer trenching done by the Bureau of Mines and by subsequent stripping and open-pit mining by C. J. Montag & Sons in 1943 and 1944. The Montag No. 1 pit was excavated between November 1943 and the end of February 1944, and later it was enlarged. Surface mining of the pegmatite between the main pit and pit No. 3 was carried on from October to December 1944. The later excavation crosscut the east and middle branches and merged with the Montag No. 1 pit. Part of the old stope on the east pegmatite also was uncovered, and mica was mined from it. The production of the Central pegmatite in the surface workings amounted to 11,966 pounds of crude mica mined from the west branch in Montag No. 1 pit during November 1943 to April 1944, plus the major part of 88,000 pounds that was mined from workings near pit No. 3 in the fall of 1944. No large amount of beryl was produced.

The three branches of the Central pegmatite contain an albite-quartz core and an irregular narrow pinch-and-swell wall zone containing rum-colored mica and beryl. The wall zone is mostly narrow and ill-defined, but wide rich spots are present. On the east side and near the south end of the schist salient lying between the east and middle branches, the wall zone at one horizon was 4 to 5 feet thick, highly quartzose, and bristling with mica books and small yellow beryl crystals several inches long. At this place the zone was estimated to contain 10 to 15 percent book mica and 25 to 35 percent beryl. The footwall part of the zone of the east branch is poorly defined. The wall zone comprises between 1 and 5 percent of the total bulk of the pegmatite exposed at the surface. Its average grade may be about 5 percent book mica and 3 percent beryl, but data are lacking for a close estimate. The west branch pegmatite as a whole yielded 0.5 percent book mica and 4.5 percent sheet mica. The greater part of the subsequent production of 88,000 pounds came from the hanging-wall zone of the east branch. Old stopes, probably running up from the east tunnel, were observed here.

Data concerning operating costs in Montag No. 1 pit from November 1943 through February 1944 are given in table 15. During this period, 1,100 tons of pegmatite, plus schist and overburden, were excavated, yielding 11,966 pounds of mine-cobbed mica from which 565.75 pounds of sheet mica were recovered. Labor employed amounted to 334.75 man-hours, or 41.84 man-shifts. Figures for quality and grade of some of the sheet mica produced from Montag No. 1 pit and other surface workings near pit No. 3 are given in table 16.

EAST TUNNEL

The east tunnel is caved and inaccessible. Sterrett [32] states that a large vein very rich in mica was reported to have been encountered in it. Possibly the Central pegmatite was cut in the end of the tunnel and the wall zones of the east and middle branches were extensively stoped.

NO. 4 LEVEL

The No. 4 level is caved and inaccessible except the north part, which was reached by raise No. 4 driven from the lower level. According to Sterrett [33] the No. 4 adit was driven some "200 feet to the 'vein,' " and "more than 300 feet of drifts, in which much stoping was done, were * * * carried to the north." Also, "the main pegmatite 'vein' ranges in thickness from 4 to 6 feet in the main original drift and the stopes above and widens out to 12 feet thick at the end of the drift." Later a 30-foot shaft reportedly was sunk from the No. 4 level, and a sublevel drift was run north on the East pegmatite from the foot of the shaft. Good mica reportedly was recovered from the stopes above No. 4 level and beryl crystals up to 1½ inches in diameter are said to have been distributed rather uniformly in the pegmatite. At

[32] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, p. 91, 1923.

[33] Idem, pp. 90, 91.

TABLE 15.—*Operating costs for the Montag No. 1 pit, Muscovite mine* [1]

Item	Total expense	Cost per ton of pegmatite mined	Cost per pound of mine-cobbed mica recovered	Cost per pound of sheet mica produced	Percent of total
Stripping and mining:					
Equipment expense: [2]					
R. D.-6 tractor	$1, 046. 50				
105 compressor	36. 00				
P & H ¾-yd. shovel	1, 526. 53				
H. D.-7 tractor	230. 75				
GMC pickup truck	125. 00				
Jackhammer, hose, steel, and other equipment	80. 00				
Total	3, 044. 78	$2. 77	$0. 254	$5. 38	65. 8
Labor	326. 19	. 30	. 027	. 58	7. 1
Taxes and insurance	30. 55	. 03	. 003	. 06	. 7
Supplies:					
Powder	175. 75				
Caps and exploders	7. 90				
Gas and oil	16. 12				
Total	199. 77	. 18	. 017	. 35	4. 3
Supervision and overhead	250. 00	. 23	. 021	. 44	5. 4
Rifting and trimming (Colonial Mica Corporation)	774. 93	. 70	. 065	1. 37	16. 7
Grand total	4, 626. 22	4. 21	. 387	8. 18	100. 0

[1] A sum of $1,000–$2,000 estimated administrative and general overhead expense should be added to above operating cost to give total production cost.

[2] Equipment rates and total hours are as follows: R. D.-6 tractor, $6.50 per hr., 161.0 hrs.; 105 compressor, $36 per mo., 1 mo.; P & H ¾-yard shovel, $10.42 per hr., 146.5 hrs.; H. D.-7 tractor, $6.50 per hr., 35.5 hrs.; GMC pick-up truck, $125 per mo. 1 mo.; Jackhammer, hose, steel, and other equipment expense, $80 per mo., 1 mo. See footnotes 2 and 3, table 17.

some time subsequent to 1910 the No. 4 level was extended farther to the north.

Both the Central and the East pegmatite are exposed in the accessible part of the No. 4 level. The position of the East pegmatite is marked by an old filled stope partly caved into the drift below. The north end of the stope appears to coincide with the north end of the East pegmatite. The extent of the old stope on the East pegmatite is not known. Possibly there are unmined blocks of ground. Book mica might be present in some of the stope filling.

TABLE 16.—*Quality and grade of total retrimmed sheet mica produced from the Montag No. 1 pit and surface workings near Pit No. 3, Muscovite mine* [1]

Grade No.	Quality (percent)				
	No. 1	No. 2	No. 2 inferior	No. 3	Total
1–A			0. 158		0. 158
1	0. 007	0. 100	. 220		. 327
2	. 041	. 267	. 522		. 830
3	. 076	. 274	. 995		1. 345
4	. 267	1. 390	2. 550		4. 207
5	1. 000	4. 080	11. 700	0. 074	16. 854
5½	. 523	2. 800	4. 930	. 013	8. 266
6	2. 462	17. 300	37. 800	. 054	57. 616
7	. 807	3. 850	5. 740		10. 397
Total	5. 183	30. 061	64. 615	. 141	100. 000

[1] Data for three lots of sheet mica retrimmed at Asheville, N. C., by Colonial Mica Corporation. The mica was classified as ruby. The total weight of the lots before retrimming was 1,025.49 pounds; after retrimming, 911.55 pounds. Thins, skimmings, washer, and scrap amounted to 113.94 pounds.

The Central pegmatite overlies the stope by 10 to 15 feet. Apparently no mining has been done on it from the No. 4 level. In a short raise driven above the level, the body is 13 feet thick. The extent of the body south of the raise has not been explored, but it is probably not great. No mica-bearing wall zones were seen in the Central pegmatite on the No. 4 level.

SUBLEVEL

The sublevel lies on the East pegmatite about 30 feet down the dip from the No. 4 level. It is possibly about 240 feet long although inaccessible along most of its length. With the exception of a single small stope or raise the East pegmatite is reported to be unmined between the sublevel and the No. 4 level. Above stope No. 3, in the north end of the sublevel, the pegmatite is exposed for a length of 35 feet as a series of small thick lenses, rich in mica. What appears to be the Central pegmatite is visible in a caved area on the west side of the sublevel.

RAISE NO. 4

Raise No. 4, driven in the fall of 1944, connects the No. 5 level with the sublevel and the No. 4 level. The raise follows the footwall of the Central pegmatite. Half a ton of crude mica was recovered during the driving of the raise. Some of the books reportedly were large and of good quality.

Seventy feet above the No. 5 level a branch raise runs east and south into the footwall of the Central pegma-

tite and follows the East pegmatite up to the old sublevel. In the branch raise the deposit is 1 to 4 feet thick.

NO. 5 LEVEL

The No. 5 level comprises 1,218 feet of crosscuts and drifts. Four stopes extend upward from it. Stopes No. 1 and No. 2 are on the West pegmatite, and stopes No. 3 and No. 4 are on the East pegmatite. The Central pegmatite has not been mined.

On the drift below stopes No. 1 and No. 2 the West pegmatite is continuous along the strike for a length of 129 feet. It strikes N. 11° W. and dips 63° W. At the south end of the level it is cut off by a small fault. At its northernmost exposure it pinches out. The pegmatite appears to rake south. (See pl. 6.)

The Central pegmatite is poorly exposed in a caved area at the north end of the level. It lies west of the drift and appears to extend northward beyond the north face of the drift. Its south end probably lies near the manway of stope No. 3, but the geology in this part of the mine is so obscured by caved ground and heavy timbering that it cannot be deciphered.

The East pegmatite exposed along the strike for a length of 80 feet at the foot of stope No. 4 and for a length of 75 feet at the foot of stope No. 3 but is not continuous between the two stopes.

The mining carried on in the stopes above No. 5 level accounted for a great portion of the total production. Table 17 gives data showing total costs of production for underground operation on and above the No. 5 level between May 1 and October 31, 1944. During this period 2,405 tons of pegmatite and 2,207 tons of schist were excavated and yielded 278,925 pounds of mine-cobbed mica. The mine-cobbed mica yielded 20,240.08 pounds of full-trimmed small sheet and full- and three-quarter-trimmed large sheet. (Table 18.) The average wage was $8.75 per shift, including overtime, and the number of man-shifts, calculated by dividing the total mine payroll by $8.75, was 2,335.

TABLE 17.—*Costs of production underground, Muscovite mine, May 1–Oct. 31, 1944*

Item	Total expense	Percent of total	Cost per ton excavated	Cost per ton of pegmatite mined	Cost per pound mine-cobbed mica recovered	Cost per pound of sheet mica mined
Underground expense:[1]						
Mine labor	$20, 407. 83					
Payroll taxes and insurance[2]	2, 217. 67					
Foreman	1, 456. 95					
Mine supplies	2, 353. 40					
Equipment rentals[3]	741. 40					
Other expense	29. 11					
Total	27, 206. 36	32. 5	$5. 91	$11. 35	$0. 099	$1. 35
Surface expense:						
Transportation	1, 356. 27					
Labor and equipment rental	805. 91					
Miscellaneous supplies	164. 85					
Total	2, 327. 03	2. 8	. 51	. 97	. 008	. 12
Commissary (net loss)[4]	1, 200. 00	1. 4	. 25	. 48	. 004	. 06
Depreciation:						
Buildings and improvements	315. 00					
Equipment	811. 32					
Total	1, 126. 32	1. 3	. 24	. 45	. 004	. 05
Mine royalties	6, 893. 15	8. 2	1. 49	2. 85	. 025	. 34
Administrative[4]	9, 000. 00	10. 7	1. 95	3. 73	. 033	. 44
Rifting and trimming:[5]						
Payroll	32, 732. 28					
Supplies and miscellaneous expense	1, 121. 81					
Payroll taxes and insurance	888. 51					
Fire insurance	39. 90					
Shop and warehouse rental	441. 00					
Salaries	1, 000. 00					
Total	36, 223. 50	43. 1	7. 84	15. 05	. 130	1. 79
Grand total	83, 976. 36	100. 0	18. 19	34. 88	. 303	4. 15

[1] Underground expense includes the expense of current development, stope preparation, stoping, underground transport, repair and retimbering, and ventilation and drainage. Stoping was the major expense for the period covered.

[2] Includes employer's social security liability, Idaho workman's compensation insurance, and unemployment compensation tax.

[3] Rental on compressor and other equipment rented from the Colonial Mica Corporation.

[4] Estimated.

[5] Private shop run by Victory Mines, Inc.

TABLE 18.—*Quality and grade of total retrimmed sheet mica produced from the underground workings, Muscovite mine*[1]

Grade No.	Quality (percent)				
	No. 1	No. 2	No. 2 inferior	No. 3	Total
1–A	------	0. 002	0. 013	------	0. 015
1	------	. 038	. 272	0. 001	. 311
2	0. 008	. 130	. 965	. 007	1. 110
3	. 018	. 233	2. 115	. 019	2. 385
4	. 046	. 830	6. 210	. 034	7. 120
5	. 179	2. 330	19. 901	. 177	22. 587
5½	. 134	1. 790	8. 250	. 071	10. 245
6	. 533	8. 020	39. 400	. 359	48. 312
7	. 105	2. 430	5. 380	------	7. 915
Total	1. 023	15. 803	82. 506	. 668	100. 000

[1] Data for 10 lots of sheet mica retrimmed at Asheville, N. C., by Colonial Mica Corporation. The mica was classified as ruby. The lots had a total weight of 16,442.88 pounds before retrimming, 14,999.42 pounds after retrimming. Thins, washer, skimmings, and scrap amounted to 1,443.46 pounds.

STOPES NO. 1 AND NO. 2

During 1943 and 1944 the West pegmatite was mined in stopes No. 1 and No. 2. The relatively low average recovery of sheets (see table 12) reflects the inferiority of the crude mica to that recovered from the East pegmatite. The average grade of the stoped pegmatite was 4.8 percent crude mica. The beryl content ranged from 1 to 3 percent, but only a few hundred pounds were saved.

Stope No. 1 was intermittently mined by Victory Mines, Inc., from October 1943 to May 1, 1944. Stoping was by the square-set method. The stope was carried up 67 feet on the dip of the pegmatite along the strike for an average length of about 25 feet. It was abandoned because the mica recovered from the upper part was soft and broken.

The mica deposit in stope No. 1 is a layer from 4 to 12 feet thick composed of large and small irregular veins and lenses of pegmatite enclosed in altered mica schist. The individual pegmatite bodies and the surrounding schist strike from N. 4° to 16° W. and dip 65° to 70° SW. The pegmatite is a varied mixture of medium-grained white semidecomposed plagioclase (albite, Ab_{90}) and light- and dark-gray quartz, with rum-colored muscovite and beryl. Plagioclase is the dominant mineral.

Stope No. 2 is a few yards north of No. 1. Early miners had stoped to about 17 feet above the sill. The back of the stope at the time Victory Mines, Inc., started mining in November 1943 was rather wide and rich. The stope was mined square-set until April 1944. During this period the average grade of the pegmatite was nearly 8 percent mine-cobbed mica. From October to December 1944 another block of ground was stoped, and an irregular raise was driven to the floor of the main pit. Mining in stope No. 2 was stopped when the high price for small sheet mica paid by the Colonial Mica Corporation was discontinued. Unmined ground remains in the West pegmatite above the tops of stopes No. 1 and No. 2.

The character of the deposit in stope No. 2 is the same as in stope No. 1. Light-green to yellowish beryl crystals up to 2 inches in diameter are scattered in the pegmatite, but recovery was difficult because of the small size and the fractured condition of the crystals. The face shown in the plan of the stope at elevation 4198, plate 7, carried 10 to 20 percent book mica on the average, and several small areas carried 30 to 40 percent. One of the books was 24 inches long and 11 inches wide, and many books were 12 inches across and from 8 to 10 inches thick, but most were of smaller size. The larger books were wedge-shaped, slightly to intensely cracked, and faintly reeved. Some lay in altered schist adjacent to pegmatite.

STOPE NO. 3

Stope No. 3 lies on the East pegmatite and, in small part, on the Central pegmatite. It was mined from April until early October 1944 by the cut-and-fill method. The stope extends from the No. 5 level 90 feet up the dip of the East pegmatite nearly to the sublevel. The mica production is given in table 12. The tonnage of pegmatite mined was 2,043 tons, containing an average of 6.5 percent mine-cobbed mica. No beryl was saved.

The East pegmatite strikes N. 5° E. to N. 20° E. and dips 50° to 70° NW. The Central body appears to strike from north to N. 30° W. and dip about 80° W. At many places the two deposits are separated by only a few feet of altered schist.

The East pegmatite contains mica, irregularly distributed, from wall to wall. Its maximum width in the stope is about 14 feet, but to the north and south, at the ends of the stope, it is 3 to 9 feet wide. The Central pegmatite was not explored laterally inasmuch as it appeared to be of low grade except at some points in close proximity to the East pegmatite. The East pegmatite contained 60 to 75 percent albite, with gray quartz, abundant mica, and some beryl. The parts richest in mica were on the footwall side of the body. The mica in many places tended to be more abundant where the pegmatite was quartzose, but this tendency was not everywhere apparent or clear-cut. One crude mica book, 36 inches long, 14 to 16 inches wide, and about 12 inches thick, weighing more than 300 pounds, was obtained from the hanging-wall part of the Central pegmatite. Many books more than 12 inches across were seen.

TABLE 19.—*Stoping costs in stope No. 3, Muscovite mine*[1]

Item	Total expense	Percent of total	Cost per ton total excavation	Cost per ton pegmatite mined	Cost per pound mine-cobbed mica mined	Cost per pound sheet mica produced
Labor	$14, 907. 15	70. 5	$3. 65	$7. 29	$0. 056	$0. 75
Foreman	1, 456. 85	6. 9	. 36	. 70	. 006	. 07
Mining supplies	2, 296. 69	10. 8	. 56	1. 12	. 009	. 11
Equipment rental[2]	758. 13	3. 6	. 19	. 37	. 003	. 04
Taxes and insurance at 11 percent of pay roll	1, 640. 00	7. 8	. 40	. 81	. 006	. 08
Other expense	90. 55	. 4	. 02	. 04		. 01
Total	21, 149. 37	100. 0	5. 18	10. 33	. 080	1. 06

[1] Data probably accurate within about 10 percent.
[2] Compressor and other equipment rented from Colonial Mica Corporation.

Stoping costs for the operation in stope No. 3 between April 13, 1944, and October 7, 1944, are given in table 19. Rock excavated by cut-and-fill methods amounted to 2,043 tons of pegmatite and 2,030 tons of schist. Mine-cobbed mica recovered amounted to 265,000 pounds, from which 19,898.83 pounds of sheet was recovered. Labor was contracted at $5 per ton for 72 tons and $4 per ton for 4,001 tons. Total man-shifts were about 1,706. A crew of 2 to 4 men was employed.

STOPE NO. 4

Stope No. 4 is on the East pegmatite, lying east of and parallel to stopes No. 1 and No. 2 on the West pegmatite. The deposit in stope No. 4 was first intersected by two raises driven east from stope No. 2. (See pl. 6, sec. B–B′.) The upper of the two raises broke into the old sublevel, and the lower raise reportedly intersected the pegmatite about 45 feet above the sill. A drift on No. 5 level was driven on the deposit for 80 feet, and in February 1945 overhand stoping by the cut-and-fill method was started. On May 1 the stope had been driven up the dip 84 feet along the strike for a length of 45 to 65 feet. The production is given in table 12. Excavation was 2,690 tons of pegmatite, and the grade of the pegmatite was 5.9 percent mine-cobbed mica. No beryl was produced although a few small crystals were seen.

The deposit at drift level is composed of two concordant closely spaced lenses, both rich in mica. One lens is at least 38 feet in length and 7 feet in maximum thickness. It strikes N. 12° W. and dips 60° to 65° SW. The other lens is more than 80 feet in length and 6 feet in maximum thickness. It strikes N. 4° W. and dips 45° to 68° SW. The average dip of the deposit as a whole is 63° to the west. The south end of the pegmatite is visible in the drift, but to the north the pegmatite extends beyond the limits of the workings. In the stope the East pegmatite is a series of irregular lenses separated by altered schist. Numerous books of rum-colored mica lying wholly or partly in altered schist were seen. Reportedly part of the mica books recovered came from 2-foot band of altered schist lying in the hanging wall adjacent to the pegmatite.

OLD DUMPS

During the spring and summer of 1944 C. J. Montag & Sons reworked the old mine dumps that were situated near the portals of No. 3 and No. 4 adits. An estimated 174,000 pounds of crude mica was recovered. Data as to quality and grade of part of the sheet mica produced are given in table 20.

TABLE 20.—*Quality and grade of total retrimmed sheet mica produced from the old dumps, Muscovite mine*[1]

Grade No.	Quality (percent)				
	No. 1	No. 2	No. 2 inferior	No. 3	Total
2		0. 021	0. 064		0. 085
3	0. 017	. 104	. 244	0. 006	. 371
4	. 017	. 533	1. 410	. 010	1. 970
5	. 237	4. 080	8. 960	. 037	13. 314
5½	. 212	3. 460	6. 750	. 006	10. 428
6	2. 100	22. 350	36. 600	. 080	61. 130
7	. 232	4. 970	7. 500		12. 702
Total	2. 815	35. 518	61. 528	. 139	100. 000

[1] Data for 5 lots of sheet mica retrimmed at Asheville, N. C., by Colonial Mica Corporation. The mica was classified as ruby. The lots had a total weight of 2,055.19 pounds before retrimming, 1,835.88 pounds after retrimming. Thins, washer, skimmings, and scrap amounted to 219.64 pounds.

RESERVES

Mica and beryl are present in the unmined parts of the three major pegmatites above the No. 5 level and in the downward extensions of the bodies below the level. Beryl and mica are present in altered schist bordering the pegmatites and in unknown quantities in the filling of the old stopes above the No. 4 level. Beryl, but little mica, is present in the mine dumps. The reserves are divided into three classes: (1) Those available to underground mining, which lie below the No. 4 level, (2) those available to open-pit mining, which lie above the No. 4 level, and (3) mine dumps.

TABLE 21.—*Indicated reserves underground in the Muscovite mine, May 1, 1945*

Reserve No.	Location	Strike length (feet)	Dip length (feet)	Average thickness (feet)	Pegmatite (tons)	Mine-cobbed mica (percent)	Sheet mica per ton of pegmatite (pounds)	Punch per ton of pegmatite (pounds)	Beryl (percent)	Total crude mica (pounds)	Total sheet mica [1] (pounds)	Total punch mica [2] (pounds)	Total beryl (tons)
1	East pegmatite, below No. 5 level, downward continuation of pegmatite mined in stope No. 3.	30	[3] 30	10	720	6.5	4.0	28.0	0.2	93,600	2,880	20,160	1.4
2	East pegmatite, between sublevel and No. 4 level, directly above stope No. 3.	35	18	4	202	6.5	4.0	28.0	.2	26,200	808	5,750	.4
3	East pegmatite, unmined part in stope No. 4, from No. 5 level up to sublevel.	------	------	4	1,000	5.0	1.8	25.2	.2	100,000	1,800	25,200	2.0
4	East pegmatite, between sublevel and No. 4 level, directly above stope No. 4.	95	25	6	1,140	5.0	1.8	25.2	.2	114,000	2,052	28,750	2.3
5	East pegmatite, below No. 5 level; directly beneath sill of stope No. 4.	80	[3] 50	6	1,920	5.0	1.8	25.2	.2	192,000	3,460	48,400	3.8
6	West pegmatite, unmined part above No. 5 level and below No. 4 level, over lateral extent of stopes No. 1 and No. 2.	------	------	------	1,200	4.0	.3	14.5	2.0	96,000	360	17,400	24.0
7	West pegmatite, below No. 5 level, over lateral extent of stopes No. 1 and No. 2.	130	[3] 50	4	2,080	5.0	.4	18.0	2.0	208,000	832	37,400	41.6
	Total	------	------	------	8,262	------	------	------	------	829,800	12,192	183,060	75.5

[1] Sheet mica 1½ by 2 inches and larger.
[2] Punch mica containing 20 percent of small sheet 1 by 1 to 1½ by 2 inches.
[3] Dip length assumed.

RESERVES AVAILABLE TO UNDERGROUND MINING

Reserves available to underground mining comprise the unmined parts of the East, Central, and West pegmatites below the No. 4 level. The mica content of these parts is known through production figures and measurements of excavation. Beryl, however, was not saved during the stoping operations, and hence the beryl content is indicated only by visual estimates and by assays of samples cut by the Geological Survey, Federal Bureau of Mines, and Idaho Bureau of Mines and Geology [34] in 1942. They indicate that the West pegmatite carries between 1 and 8 percent beryl, probably averaging about 2 percent. The average of the East pegmatite is estimated roughly as 0.2 percent beryl.

Indicated reserves available underground are given in table 21. The figures for sheet and punch mica are based largely on the actual recoveries realized during 1943 and 1944. Improved rifting and trimming practice would increase the percentage recovery of sheet and punch mica. Inferred reserves underground are given in table 22.

TABLE 22.—*Inferred reserves underground, Muscovite mine*

Reserve	Pegmatite (tons)	Mine-cobbed mica (pounds)
East pegmatite between No. 4 and No. 5 levels, north and south of stope No. 3, north of stope No. 4, and above sublevel between stopes No. 3 and No. 4.	1,000 to 4,000	60,000 to 480,000
Central pegmatite between No. 4 and No. 5 levels.	5,000 to 20,000	50,000 to 200,000
Total	6,000 to 24,000	110,000 to 680,000

[34] Forrester, J. D., Mica and beryl occurrence in eastern Latah County, Idaho: Idaho Bur. Mines and Geology Pamph. 58, p. 12, 1942.

Below the No. 5 level minable areas in both East and West pegmatites might extend laterally or downward beyond the limits assumed in the calculation of indicated reserves. The extension of the Central pegmatite below the No. 5 level is likewise excluded from calculations the results of which are given in tables 21 and 22. Such an extension could be explored in conjunction with deeper development of the East and West bodies.

OPEN-PIT RESERVES

An appreciable tonnage of mica- and beryl-bearing material lies in unmined pegmatite, altered schist, and stope filling above the No. 4 level. The recovery of mica and beryl from this material probably could be best accomplished by open-pit mining and by hand-picking, screening, and milling the mined material. Part of the available tonnage could be mined by underground methods. All the open-pit reserves, given in table 23, are inferred.

Eleven channel samples of altered schist, taken by the Geological Survey [35] in 1942, were analyzed spectroscopically for beryllium. The analyses showed from 0.004 to 0.20 percent BeO, corresponding to 0.028 to 1.4 percent beryl, on a basis of 14 percent BeO in beryl. The Bureau of Mines [36] subsequently cut three channel samples of altered schist in the main pit, and the samples were analyzed spectrographically. All three samples showed less than 0.02 percent BeO. The grade is variable because the beryl crystals are irregularly distributed, but the average grade is probably low.

[35] Page, L. R., and Heinrich, E. W., Beryl-mica deposits, Muscovite claim, Latah County Idaho: U. S. Geol. Survey unpublished rept., p. 11, August 1942.
[36] Lorain, S. H., The Muscovite mine, Latah County, Idaho: U. S. Bureau of Mines unpublished rept., p. 5, February 1943.

TABLE 23.—*Inferred reserves in the open pit, Muscovite mine*

Reserve	Pegmatite (tons)	Mine-cobbed mica (pounds)	Beryl (tons)
Central pegmatite above No. 4 level.	50, 000	150, 000	45
East and West pegmatites above No. 4 level, including old stope fill.	5, 000	50, 000 to 300, 000	25 to 75
Altered schist above No. 4 level.	35, 000	----------	35
Total	90, 000	200, 000 to 450, 000	105 to 155

DUMPS

The total dump tonnage is roughly 100,000 tons. All the mine dumps on the Muscovite property contain probably 15,000 to 30,000 tons of pegmatite, including possibly 50 to 300 tons of beryl. Little book mica is present. More than 75 percent of the dump tonnage of pegmatite is mixed with three times or more the amount of schist, and the grade of the dumps is therefore low.

OLSON MINE

The Olson mine is in sec. 27 about 1,000 feet west of the Steelsmith property. It is said to have been operated about 1905 as the Scott Rogers mine. The old workings include a tunnel, cuts, and a caved shaft, situated on State land leased by George Fitzgerald, of Spokane, Wash. In the summer of 1944 the Bureau of Mines, in cutting exploratory trenches near the old surface workings, uncovered a small mica pegmatite, which was subsequently leased by Albert Olson, of Moscow, Idaho. During October and November 1944 Olson and a helper mined the deposit to a depth of about 20 feet in a small open pit. An old stope, which probably connects with caved workings in the tunnel, was encountered in the open pit a few yards below the surface. Operating data and costs for the approximate period October 1 to November 30, 1944, are given in table 24. In addition to the mica, a few hundred pounds of beryl were recovered. Excavation was 420 tons of pegmatite, together with soil and schist. From the pegmatite 18,000 pounds of mine-cobbed mica were recovered, and trimming of this mica yielded 831.92 pounds of sheet mica and 15.0 pounds of punch mica. The total value of sheet and punch mica was $5,255.12. Labor amounted to 85 man-shifts.

In the winter of 1944–45, after cessation of open-pit mining, Burt Clayton, of Deary, Idaho, cleaned out the tunnel and drove three raises to the north in an attempt to intersect the pegmatite exposed in the open pit. Reportedly it was encountered in one of the raises, but caving prevented the recovery of much mica. By February 1945 about a ton of crude mica had been produced from underground. The mica yielded 354.81 pounds of punch and sheets, of $409.13 gross value. The workings and geology of the Olson mine are shown in figure 17.

TABLE 24.—*Costs of production in the Olson mine, Oct. 1–Nov. 30, 1944*

Item	Total expense	Percentage of total	Cost per ton of pegmatite mined	Cost per pound of mine-cobbed mica recovered [1]	Cost per pound of sheet mica produced
Mining:					
Labor	$724. 00	24. 4	$1. 72	$0. 040	$0. 88
Supplies	75. 00	2. 5	. 18	. 004	. 09
Rental of bulldozer	75. 00	2. 5	. 18	. 004	. 09
Rental, ore car, and rail	6. 80	. 2	. 01	------	. 01
Total	880. 80	29. 6	2. 09	. 048	1. 07
General:					
Paid for lease	200. 00	6. 7	. 48	. 011	. 24
Royalty	[2] 245. 00	8. 2	. 58	. 014	. 29
Total	445. 00	14. 9	1. 06	0. 025	0. 53
Rifting and trimming	[2]1,648.44	55. 5	3. 93	. 092	1. 98
Grand total	2, 974. 24	100. 0	7. 08	. 165	3. 58

[1] Excluding 4,000 to 5,000 pounds mine scrap.
[2] Close approximation.

The pegmatite exposed in the open pit is very irregular. The average strike is N. 68° W., and the dip is 45°–65° NE. The average dip is about 50°. Rolls in the pegmatite contact and minor crumples in the adjoining mica schist plunge 20° to 60° E. or NE. The pegmatite is 47 feet long and ranges from less than a foot to 15 feet thick. The foliation of the enclosing biotite-muscovite-quartz schist is at most points parallel to the pegmatite contacts. A thin tabular projection of schist extends from the hanging wall into the widest part of the pegmatite. The schist adjoining the hanging wall contact is altered to a plagioclase-muscovite-quartz-schorl rock containing a little brown biotite.

The pegmatite is chiefly a mixture of medium- to coarse-grained white albite and gray quartz, in which the albite is the dominant mineral. Book mica of pale-rum color is associated with irregular pods of gray quartz, which run diagonally across the strike of the pegmatite in its central part. Many of the quartz-mica pods strike northwest and dip northeast. One book weighing 30 pounds and another weighing 8 to 9 pounds were recovered. Many books are slightly warped and cracked but are clear except for clay stains and inclusions of quartz and tourmaline. A second type of mica is associated with albite. Thin sheets of it are colorless to very pale brownish green. The crude

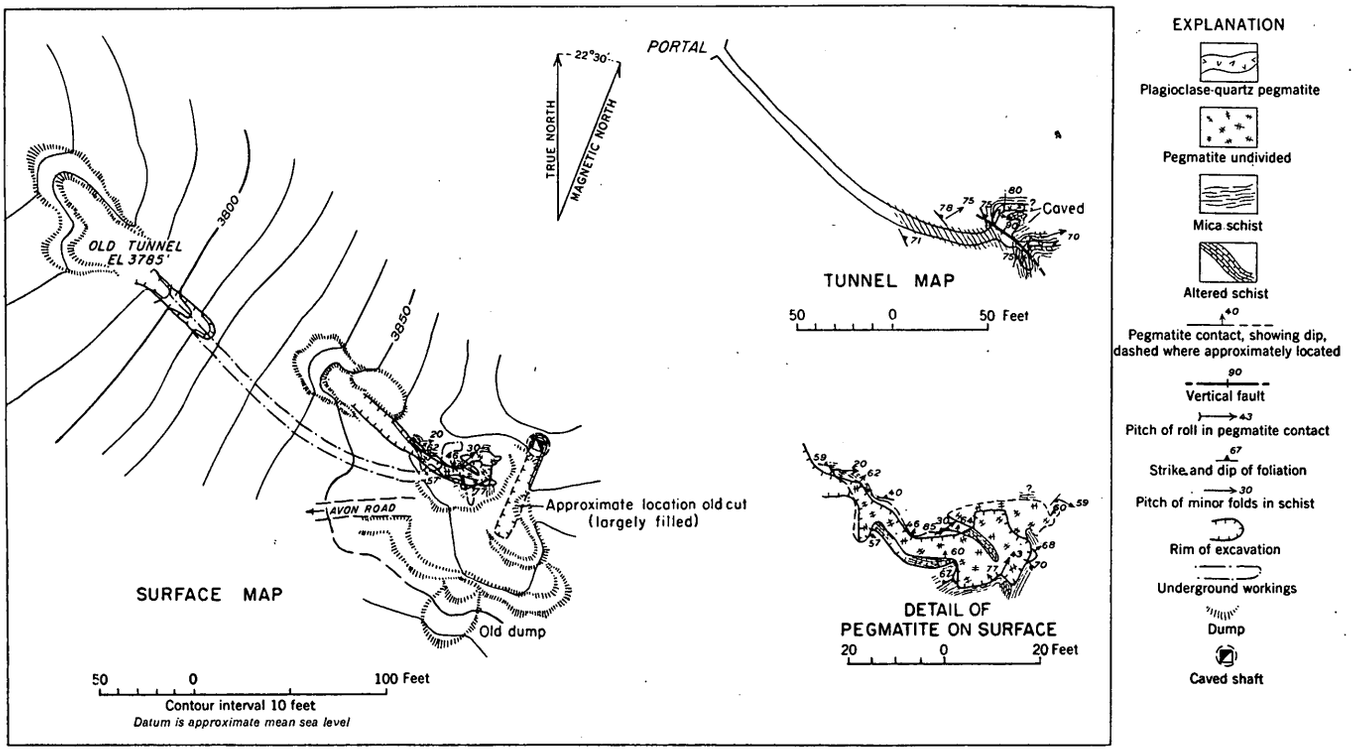


FIGURE 17.—Surface and tunnel maps, Olson mine, Latah County, Idaho.

books are corrugated and cracked. Both pale-rum mica and brownish-green mica were saved for rifting and trimming. The largest beryl crystal seen was 6 inches in diameter and 9 inches in length.

When examined, the old tunnel was open only to 190 feet from the portal, but small caved and inaccessible openings appeared to extend farther north. Only one of three raises driven in 1944–45 was accessible. The mica schist exposed in the tunnel strikes N. 11° E. to N. 38° W. and dips 70° to 80° SE. or NE. Minor folds in the schist plunge steeply northeast. Two narrow pegmatites, arcuate in plan, are exposed in short drifts branching from the tunnel. They lie in the trough and limbs of a steeply plunging synclinal fold in schist, and the contacts follow the curvature of the schistosity. The pegmatites are composed of white albite, gray quartz, and small curved cracked books of muscovite. Similar pegmatite is exposed at the head of one of the raises.

The chances of producing mica underground do not appear good, but sheet mica of fair quality could probably be produced in small amounts by widening and deepening the open pit.

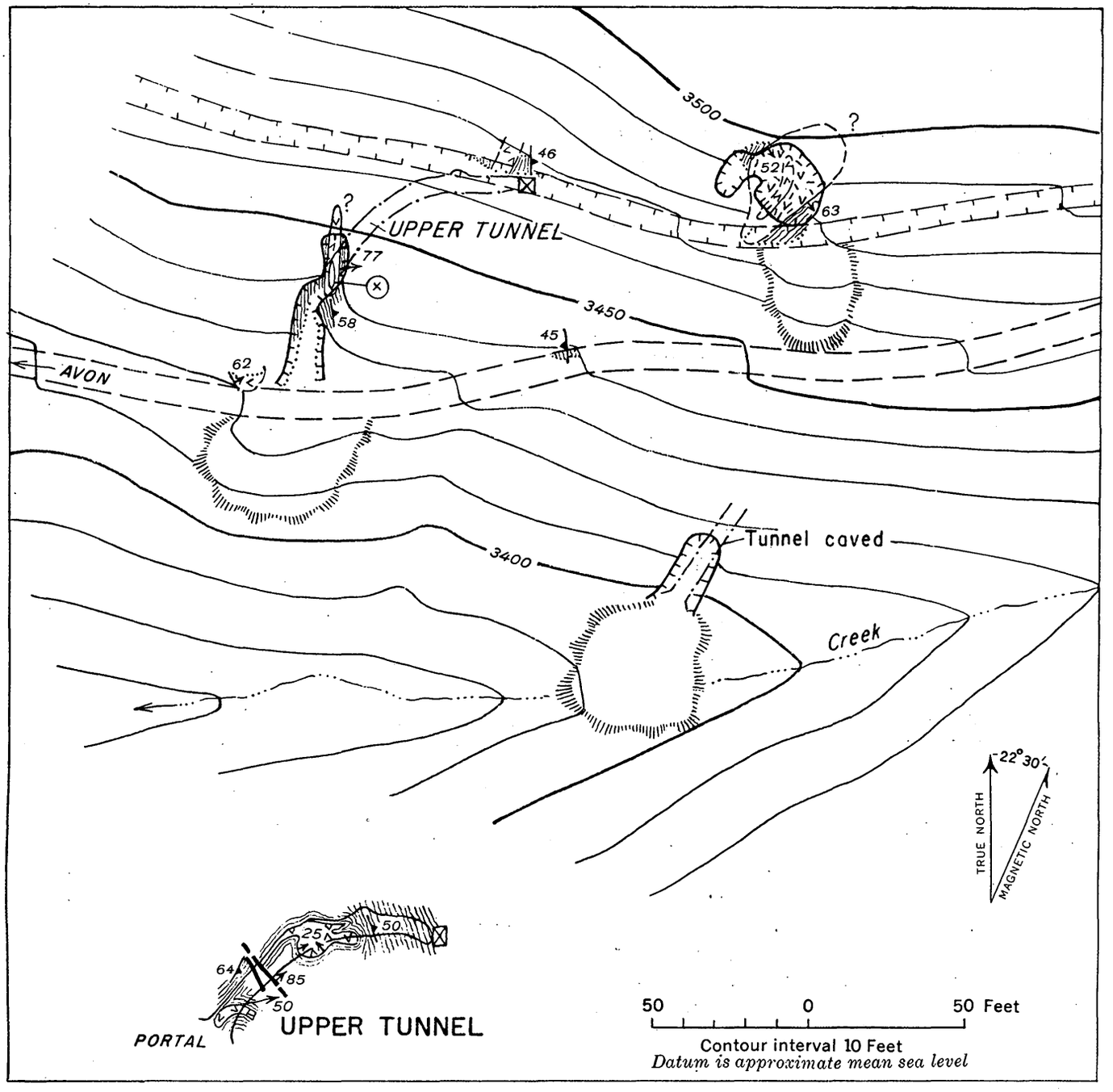
SILVER WHITE PROSPECT

The Silver White prospect lies in sec. 22 approximately 700 feet west of the Last Chance mine, with which it is connected by an old dirt road. The property is owned by Thatuna Mines, of Lewiston, Idaho. In May and June 1944 a little work was done on the property by Jack Wright and Robert Green, working for the owners, and a few pounds of sheet mica was produced. Since that time the prospect has been idle.

The workings, all driven before 1943, comprise two tunnels, two small open pits, and several hundred feet of exploration trenches. Four small pegmatites are exposed in the upper tunnel. The lower tunnel is caved. None of the deposits contain appreciable amounts of sheet mica. The geology and workings are shown in figure 18.

In the upper pit a single pegmatite, striking N. 42° E. and dipping 52° to 63° SE., is exposed. The maximum thickness of the body is about 19 feet, and the length is probably between 35 and 50 feet. The minerals in it are plagioclase, quartz, muscovite, biotite, and schorl. Massive coarse-grained white quartz forms a core 1½ feet thick. The pegmatite on both sides is composed chiefly of plagioclase, scrap mica, and minor amounts of quartz. The pegmatite contains from 4 to 8 percent scrap mica, mostly next to the quartz core, between the quartz and the footwall.

A pegmatite lens exposed in the lower pit is 4 feet thick and exposed for a length of 10 feet. It strikes about north and dips 77° to 83° E., parallel to the foliation of the adjoining mica schist. White to translucent massive quartz, 1 foot thick and containing a few small



EXPLANATION

Quartz

Plagioclase-quartz pegmatite

Plagioclase-quartz muscovite (scrap mica) pegmatite

Mica schist

63 Pegmatite contact, showing dip, dashed where approximately located

50 Plunge of pegmatite

45 Strike and dip of foliation

85 Fault, showing dip, dashed where approximately located

Limit of exposure

Rim of excavation

Underground workings

Foot of raise

Dump

Bulldozer trench

FIGURE 18.—Surface and tunnel maps, Silver White prospect, Latah County. Idaho.

books of scrap mica, forms the core of the pegmatite. The wall zone, 1 foot thick along the footwall and 2 feet thick along the hanging wall, is composed of albite with minor amounts of quartz and small clusters of scrap-mica books and flakes. Another pegmatite exposure, on the road near the upper tunnel, consists of plagioclase, scrap mica, schorl, and a little gray quartz. Small plunging pegmatites exposed in the upper tunnel are similar in composition. None of the exposed pegmatites contain commercial quantities of mica.

STEELSMITH PROPERTY

LOCATION AND ACCESS

The Steelsmith property, in sections 22 and 27, is 3,200 feet south of the Muscovite mine. The workings lie on the top and sides of a steep flat-topped knoll at altitudes ranging from 3,980 to 4,140 feet. From the mine access road the property is reached by several dirt roads and trails.

HISTORY, WORKINGS, AND PRODUCTION

Part of the Steelsmith property was known formerly as the Levi Anderson mine and was worked before 1910.[37] The early production is unknown. The owners are Robert Olson and Herman Krier, of Troy, Idaho. During 1943 and 1944 they leased the property to Tonopah Mines, Inc., a local organization headed by O. H. Gleason, of Moscow, Idaho, and R. Williams, of Lewiston, Idaho. A number of miners obtained subleases to work on various parts of the property.

The surface and underground workings expose more than a dozen pegmatites. The old workings include an upper tunnel with connecting stopes, a small open pit, and a lower tunnel. Parts of both the upper tunnel and the pit are on the main pegmatite. New workings, excavated in 1943 and 1944, comprise stopes, a short crosscut, and drifts on the upper tunnel level, five open pits and cuts, and numerous exploratory trenches made by the Bureau of Mines. The workings and geology are shown in plate 9, except the lower tunnel.

During 1943 and 1944 an estimated 24,600 pounds of crude book mica was mined from the upper tunnel and the small surface workings above the tunnel. From the Tonopah North and South cuts (pl. 9), 5,300 pounds was produced. Other workings probably yielded about 3,000 pounds. The total production during these years is thus about 32,900 pounds of crude book mica, excluding an unknown quantity of mine scrap. Sales during 1943, 1944, and to April 2, 1945, were 1,420.78 pounds of sheet mica, of which 1,208.74 pounds was small sheet and 212.04 pounds was large sheet. The gross value of the sheet mica was $8,036.77. Available data on quality and grade are given in table 25. The lot of mica referred to in the table probably came from the stopes in the upper tunnel.

[37] Sterrett, D. B., op. cit. (Bull. 740), p. 89.

TABLE 25.—*Quality and grade of total retrimmed sheet mica, Steelsmith mine* [1]

Grade No.	Quality (percent)				
	No. 1	No. 2	No. 2 inferior	No. 3	Total
1		0. 016	0. 130		0. 146
2	0. 051	. 332	. 230		. 613
3	. 044	. 436	. 882	0. 016	1. 378
4	. 039	1. 501	2. 885		4. 425
5	. 503	3. 750	5. 590	. 064	9. 907
5½	. 394	3. 095	3. 140	. 016	6. 645
6	2. 305	29. 750	33. 250	. 212	65. 517
7	. 409	4. 850	6. 110		11. 369
Total	3. 745	43. 730	52. 217	. 308	100. 000

[1] Data for one lot of sheet mica retrimmed at Asheville, N. C., by Colonial Mica Corporation. The mica was classified as ruby. The total weight of the lot before retrimming was 875.19 pounds; after retrimming, 777.29 pounds. Thins, skimmings, small washer, and scrap amounted to 97.90 pounds.

MICA DEPOSITS

Upper tunnel.—The main pegmatite is exposed in an old open pit and in the upper tunnel. (See pl. 9.) During 1943 and 1944, after cleaning out the caved workings, Tonopah Mines, Inc., and other lessees enlarged the old stopes and mined new ground above the tunnel, drove a raise to the surface, and sank a 10-foot winze. A short crosscut was driven into the hanging wall to a second pegmatite, which was explored by short drifts and a raise. Almost all of the 24,600 pounds of crude mica produced by Tonapah Mines, Inc., and all the sheet mica produced on the property with the exception of about 300 pounds came from the stopes on the main pegmatite above the upper tunnel.

The country rocks exposed in the tunnel are light-colored soft muscovite-quartz-feldspar schist containing minor quantities of biotite, and dark gray, biotite-feldspar-quartz gneiss, more massive and somewhat finer grained than the schist. The schist and gneiss are interbedded. The foliation of the rocks appears to be parallel to the original bedding at most places. Where adjacent to pegmatite, the wall rocks are altered to a light-colored fine-grained faintly schistose mixture of white plagioclase, mucovite, and quartz with subordinate amounts of schorl and garnet.

The main pegmatite is a pipe-like body, oval in plan. (See pl. 9.) It plunges S. 37° W. at an angle of 50°. On the tunnel level it is 58 feet long and 20 feet thick. The pegmatite extends below the tunnel floor and has been followed in stopes and raises from the tunnel to the surface, a distance of about 100 feet. The body lies concordantly within the enclosing schist and gneiss except at the blunt lateral terminations. Three well-

defined zones are present: A core of quartz, a wall zone containing muscovite and beryl, and a border zone. The core, more than 10 feet in maximum thickness, is composed of light to dark gray coarse massive quartz with minor quantities of pale-gray microcline-perthite. The wall zone is 1 foot to 10 feet thick and completely encloses the quartz core. It consists of white highly weathered albite, gray quartz, microcline-perthite, varying amounts of muscovite, and scattered crystals of beryl. Most of the mica books in the wall zone lie adjacent to the quartz core, although some books lie distant from the core. The border zone is 12 inches wide and contains abundant black tourmaline and muscovite of scrap quality. Bands of black tourmaline lie in the schist adjoining the pegmatite.

Much of the mica in the wall zone is of scrap quality, but some books are flat and unbroken. The proportion of good mica, as well as the total mica content of the wall zone is highly varied. A block of ground stoped from the footwall part of the zone yielded roughly 1.3 percent of book mica, excluding mine scrap, and 1.25 pounds of sheet mica, 1 by 1 inch and larger, per ton of pegmatite. Another stope, in the hanging-wall part of the zone, yielded 1.8 percent of book mica, excluding mine scrap, which was equivalent to 0.9 pound of sheet mica per ton of pegmatite. Some books as much as 10 inches across were obtained. The sheets cut from the books range from pale rum to nearly colorless. Good mica reportedly was recovered from the winze, but this was flooded at the time of the writer's visits.

Beryl is unevenly distributed in the wall zone. One crystal, recovered from caved material in the tunnel, was 5 to 6 inches in diameter, 9 inches in length, and pale yellow. It contained about 20 percent of quartz and muscovite inclusions. Miners reported seeing crystals as much as a foot across, but most are a few inches or less in diameter.

The workings in the hanging wall of the main pegmatite expose another body, which is U-shaped in plan and cross section. The pegmatite, perhaps 15 feet in maximum thickness, plunges 42° to 60° SSW., following the plunge of a complex fold. It consists of white plagioclase containing blebs, small masses and stringers of gray quartz, disseminated flakes and small books of muscovite, and small crystals of schorl. The sheet mica content of the pegmatite is very low, and only a few pounds were recovered during development.

Open pit, main pegmatite.—The outcrop of the main pegmatite is opened by an old pit 40 feet long, 7 to 20 feet wide, and 10 feet deep. The pegmatite appears to be about 20 feet thick in the pit, but the walls are slumped and little is visible except the quartz core, which crops out rather prominently. A single exposure of the feldspathic wall zone is barren of sheet mica.

Gleason pegmatite.—Near the old open pit a second pegmatite, discovered by angledozer trenching carried on by Tonopah Mines, Inc., in the spring of 1944, is exposed in a small open cut and a shaft 12 feet deep. The pegmatite is a lens more than 120 feet long and as much as 8 feet wide. It pinches out above the level of the upper tunnel. The strike of the lens is N. 3° W. and the dip is 65°–75° W. The constituents of the deposit are white albite, gray quartz, black tourmaline, and scattered flakes and small books of muscovite. Hard rum-colored mica books are associated with small pods of quartz. The average size of the books is small; the largest one seen was 5 inches in diameter. Some books are curved and broken. Clay stains are present, but otherwise the mica is clear. A second type of muscovite is present, forming soft white curved and broken books. The total mica content of the pegmatite is 1 to 2 percent, but most of the crystals are too small to yield sheets.

Murphy lease.—A pegmatite discovered by the Bureau of Mines was worked on a small scale by J. D. Murphy in the summer of 1944. A small cut was excavated with scraper and hoist, and a few hundred pounds of crude mica was produced. The pegmatite is possibly 90 feet in length and 14 feet in maximum thickness. The strike is approximately north. The principal minerals are weathered white plagioclase, quartz, and muscovite. The mica books, white and of poor quality, are found mainly on the borders of small segregations of massive quartz lying near the center of the deposit.

Tonopah north and south cuts.—The Tonopah north and south cuts, situated on the west and northwest flanks of the knoll, were excavated with a bulldozer and a hoist-driven scraper by C. C. Weipert, of Spokane, Wash. The pegmatites were discovered by the Bureau of Mines. The production of crude mica was 5,300 pounds, from which 131.43 pounds of sheets were cut and sold. Only about 10 pounds of the sheet mica was 1½ by 2 inches or larger.

Three narrow pegmatites are exposed in the south cut. They consist chiefly of an aggregate of medium-grained white albite and dark-gray quartz. A few books of pale rum-colored muscovite, up to several inches in diameter, are associated with pods of gray quartz. Black tourmaline and soft white muscovite are present in minor quantities. The pegmatites contain less than 0.1 pound of sheet mica per ton.

In the north cut several pegmatites were exposed, but only one was mined. It is a lens 63 feet in length and 7 feet in maximum thickness, striking N. 50° W.

and dipping 83° SW. Albite and quartz, in a medium-grained intergrowth, are the chief minerals. The mica books, present in minor amount, are white in color and badly cracked and warped. The pegmatite probably contains about 0.1 pound of sheet mica per ton.

McDonnell lease.—A pegmatite that had been worked to a small extent in early days was leased in 1944 by Finley McDonnell. The pegmatite lens strike N. 10° E. and dips steeply to the west, parallel to the foliation of the enclosing mica schist. It is about 70 feet in length and 7 feet in maximum thickness. Plagioclase and quartz, in medium- to coarse-grained mixtures, are the chief minerals. Mica books up to 6 inches across are said to have been found.

A 75-foot adit was driven about 20 feet below the outcrop and intersected what is probably a second pegmatite (see pl. 9), whose strike is N. 30° E. and dip is 67° to 85° NW., parallel to the schistosity. It is a medium-grained mixture composed of 85 percent plagioclase and white perthite, 13 percent gray quartz, 1 percent scrap muscovite, and 1 percent schorl, by visual estimate. Fine-grained selvages from 1 inch to 4 inches wide are present.

McDonnell produced 78.31 pounds of sheet mica in 1944 and 1945. Most of it came from the surface.

Lower tunnel.—The Steelsmith lower tunnel (pl. 9) was driven many years ago, apparently to intersect the pegmatite that was later worked by McDonnell. The end of the tunnel, however, does not show pegmatite. A very few small bodies of feldspar-quartz pegmatite are exposed near the portal.

RESERVES

The calculable reserves of sheet mica on the Steelsmith property lie entirely in the wall zone of the main pegmatite exposed in the upper tunnel, and small additional amounts of mica are recoverable from other deposits, especially from the Gleason pegmatite and the McDonnell lease.

Roughly 3,000 tons of unmined pegmatite lie in the wall zone of the main deposit above the tunnel level. Judging from the exposures in raises and stopes, the average grade is very low, but small quantities of sheet mica and beryl are probably recoverable from this ground.

Most of the mica has come from stopes extending a few rods above the tunnel, and the principal reserves probably lie below the tunnel level. The tonnage of pegmatite in the wall zone to 25 feet below the tunnel level is estimated at 1,320 tons. If the average grade is 1.5 percent book mica excluding mine scrap, the indicated reserve is 39,600 pounds of book mica containing 277 pounds of sheet mica and 7,730 pounds of crude punch. An additional amount of crude mica containing clear flat areas less than 1 by 1 inch should be available. Likewise, beryl should be recoverable, but the available data do not permit computation of reserves. If the pegmatite and the wall zone are found to extend to depths greater than 25 feet below the tunnel, as seems possible, then the reserves would be proportionately greater than estimated above.

SUNSHINE CLAIM

The Sunshine claim, in section 15, adjoins the Morning Star claim on the north. The trail from the Muscovite mine to the Morning Star continues along the crest of the ridge to and beyond the Sunshine claim. Little work has been done on the property, and no production is known. David Peterson owned the claim in 1910.[38] In 1942 the property was under lease to Victory Metals, Inc., of Salt Lake City, Utah. The following description is abstracted from a report by E. W. Heinrich.[39]

The workings comprise a shaft, a pit, and a small open cut. The shaft is a few feet south of the trail, near the northeast end of the claim. It is about 30 feet deep, but inaccessible. Pegmatite is visible 5 feet below the collar. Forty feet southwest of the shaft is a pit 10 feet long that exposes pegmatite along its entire length. The pegmatite is an intergrowth of gray quartz, feldspar, muscovite, and black tourmaline. The open cut is about 400 feet southeast of the shaft and 100 feet below the crest of the ridge. It is 18 feet long and 8 feet wide and exposes a pegmatite 6 feet wide striking N. 40° E. and dipping 55° NW. The foliation of the country rock, a fine-grained gray muscovite schist, lies parallel to the walls of the pegmatite. The central part of the body is an intergrowth of quartz and feldspar containing books of pale-yellow muscovite and a few small crystals of schorl. The borders of the pegmatite are richer in quartz and muscovite and contain many large crystals of highly fractured schorl as much as 10 inches in length. Books of mica up to 2 inches in diameter were seen in both the open cut and the pit, but the mica is all scrap quality.

Along the trail north of the Sunshine claim quartz float is present in many places. A quartz vein is traceable for 150 feet, but no other exposures of pegmatite were seen near the crest of the ridge for about a mile north of the claim.

[38] Sterrett, D. B., op. cit. (Bull. 740), p. 87.

[39] Heinrich, E. W., Some mica-beryl prospects, Avon district, Latah County, Idaho: U. S. Geol. Survey unpublished rept., p. 8, September 1942.

WITHEROW LEASE

The Witherow lease is on, and near the east end of, the Last Chance claim, in sec. 22. The mine was worked many years ago as shown by old workings, which include a caved adit and a small open pit. Trenching by the Bureau of Mines in 1944 revealed other pegmatites close to the open pit. A lease on the small area including the discoveries and the old workings was obtained by Jack Witherow who was later joined by several partners. A small open pit was dug in pegmatite in the fall of 1944, and a stope and short drift were driven in the winter of 1944–45. An effort was made to reopen the old adit, but the opening caved again and the project was given up. In February 1945 no more than a couple of hundred pounds of small-sized sheet mica had been produced.

Probably four or five pegmatites lie in and near the open pits, but only a part of the deposit mined by Witherow is well-exposed. The average trend of this body is north, but it curves abruptly at several places. The dip is east at angles of 40° to 60°. The hanging wall is indented by a sharp fold of schist that plunges down the dip. The thickness of the pegmatite appears to range from a few feet to possibly 20 feet; the length is probably about 70 feet. Most of the mica lies in a fairly well defined hanging-wall zone, which is as much as 3 feet thick. Many of the mica books in the zone lie with the flat sides perpendicular to the wall. A small amount of mica was found near the footwall of the body at one place. The central zone is albite with subordinate amounts of quartz and scrap mica. Most of the books in the pegmatite are curved and broken and thus yield a low proportion of sheets. The sheet mica ranges from pale rum to colorless.

The other pegmatites appear to be small lenses; possibly some of them are curving bodies of more complex shape. Narrow wall zones containing small amounts of sheet muscovite were seen in the pegmatites exposed in the old pit, but these were not mined. Small additional amounts of sheet mica could be produced from the Witherow lease, but the deposits could be profitably worked only if prices for mica were high.

LEMHI COUNTY

GLENAN PROSPECT

Four claims owned by Frank Glenan, of North Fork, Idaho, in the Salmon River Valley 13.3 miles by road west of North Fork, were visited by Roy P. Full, of the Geological Survey, in September 1944. The claims are 1,500 feet north of the road, in the first gulch west of a ranch house belonging to Earl Pointer. Two small pits lie on the east side of the gulch about 75 feet above the bottom. The exposed pegmatite contains mica books measuring from a fraction of an inch to 2 inches across and a few books as large as 5 inches across. The larger books are badly fractured, and all the mica seen was stained.

VALLEY COUNTY

PANTHER PROSPECT

The Panther prospect is in the valley of the Middle Fork of the Payette River, 1¾ miles northeast of Boiling Spring, in or near sec. 14, T. 12 N., R. 5 E., Boise meridian. Its location is shown in figure 4. From Banks, on State highway 15, the prospect is reached by road through Garden Valley and up the Middle Fork of the Payette River to the Boiling Spring Ranger Station. From the ranger station a trail leads about 2 miles northeastward to the prospect, which is situated south of Bryan Creek on the east wall of the Middle Fork Valley about 600 feet above the stream. The claim was staked in 1944 by Erwin Mickey, of Council, and Sheldon Bowers, of Moscow, Idaho. The writer visited it on July 2, 1944, with Mr. Mickey.

A ledge of pegmatite, trending N. 12° W., crops out at places for a distance of 200 yards on the steep timbered valley side. The outcrops and several small cuts show cream-colored microcline-perthite, massive white quartz, semidecomposed white plagioclase, and radial aggregates of mica books lying in the feldspar. The muscovite is colorless, pale green, gray, or brownish. The books are strongly reeved and contain splotches and dots of black stain. No sheets could be cut from them. The surrounding country rock is granodiorite of the Idaho batholith.

Mr. Mickey showed the writer samples of mica taken from other outcrops in the Middle Fork Valley a few miles south of Boiling Spring and on the west wall of Trail Creek west of the mouth of Peace Creek. The samples, like the mica in the Panther claim, were reeved and black-stained.

MINES AND PROSPECTS IN MONTANA

DISTRIBUTION OF KNOWN DEPOSITS

The number of known mica deposits in Montana is small. Sterrett[40] mentions one prospect 8 miles southeast of Dillon, in Beaverhead County, which is said to have yielded plates 8¼ by 18¾ inches, and he reports another prospect near Barker, in Cascade County, where mica of good quality is said to have been found in a "vein" 4 feet thick. In 1944 excellent samples of mica reportedly were received by the Colonial Mica Corporation in Custer, S. Dak., from T. J. Vaughn-Rhys, superintendent of the Faith Mining Co., Hughesville,

[40] Sterrett, D. B., op. cit. (Bull. 740), p. 105.

Mont. The mica deposit is on the San Miguel group of claims, near the town of Monarch, 46 miles southeast of Great Falls. Field work by the Geological Survey was limited to the examination of the mica mines and prospects in the Tobacco Root Mountains in Madison County, which include the Big Chief, Dulea, Montana, Rim Rock, White Swan, and Vetter properties.

PRODUCTION AND RESERVES

All the known production in 1943 and 1944 came from Madison County and probably amounted to less than 1,000 pounds of sheet mica. Small reserves of sheet and punch mica are present on the Big Chief property. Sheet mica can be produced in small quantities from the pegmatites on the Montana and White Swan properties, but the pegmatites on the other properties appear to contain only very small amounts of sheet mica. Except for the Big Chief, all the pegmatites examined are of low grade. None of them could be worked at a profit at ordinary sheet-mica prices. The area of the Tobacco Root Mountains has not been thoroughly prospected for mica and beryl. Geologically the area is favorable, and there is the possibility that workable deposits can be found.

MICA IN THE TOBACCO ROOT MOUNTAINS, MADISON COUNTY

LOCATION AND ACCESSIBILITY

The Tobacco Root Mountains lie in Madison County about 40 miles southeast of Butte. (See fig. 19.) The range forms the divide between the Madison River on the east and the Ruby and Jefferson Rivers on the west. The principal nearby towns are Sheridan, on the Ruby River; Ennis, on the Madison River; and Virginia City, an old placer gold town.

The Northern Pacific Railway and the Chicago, Milwaukee, St. Paul and Pacific Railroad pass close to the northern limit of the range. State highways and branch lines of the Northern Pacific follow the valleys lying east and west of the range, and a transmountain highway, running between Ennis and Alder, passes through Virginia City. Dirt roads and trails follow many of the small mountain streams that drain the area.

GEOLOGY

The Tobacco Root Mountains are underlain by metamorphic and igneous rocks of the Pony series, Cherry Creek series, and Belt series, of pre-Cambrian age; by sedimentary rocks of Paleozoic and Mesozoic age; and by Cretaceous and Tertiary intrusive and extrusive rocks. All the pegmatites examined lie in the Cherry Creek series, a typical section of which consists of

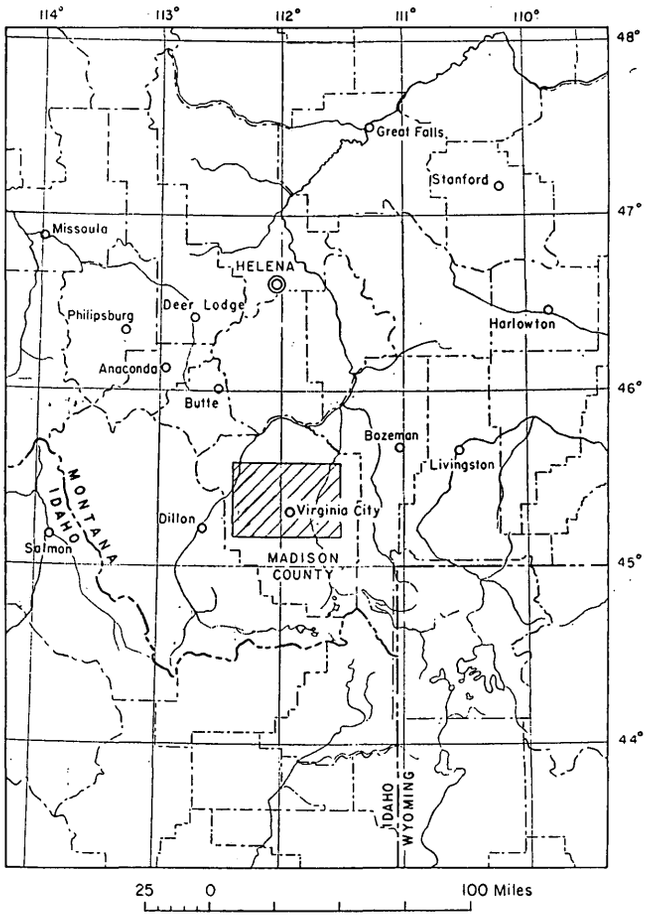


FIGURE 19.—Map of western Montana showing location of mica area in the Tobacco Root Mountains, Madison County, Mont.

quartz-feldspar gneiss, quartz-mica schist, crystalline limestone, quartzite, and hornblende-biotite schist.[41]

PEGMATITES

Many hundreds of pegmatites crop out in the metamorphic terrain of the Tobacco Root Mountains, but probably few of them have been thoroughly explored. The White Swan, Montana, Dulea, and Big Chief properties have been mined on a small scale, and the Rim Rock, Vetter, Trail-Moran, and Todd properties, and a few other localities have been prospected. (See fig. 20.)

A few of the many dikes cropping out near the road between Ennis and Virginia City were briefly inspected during the field work. They contain microcline and quartz but lack appreciable quantities of muscovite and plagioclase. The pegmatites elsewhere, which were examined in more detail and which have been prospected or mined for mica, consist of microcline, quartz, plagioclase, and muscovite, with minor amounts of black

[41] Tansley, W., Schaefer, P. A., and Hart, L. H., A geological reconnaissance of the Tobacco Root Mountains, Madison County, Mont.: Montana Bur. Mines and Geology Mem., 9, p. 9 and pl. 1, 1933.

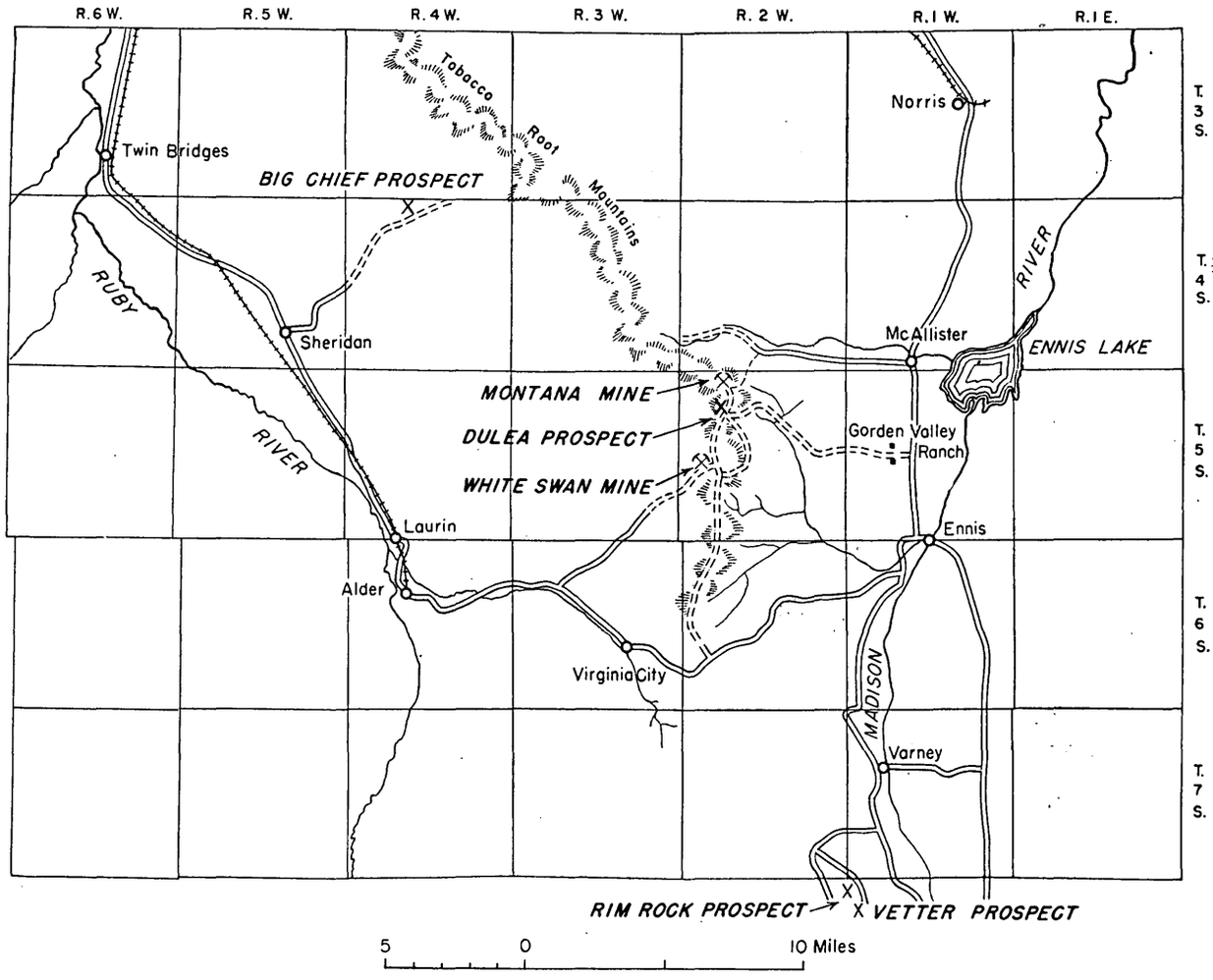


FIGURE 20.—Map showing location of mica mines and prospects in the Tobacco Root Mountains, Madison County, Mont.

tourmaline and biotite. A few small crystals of green beryl have been found in the Big Chief mine and in one or more of the White Swan pegmatites. The proportions of the principal minerals in the mica-pegmatites are varied. In some deposits there is more microcline than plagioclase, and in other deposits the opposite is true. Some pegmatites are distinctly zoned, but in others the zoning is ill-defined.

Some of the microcline is visibly perthitic. The plagioclase is oligoclase; its composition, as judged from three samples, ranges from Ab_{77} to Ab_{88}. White coarse-grained quartz forms massive practically monomineralic zones within some of the pegmatites. Quartz of white or gray color, in part translucent, occurs as small blebs and irregular masses intergrown with feldspar.

The sheet mica ranges from red-ruby and rum to colorless. Much of it appears streaked or mottled owing to the differently colored areas within a single sheet. It lies in association with plagioclase, with quartz, and with mixtures of plagioclase, microcline, and quartz. Mica of greenish or brownish color, some of it exhibiting black stains, is present in some deposits and is associated with plagioclase. Mica containing clear sheets is probably more abundant than that containing stained sheets.

The pegmatites are mostly lenticular. Some lenses are thick and blunt and others are slender. In some places apophyses of pegmatite project outward from the main body of a lens into the country rock. The pegmatites are as long as 220 feet and as wide as 65 feet. Most of them cut across the bedding or schistosity of the enclosing rocks, but some lie concordantly with the wall rocks. A few pegmatites, including those on the Big Chief property, appear to be small plunging pipelike bodies, or groups of parallel, connected pipes.

CONDITIONS AFFECTING MINING

Difficult access is a serious economic drawback to mica mining in the Tobacco Root Mountains. The deposits that were examined lie at altitudes between 5,500 and

8,500 feet. From October to April the higher ones are snow-covered and the mountain roads are usually impassable to automobile travel. During even the best weather many of the roads are quite poor. One of the properties examined, the Big Chief, is about a mile from the nearest road; access is gained by a steep and tortuous trail. The remoteness of the district from supply centers and from the main commercial buying centers for mica imposes relatively large transportation charges on producers. Timber and water lie within short hauling distance of most of the deposits examined.

BIG CHIEF PROSPECT

The Big Chief prospect is on the west slope of the Tobacco Root Mountains 5 miles northeast of Sheridan. It is in unsurveyed sec. 4 or 5, T. 4 S., R. 4 W., Montana principal meridian, on Indian Creek, a southwestward-flowing tributary of the Ruby River. The property is owned by Ivan Winslow, of Sheridan. During 1943–44 the owner mined, rifted, and trimmed a small quantity of high-quality sheet mica, which was sold to the Colonial Mica Corporation in Custer, S. Dak. One shipment reportedly contained more than 90 percent of sheets of No. 1 and No. 2 qualities.

The prospect is reached by the Indian Creek road and by a trail ascending the northwest valley wall for about 1¼ miles. The workings are 1,140 feet above the valley floor. The pegmatites crop out on a small steep, rugged promontory jutting from the steep slope of the valley wall. The promontory, about 100 feet long, is composed of mica gneiss, but the main valley wall immediately up slope from the top of the promontory is composed of coarse hornblende-feldspar gneiss. The local topography and the change in the rock suggest that a steep eastward- or northeastward-trending fault cuts across the base of the promontory and separates the mica gneiss with its enclosed pegmatites from the hornblende gneiss that forms the main slope of the valley wall. Such a fault would closely limit the area in which extensions of the main pegmatite might be found.

Five pegmatites, from 4 to 55 feet long and 3 to 15 feet wide, are enclosed in fine-grained quartz-biotite-garnet gneiss. The gneiss strikes about north and dips steeply west but locally is greatly contorted. At most points the pegmatites are parallel to the foliation. The largest pegmatite crops out on the point of the promontary about 60 feet below the top. It is traceable for about 55 feet and is 5 to 15 feet wide. The only working is an open cut 9 feet long, 5 feet wide, and 7 feet deep. (See fig. 21.) Only the main body contains appreciable quantities of sheet mica. It appears to be a group of connected, parallel pipes plunging N. 25° E. at low angles. In the open cut it is offset by a small

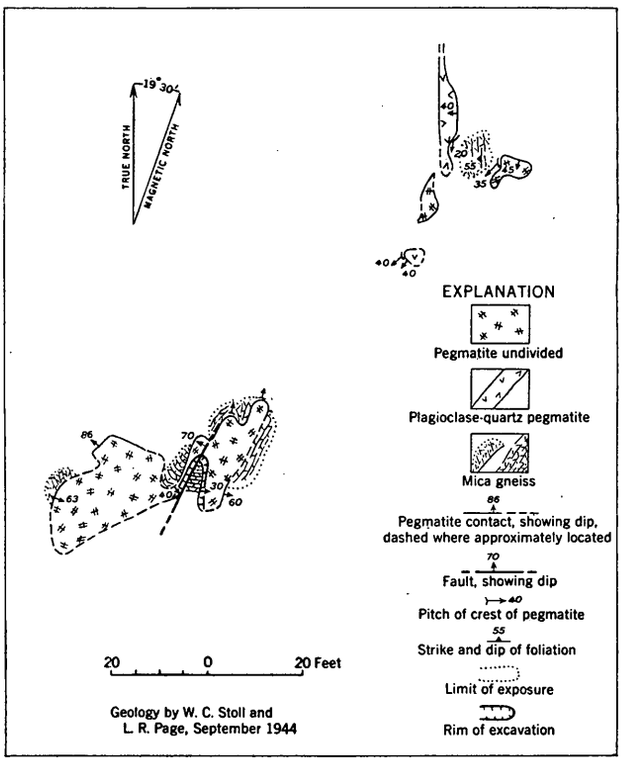


FIGURE 21.—Sketch map of the Big Chief prospect, Madison County, Mont.

normal fault. The other four pegmatites crop out on the northeast side of the promontory, 70 feet from the open cut. They plunge 20° to 40° to the southwest.

The pegmatite minerals are quartz, plagioclase, muscovite, beryl, schorl, biotite, and apatite. Green copper stains are present. Gray to white quartz forms blebs and pods more than 12 inches across, containing rum mica books. Clusters of flakes and tiny books of pale brownish-green to white mica and books of biotite are associated with plagioclase.

For several feet on each side of the open cut, books of rum mica are present in abundance, and other books are more sparsely scattered throughout the main pegmatite. The richer spots may contain as much as 10 percent book mica, but the outcrop as a whole shows about 2 percent. The mica is flat, hard, and free of inclusions. Sheets as large as 4 by 6 inches have been produced, but most books are a quarter of an inch to 3 inches in diameter.

A few small euhedral beryl crystals of gray-green to white color have been recovered. Some of the plagioclase is pale greenish-blue and may be mistaken for beryl.

DULEA PROSPECT

The Dulea prospect is on the East Fork of Granite Creek, several miles above the White Swan mine. Jack Dulea, of Virginia City, located the claim in 1941.

Small-scale open-pit mining was carried on during parts of 1942 and 1943, and $55 worth of mica reportedly was sold to the Colonial Mica Corp. The prospect consists of a single dike, striking northwestward and dipping steeply, opened by a pit 10 feet deep and about 12 by 15 feet in plan. Muscovite books of inferior quality are sparsely distributed in coarse feldspar-quartz pegmatite. The books are colorless to olive; many of them show streaked black and green stains or black dots of mineral inclusions. Sheets, chiefly of No. 3 quality, could be cut from part of the crude mica.

MONTANA MINE

The Montana mine is in and near the east boundary of sec. 5, T. 5 S., R. 2 W., Montana principal meridian. The owner is Dr. M. I. Meeker, of Pocatello, Idaho. Reportedly the main pegmatite was first opened by a shaft some 40 years ago and "two wagonloads" of mica were taken out. In 1928 the ground was relocated by Red Sheldon, and the shaft may have been deepened at that time. Dr. Meeker relocated it in 1939. In 1942 a prospector by the name of Howlett dug the open cut by hand. He is reported to have removed about 1,500 pounds of rifted, untrimmed mica of good quality. The mine was idle in 1944, but the Bureau of Mines trenched the main pegmatite and several others during the summer.

The mine is in open pine forest at an elevation near 7,500 feet, a few miles north of the White Swan and Dulea properties. It is accessible by the steep South Meadow Creek road starting at McAllister and by the Granite Creek road, branching north from route 34, about 3 miles northwest of Virginia City.

The workings consist of a vertical shaft 33 feet deep, with two small drifts; an open pit 10 feet deep, on the same pegmatite as that exposed in the shaft; and small prospect pits and angledozer trenches on other pegmatites northeast and south of the main one. Only the principal workings are shown in figure 22.

The main pegmatite is incompletely exposed. The strike is roughly northwest, and the average dip is about 45° SW. The maximum thickness is probably about 16 feet. In the open cut and shaft the pegmatite is principally a mixture of coarse plagioclase (oligoclase, Ab_{88}) and coarse microcline, both of pale buff color, and coarse white to translucent quartz, some of which occurs as massive segregations several feet across. Biotite is present in the deposit, mostly adjacent to the hanging wall, and in joints cutting pegmatite, where it is associated with muscovite. Biotite books as large as 6 by 8 inches across are present. Very little sheet mica was seen. Some flat clear ruby books, 1 inch in diameter, are embedded in blocky plagioclase, and small books ranging from a quarter of an inch to half an inch across lie at all angles as clusters embedded in quartz. Several large books of good quality were reportedly recovered during prospecting in 1944.

The wall rock exposed in the workings is coarse-grained dark-colored gneiss, composed of dark-green

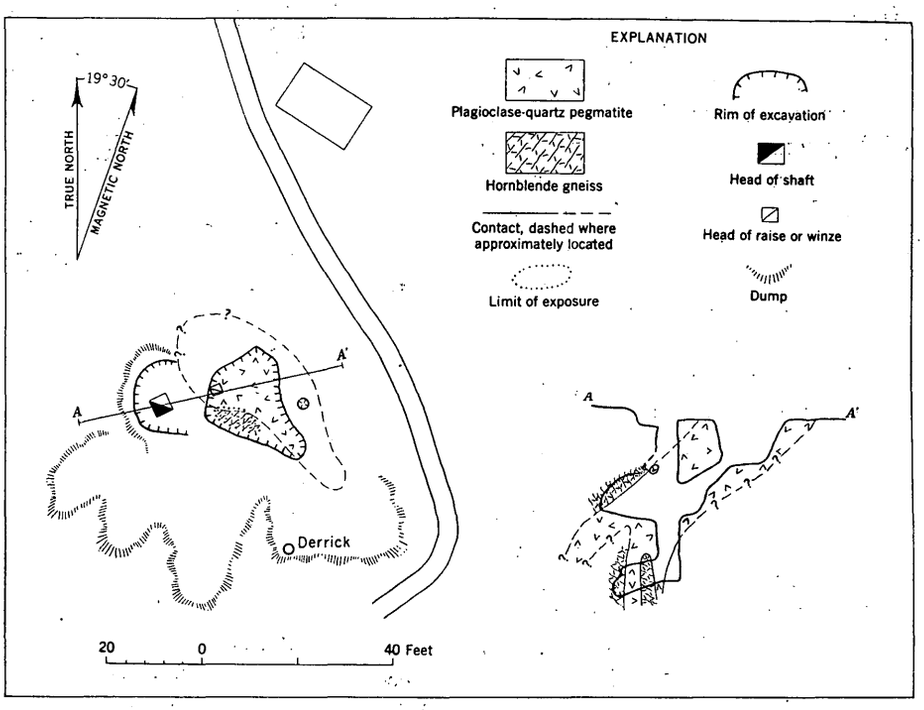


FIGURE 22.—Map and section of the Montana mine, Madison County, Mont.

hornblende, brownish-red garnet, and quartz. Where adjacent to the pegmatite, the hornblende has been changed to biotite. The walls of the pegmatite transect the indistinct foliation.

Several small northeastward-striking pegmatites, cropping out 200 feet south of the open pit, were trenched by the Bureau of Mines. They consist largely of buff-colored feldspar and massive white quartz. Biotite and small flakes and books of muscovite are scantily distributed in the feldspar. The largest muscovite book seen was 2 by 2 inches.

Several hundred feet northeast of the open pit a trench cut by the Bureau of Mines exposes a pegmatite 8 feet wide striking about due west. The dike includes a quartz core 2 to 3 feet thick and a wall zone consisting of white and gray feldspar, gray quartz, and scattered books of pale-green mica.

One hundred feet farther east is a second similar dike striking N. 87° W. At one place it includes a quartz core 4½ feet thick and a wall zone 1½ to 2 feet thick consisting of plagioclase, quartz, biotite, and small flakes of muscovite. Gneiss containing hornblende and biotite crops out nearby.

A third dike, 200 to 250 feet south of the second, is exposed in another trench. It strikes N. 70° W. for an exposed length of 60 feet. The width is from 3 to more than 5 feet. The quartz core of the pegmatite is narrow and discontinuous. The wall zone, consisting of plagioclase, quartz, muscovite, and biotite, contains books of clear pale-ruby mica as large as 3 by 3 inches lying next to the core.

RIM ROCK PROSPECT

The Rim Rock prospect is in the north part of sec. 6, T. 8 S., R. 1 W., Montana principal meridian. It is held under location by Ernest Vetter, of Ennis, and several partners, who performed a little prospecting work during the 3 or 4 years preceding 1944. The claim is about 20 miles by road from Ennis and is approached through Varney, on the west side of the Madison River. The pegmatite crops out on the southwest slope of a limestone knoll that forms a rounded promotory in the middle part of the north side of a broad tributary valley descending eastward to the Madison River.

In outcrop the pegmatite is crudely elliptical and elongate in a northeasterly direction, with apophyses projecting from the main body into the wall rocks. (See fig. 23.) It is exposed for a length of 220 feet and its width ranges from 3 feet, near the northeast end, to 65 feet at the middle. At the top of the knoll the pegmatite pinches out. To the southwest, in a small transverse gully, it is cut off by a fault. The body is exposed through a vertical range of 55 feet.

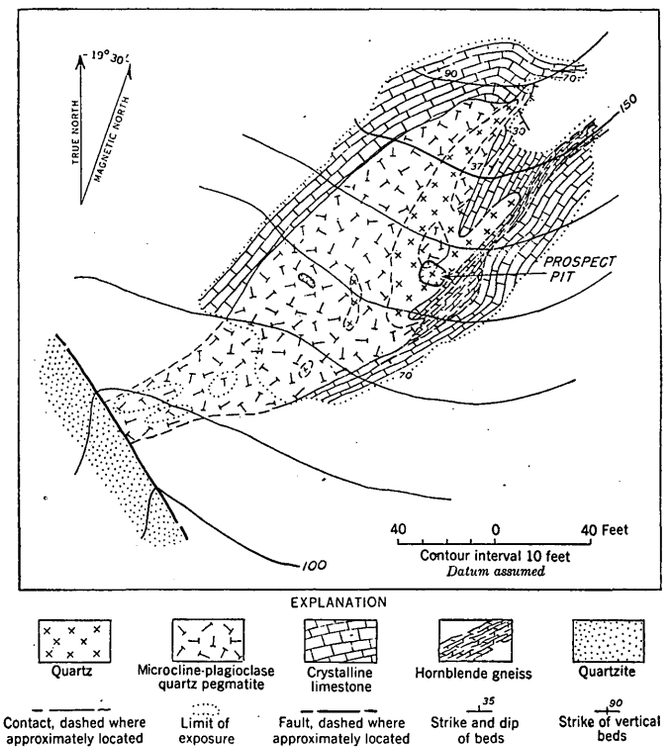


FIGURE 23.—Map of Rim Rock prospect, Madison County, Mont.

The pegmatite minerals are microcline, plagioclase (Ab_{77}), quartz, schorl, muscovite, and biotite. The core consists of coarse massive white quartz, with minor quantities of pink microcline and schorl. A second zone consists of an irregular mixture of white plagioclase, pink microcline, and light-gray to white glassy quartz, with scattered silvery muscovite flakes, schorl crystals, and books of biotite.

A few books of clear sheet-bearing mica, as much as 2 inches in diameter, were seen in an area of several square feet near a shallow prospect cut a few feet west of the discovery monument. Several pounds of sheet-bearing mica were removed during prospecting, but none was sold. It is a red-ruby mica and is hard, flat, and clear. A notable pecularity is the presence of areas of colorless mica forming streaks and irregular mottlings against the ruby background. Scales of muscovite, mixed with feldspar, and a few small books were seen at other parts of the outcrop, but the average sheet mica content of the pegmatite appears to be very low.

The pegmatite lies in crystalline limestone except adjacent to the fault at the southwest end, where it adjoins reddish-brown thin-bedded quartzite. The limestone is white, buff, or light gray on fresh surfaces, and brown where weathered. Where adjacent to the pegmatite it contains small green fibrous crystals of actinolite. Thin discontinuous layers of black hornblende-feldspar-garnet gneiss are interbedded with the

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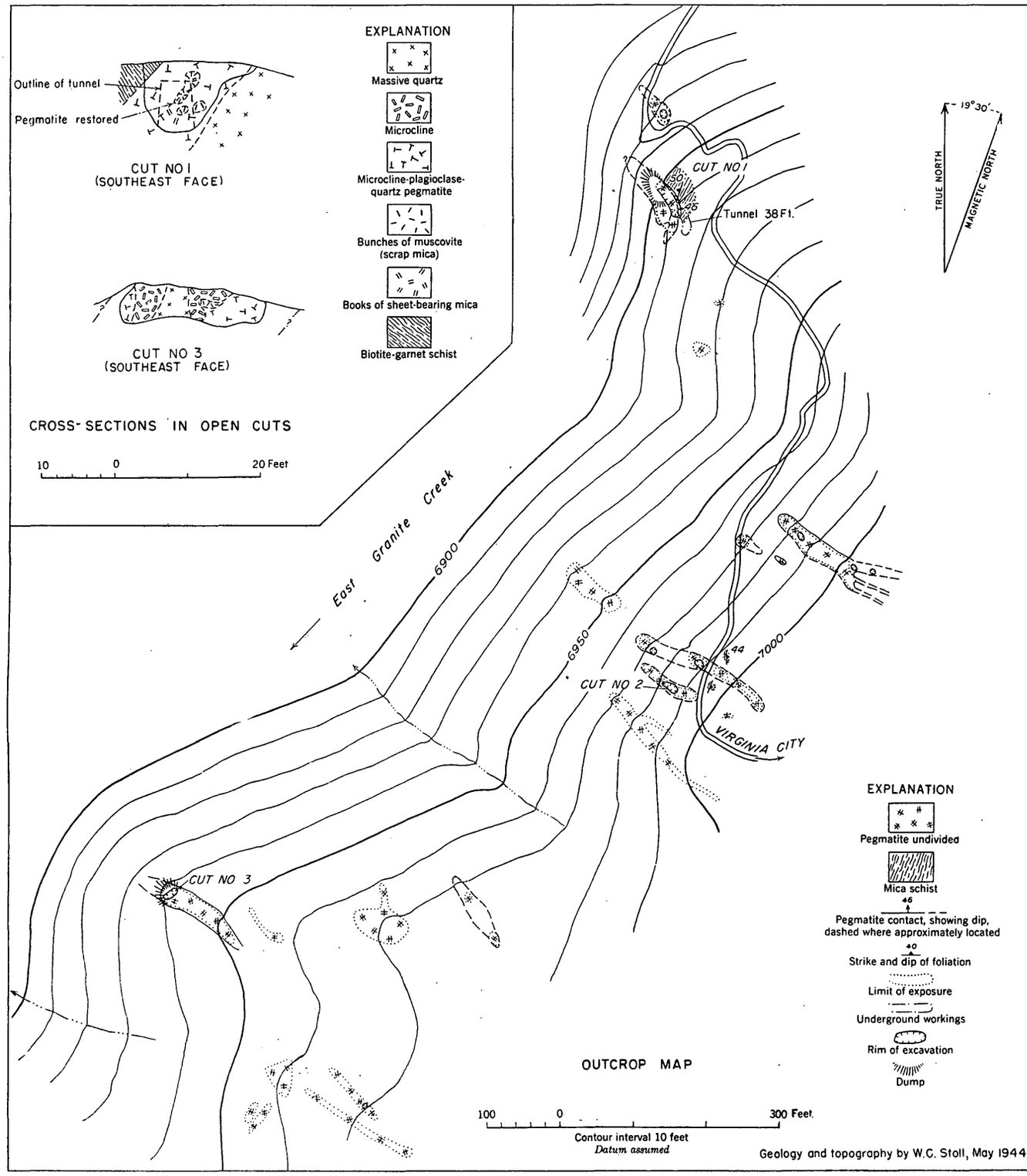

FIGURE 24.—Map and cross sections of White Swan mica mine, Madison County, Mont.

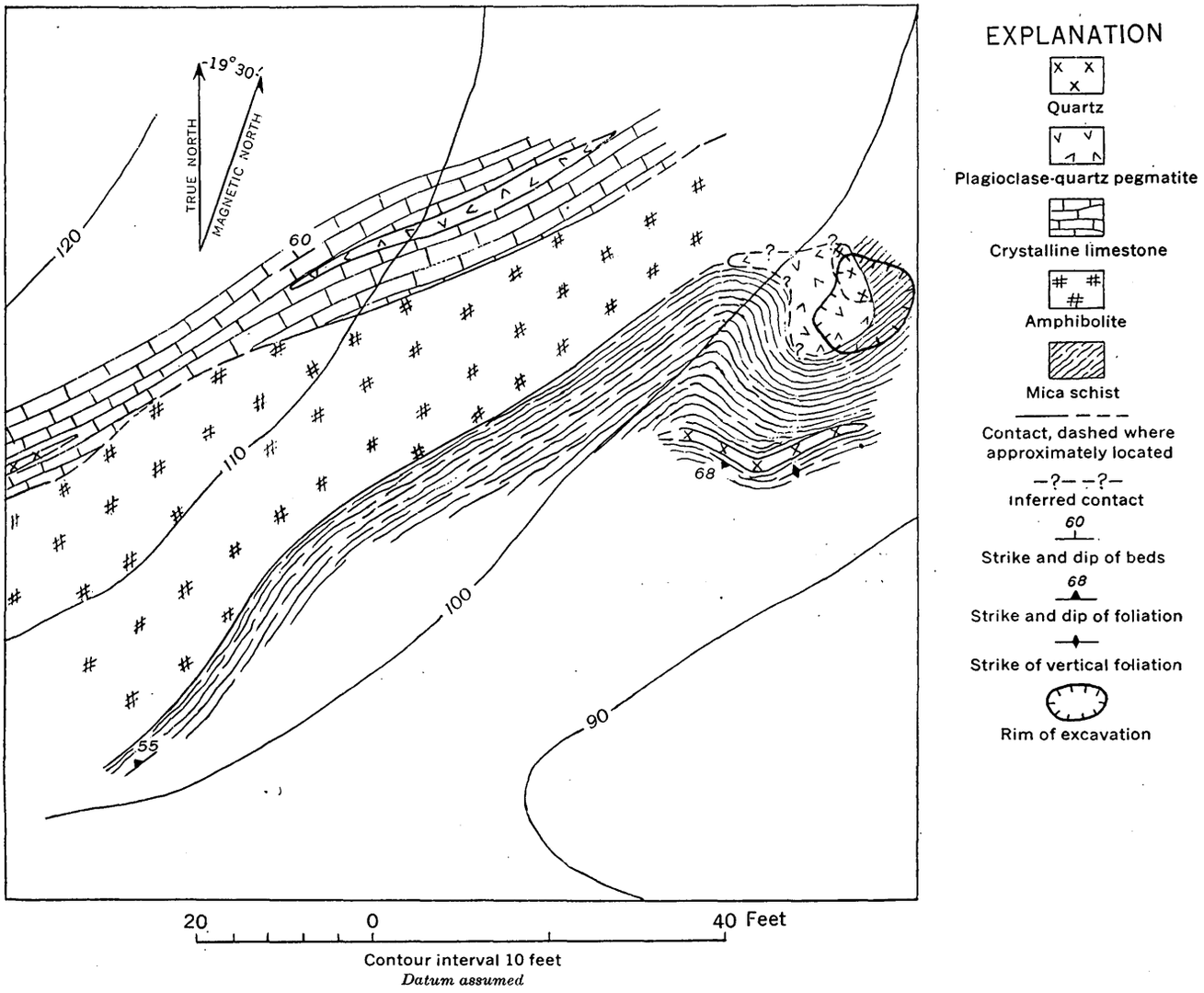

FIGURE 25.—Map of Vetter prospect, Madison County, Mont.

limestone. The beds strike north of east and dip moderately to steeply southward.

Within a few hundred yards to the east of the main body are other smaller pegmatites of similar composition. No noteworthy concentrations of mica were seen in them.

WHITE SWAN MINE

The White Swan group, (fig. 24) comprising two claims located on Taylor grazing land, is in sec. 19, T. 5 S., R. 2 W., Montana principal meridian, on the East Fork of Granite Creek. The mine is reached by way of the Granite Creek Road, which branches northward from route 34 about 3 miles northwest of Virginia City. The road is rough in many places and is passable in wet weather only with difficulty.

Some of the pegmatites on what is now the White Swan property were prospected in the 1870's by gold miners from Virginia City. In 1941, Charles W. Scott, of Butte, Mont., staked the ground. During 6 weeks in the fall of 1943 he obtained a small quantity of sheet mica. The operation was resumed between May and August 1944, and during this period the Bureau of Mines trenched the pegmatites.

At least a dozen pegmatites crop out as low northwestward-trending knolls and narrow ribs a few feet high. The pegmatites are lenses with irregular offshoots. They are from a few yards to 200 feet long and from a foot to 30 feet wide in biotite-garnet schist and quartz-garnet rock.

The pegmatite minerals include microcline-perthite, plagioclase (Ab_{85}), quartz, muscovite, biotite, and black tourmaline. Some pegmatites contain cores of massive white quartz. Sheet mica was produced from three open cuts and a 38-foot tunnel which were excavated in three pegmatites. The average grade of the deposits is

low. The pegmatite excavated in cut No. 1 contained an estimated 0.4 pound of sheet mica per ton.

Most of the mining was done in cut No. 1 and the tunnel, which are on the hanging-wall part of the wall zone of a pegmatite about 25 feet thick. The hanging-wall contact strikes N. 23° W. and dips 46° NE. The foliation of the enclosing biotite-garnet schist strikes N. 23° E. and dips 50° NW. The core of the pegmatite is massive white quartz. The wall zone is 6 to 10 feet thick along the hanging wall. It contains muscovite books from half an inch to 5 inches across lying in plagioclase and in feldspar-quartz mixtures. Within a few feet of the surface the muscovite is heavily clay-stained. Many books are reeved, but sheets can be cut from the centers of some reeved books. Some sheets are rum-colored, others are colorless, and some show a crisscross pattern or a banding of rum areas on a colorless background, and vice versa.

VETTER PROSPECT

The Vetter prospect (fig. 25) lies in the S½ sec. 6, T. 8 S., R. 1 W., Montana principal meridian, about half a mile south of the Rim Rock prospect. Ernest Vetter, of Ennis, dug a prospect pit on a small showing of pegmatite and removed a small quantity of mica between 1940 and 1944.

Four small bodies of pegmatite crop out within an area of 200 square yards underlain by northeastward-striking and northwestward-dipping beds of limestone, amphibolite, and biotite schist and gneiss. Three of the pegmatites are narrow lenses up to 40 feet long, lying parallel to the bedding or schistosity of the enclosing rocks. The fourth pegmatite, incompletely exposed in the prospect pit, may possibly be a small pipe-like body. The pegmatites are composed of massive quartz and of mixtures of quartz, plagioclase, and muscovite flakes. A few feet south of the prospect pit a small rich pocket of high-quality mica is present in one of the narrow lenses. The mica is red-ruby, flat, and hard, but most of it is too small to yield sheets. Aside from the pocket, very little book mica was seen in the pegmatites.

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