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MICA DEPOSITS OF THE UNITED STATES

BY

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MICA DEPOSITS OF THE UNITED STATES.

By DOUGLAS B. STERRETT.

INTRODUCTION.

Material for this report has been gathered at different times during the last 20 years, chiefly under the direction of the United States Geological Survey, but a large part of the work in North Carolina was done under the auspices of the North Carolina Geological and Economic Survey. Much of the earlier field work was done in connection with other geologic investigations; not as a consecutive study of the mica deposits. This is unfortunate, for it has not been possible to revisit some of the mines examined, which have since been considerably developed.

Several preliminary reports on the occurrence of mica in certain States have been published by the United States Geological Survey, and a few descriptions of mines and general information on mica have appeared in the annual reports on the Mineral Resources of the United States. Parts of these reports have been reprinted in this volume, with revision where necessary, and general information has also been freely abstracted from them. The writer has tried to give proper credit to other authors for their work. Thus the reports of E. S. Bastin and S. H. Ball are used in the description of mica deposits of Maine and Wyoming, respectively, for the writer has done practically no field work on mica in those States. Bastin's report on feldspar has also furnished sources of information regarding mica in Connecticut, New York, and Pennsylvania. Only a few mica deposits in Georgia have been visited by the writer, and the rest of the information on deposits in Georgia has been abstracted from a State report on the feldspar and mica deposits of Georgia by S. L. Galpin. These reports and others are entered in the following bibliography.

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GEOLOGY.

GENERAL FEATURES.

Mica is a very common mineral and occurs in igneous, sedimentary, and metamorphic rocks, usually as small scattered scales, though some rocks are composed almost entirely of mica. Large crystals of muscovite and biotite, the two most common forms of mica, are found in pegmatite (a coarse-textured igneous rock) and large crystals of phlogopite, a less common form, are found in pyroxenic rocks. As muscovite and a little biotite are the only forms of mica found in commercial sizes in the United States pegmatite will receive special attention in this report.

Mica-bearing pegmatites are confined to areas of crystalline rocks, especially ancient metamorphic rocks. The absence of areas of such rocks in any region indicates the absence of valuable deposits of mica, but, on the other hand, their presence does not indicate the presence of mica; it only indicates that mica may be found in them.

A study of the geologic map of North America[1] shows that deposits of mica may occur in the following regions of the United States: The eastern Appalachian region from Alabama to New York and the New England States; northern Wisconsin, Michigan, and Minnesota and the region including corners of Minnesota and Iowa and part of South Dakota; southeastern Missouri; the Black Hills of South Dakota; the Rocky Mountain region from New Mexico to Montana; and many smaller more or less isolated areas in nearly all the Western States from Texas to California and Washington. The same map shows large areas in which a mantle of younger sedimentary rocks that ranges in thickness from hundreds to thousands of feet covers the older crystalline rocks, and in which, accordingly, mica deposits are not likely to be found.

The crystalline rocks, composed of metamorphosed sedimentary rocks and granitoid intrusions, were formed at least 5,000 feet below the surface and probably at much greater depth. The pegmatites, which are generally composed of shoots from granitic rocks, are also supposed to have been formed deep in the earth's crust. These rocks accordingly are now found in regions where erosion has been sufficiently prolonged to remove the overlying unmetamorphosed formations and to expose the crystalline rocks and the mica-bearing pegmatites.

The crystalline gneisses and schists have received their texture and composition either from regional metamorphism or from contact or injection metamorphism or both.

[1] Willis, Bailey, and Stose, G. W., Geologic map of North America: U. S. Geol. Survey, 1911.

Regional metamorphism in general has produced foliated rocks that do not contain large quantities of granite or feldspathic material, such as ordinary mica, quartz-mica, garnet, and kyanite gneisses and schists. Contact or injection metamorphism has produced considerable feldspathic material in gneisses and schists. This material consists in some places of granite, in others of pegmatite, and in still others of intermediate phases of rock. In a few places there is less feldspar and much quartz and mica. This granite or pegmatitic material has been injected into the gneisses and schists, cutting them both parallel to and across the bedding. In places this pegmatization is so thorough that mica gneisses become strikingly like granite gneisses.

PEGMATITE.

OCCURRENCE.

A discussion of the occurrence of muscovite mica means practically a discussion of the occurence of pegmatite, for mica is found in a great many types of this rock. Pegmatite occurs as intrusions of bulky masses, in veinlike or dikelike sheets, in lenses, and in various irregular-shaped deposits. The deposits range in thickness from a small fraction of an inch to more than 200 feet. The larger masses resemble granitic intrusions. Some of the smaller deposits are more like veins.

Many of the more persistent pegmatites occupy straight fissures that hold their direction for long distances; others are folded with the country rock or bent and twisted into various shapes. Some are more or less conformable with the bedding of the gneisses and schists and are therefore subject to the deformation of the country rock. Some large deposits cut across the foliation of the country rock and send out forks or apophyses conformable with strata of the inclosing gneiss or schist. In some deposits parallel and overlapping sheets and lenses of pegmatite conformable with the foliation of the country rock are common. Smaller beds or veins of pegmatite may cut across the strata and connect larger deposits. Locally there may be an elbowing or bulging out on one wall of the pegmatite but no similar irregularity on the other wall. Lens-shaped bodies may lie in the same plane of bedding or schistosity and be connected by smaller streaks or stringers of pegmatite or by mere seams in the rock.

The irregularities of pegmatite and the consequent difficulties in mining mica from it are well illustrated in clean rock exposures, cuts, or quarry faces where pegmatized gneiss or schist has been exposed. The lenticular shapes, pinching and swelling, crumpling, forking,

folding, and faulting seen at such places are nearly duplicated in some of the larger deposits of pegmatites opened for mica. Such small bodies of pegmatite may grade into larger ones that contain mica of commercial value. Occasionally the two can be seen at the same locality.

The minimum size of pegmatite deposits that can be profitably worked for mica can not be definitely stated. A deposit measuring only 2 feet across may be worked if it is rich, regular, and continuous for a long distance. It seldom pays to remove all the pegmatite from a deposit that is more than 25 feet thick to obtain mica alone. but if the deposit is worked for other minerals also, such as feldspar or gems, mining for mica may be profitable.

Horses, or inclusions of wall rock, are common in pegmatite. Some of them form bands or sheets parallel to the walls, and the schistosity of the bands is also parallel to the walls. They range in thickness from an inch or two up to several feet, and their length may be many times their width. Others occur as irregular-shaped masses, from a few inches to several feet in thickness. If the bedding has been preserved it may lie at any angle with that of the inclosing wall rock. In some places the horses are partly pegmatized by ramifying streaks of pegmatite and by the development of considerable feldspar and quartz. In such places no sharp line can be drawn between the pegmatite and the original horse.

In pegmatite, as in granite, the essential constituents are feldspar and quartz, which are accompanied by mica and other accessory minerals.

Hornblende is rather common in granite but is less so in pegmatite. Orthoclase and microcline are the most common varieties of feldspar in pegmatite. In many places, however, a variety of plagioclase, either albite or oligoclase, makes up part or all of the feldspar. The feldspar occurs in masses and rough crystals, some of which have a diameter of several feet.

Quartz assumes various forms and positions in the pegmatite. In many places it bears much the same relation to the feldspar and mica as in granite, the three minerals being thoroughly mixed with one another; but the individual grains are many times larger than in ordinary granite. Not uncommonly the quartz and feldspar assume the texture of a graphic granite in a part of the pegmatite. Another common feature is the occurrence of large separate masses of quartz in various positions in the pegmatite. Such masses may be irregular in form and may be but little influenced by the shape of the pegmatite or the inclosing wall. Many of them, however, lie in bands or sheets parallel to the walls, and one or more of these quartz bands may constitute varying proportions of the pegmatite.

Their thickness ranges from a fraction of an inch up to 6 feet or more. Many of them are lenticular, their length ranging from four or five to twenty or more times their thickness. At many places these quartz streaks or veins are persistent through the whole length of the pegmatite exposed. Some of them inclose bodies of feldspar or mica; others do not. The quartz of these segregations is massive and generally granular, though at some places it may be crystallized. If crystallized, it may be translucent or clear and of a dark smoky or light color. It is generally rather pure and does not contain much feldspar or mica.

Some masses of pegmatite contain large bodies of graphic intergrowths of potash feldspar and quartz, which form what is called "graphic granite." (See Pl. I.)[2] "Graphic granite" is abundant in pegmatites that are mined for feldspar and gem minerals but is not plentiful in the pegmatites that are of greatest value for mica.

Muscovite is the most common mica in pegmatite and is the principal variety mined in the United States. Biotite occurs in moderate quantity in a few deposits and in smaller quantity in many others. Where muscovite and biotite occur together in a deposit the muscovite is generally clear and of good color. Again, mica from deposits in rocks that contain abundant ferromagnesian minerals, such as hornblende or biotite gneiss and schist, is generally clear and of light color. Mica from pegmatite in granite or closely associated with it, with few ferromagnesian minerals, is generally dark, and much of it is "specked."

Mica occupies various positions in pegmatite. If the rock has a typical granitic texture the mica may be evenly distributed through it, but more commonly the larger crystals are either clustered at intervals through the "vein," in places connected by streaks of small crystals, or are collected along one or both walls of the pegmatite, some of the crystals being partly embedded in the wall rock. If there is a quartz streak in the pegmatite the mica occurs on either or both sides of it. The mica may be partly embedded in the quartz or be scattered through the remaining portion of the pegmatite, which generally is composed largely of feldspar.

The proportion of mica to the other minerals of the pegmatite is variable, ranging from less than 1 per cent to possibly more than 10 per cent, with local enrichments where the mica may compose more than 50 per cent of the "vein" for short distances. All the mica of the pegmatite is not suitable for splitting into sheets. In some deposits the mica occurs in aggregations or bunches such as "mica capping" and "solid" mica. "Mica capping" is a miner's term

[2] Bastin, E. S., Geology of the pegmatites and associated rocks of Maine: U. S. Geol. Survey Bull. 445, pl. 7, 1911.

for an aggregation of mica and quartz, with or without feldspar and other minerals, in which the mica is small or occurs in distorted crystals so as to be of little commercial value. The mica does not invariably form a capping to a regular "vein" below or near by, for some such deposits carry nothing but "mica capping." The mica of "mica capping" commonly occurs in "wedge" shaped blocks with A structure, in many places is more or less distorted or twisted, and may contain inclusions of quartz. Plate II, *A*, shows a block of "mica capping."

Aggregations consisting wholly or almost wholly of mica crystals occur in some of the pegmatites. Some of these masses measure several feet across. The crystals composing such massive mica range from a small fraction of an inch to 2 inches or more in diameter and thickness. Massive mica generally occurs in irregular-shaped bodies without definite arrangement in the pegmatite. A mass of large mica crystals, of the "solid" mica variety, is shown in Plate II, *B*.[3]

A large number of valuable minerals have been found in the pegmatite deposits of the United States. Some of these minerals are valuable for commercial use or as specimens; others are of interest only because they show one of the modes of their occurrence. The minerals of chief value in most of the pegmatite mined are feldspar and mica, but quartz also is sometimes saved. Some bodies of pegmatite contain gem minerals, such as beryl (emerald, blue and golden beryl, aquamarine, etc.), tourmaline (of various colors), spodumene (hiddenite and kunzite), garnet (almandite and spessartite), topaz, quartz (crystal, smoky, amethyst, colorless, and rose), amazonstone, and moonstone. Among the commercial minerals, besides mica are cassiterite (tin ore), amblygonite, lepidolite, graphite, zircon, monazite, and a number of rare-earth minerals. Other valuable minerals found in pegmatite mined for mica are beryl, amazon stone, moonstone, uranium minerals, and mineral specimens,

GENESIS.

The origin of pegmatites has been a subject of much discussion. Some geologists contend that all pegmatites were formed by intrusions of igneous magmas; others, that they were vein deposits. Many now believe that they have been formed by both processes, one mode of formation grading into the other, and the possibility that there has been such a gradation will become more evident after the conditions producing pegmatite magmas or solutions have been considered.

Pegmatitic magmas and solutions, which are believed to represent the final stages of solidification of masses of granite magma, have been

[3] Bastin, E. S., op. cit., pl. 9.

formed by the accumulation of water vapor and other mineralizing solutions or gases in parts of the still molten magma. This accumulation is caused by the occlusion of these vapors from the anyhydrous minerals that are crystallizing out of the magma. The proportion of vapors to other mineral matter in solution increases as crystallization proceeds, and the remaining magma becomes more fluid through the presence of the vapors. In this way the highly fluid magma or solution accumulates in large quantities within the granite masses. When these partly solidified granite masses are fractured by earth movement this highly fluid aqueo-igneous material is forced out through the fractures in the granite mass into the surrounding country rock. Some parts of this material remain in the fractured planes and crystallize out as intrusive pegmatite. Other parts travel through the fractured zones depositing vein material. Such minerals as mica and feldspar crystallize out from these magmatic solutions and leave an increased proportion of mineralizing fluid and vapors to accompany the silica still in solution. The silica is then carried beyond the zone in which the pegmatite is deposited and forms quartz veins.

The above outline of the method of forming pegmatite agrees well with facts observed. Pegmatite deposits that fill fractures in the parent granite mass and deposits in the country rock near such a mass are highly feldspathic and resemble dikes. Pegmatite deposits farther away from the granite mass contain a proportion of quartz segregations that increases with distance from the mass, and these segregations tend to assume veinlike forms within the pegmatite. At a still greater distance less mica and feldspar appear and the deposits grade into ordinary quartz veins.

The blending between the conditions of fusion and solution conceived to exist under heat and pressure, such as prevail in deeply buried granite magmas where water is present in considerable quantity, has been well set forth by Van Hise,[4] Crosby and Fuller,[5] and Williams.[6] As stated by Van Hise, given the two conditions, a magma and a solution with no sharp line of demarcation between them, we may expect to have injections of dikes and aqueous cementation, which grade into each other and between which no sharp distinction can be drawn.

It is difficult to conceive that pegmatite may be formed by injection into gneissic rocks, as an ordinary magma, in streaks or bands a fraction of an inch thick in many places having no visible connection with other bodies of pegmatite. On the other hand, it is easy to conceive that a solution might be forced through the smallest

[4] Van Hise, C. R., A treatise on metamorphism: U. S. Geol. Survey Mon. 47, 1904.
[5] Crosby, W. O., and Fuller, M. L., Origin of pegmatite: Am. Geologist, vol. 19, 1897.
[6] Williams, G. H., General relations of the granitic rocks in the Middle Atlantic Piedmont Plateau: U. S. Geol. Survey Fifteenth Ann. Rept., 1895.

fractures or might work its way between the mineral particles and deposit its load. This process would not require temperatures so high, either in the solution or in the country rock, as those required for the injection of a magma in order that it might not be cooled so quickly as to prevent coarse crystallization. The possibility that the smaller deposits of pegmatite may be formed by the injection of a highly fluid aqueo-igneous magma is not denied, especially if the magma approaches closely the conditions of a solution, but it is thought that the theory of its formation by aqueous processes affords a simpler and therefore more reasonable explanation.

Rock masses are probably pegmatized either by recrystallization due to aqueous agencies or by the addition of more material from solutions passing through the formations. In the first process water occluded in the rock, aided by the heat generated during regional metamorphism, may have caused recrystallization and consequent pegmatitic texture. In the second process pegmatization may have been caused by solutions that were forced through the rock along cracks, seams, or bedding planes and there deposited their load. Where the pegmatized rock contains much feldspar the solutions were probably of magnetic origin, and one generally does not have to look far to find intrusive granite in the neighborhood of a deposit of pegmatite.

It is difficult to decide whether some deposits of pegmatite were formed as dikes or as veins, but the conditions in others clearly point to the one or to the other mode of origin. There seems to be no objection to assuming an intrusive origin for most pegmatites which have a typical granitic texture and in which none of the constituent minerals are separated out into sheetlike masses parallel to the walls, especially those that are more persistent in extent in regions where granite intrusions are large or plentiful. On the other hand, deposits that are banded with veinlike sheets of quartz parallel with the walls, and smaller irregular masses, streaks, lenses, augen, or balls that have no visible connection with other bodies of pegmatite, were probably formed from solutions. Some pegmatites were possibly formed in part by the intrusion of a magma and later modified by the passage of solutions from the same source.

The mica-bearing pegmatites of the United States were probably formed both as intrusions and as veins, and include many intermediate types, but it is not possible to define the types that will be found in any particular region, for more than one type may be found in the same region. E. S. Bastin[7] shows that most of the pegmatites mined for commercial minerals in Maine are of probable intrusive origin. The writer's observations confirm this conclu-

[7] Geology of the pegmatites and associated rocks of Maine, including feldspar, quartz, mica, and gem deposits: U. S. Geol. Survey Bull. 445, 1911.

sion and lead to a similar one regarding the deposits in New Hampshire and Connecticut. The pegmatites mined for mica in South Dakota, however, possess many features of dikes. The deposits of the southern Appalachians present features of both intrusions and dikes, but most of them would probably be classed as intrusions.

MINERALOGY.

COMPOSITION.

The term mica as used in mineralogy includes a number of minerals that have certain physical characteristics in common, but it is applied commercially to only a few of them, which are valuable because of these physical properties. In mineralogy several species of mica are recognized, among them muscovite, phlogopite, biotite, lepidomelane, lepidolite, paragonite, zinnwaldite, and roscoelite. These minerals are aluminum silicates, whose bases include different elements. Muscovite is an orthosilicate of aluminum and potassium; phlogopite contains in addition magnesia and a little fluorine; lepidomelane contains much ferric iron and a little magnesia; biotite contains iron and magnesia; lepidolite is a lithia-bearing and paragonite is a soda-bearing mica corresponding to the potash variety, muscovite; zinnwaldite is a lithia and iron bearing mica; and roscoelite is a vanadium-bearing mica.

These are two groups of micaceous minerals that do not have all the physical properties common to the true micas, especially flexibility and elasticity of the cleavage sheets—the clintonites, or brittle micas, and the chlorites. The clintonites, of which margarite is a typical variety, are characterized by brittle cleavage sheets. The chlorites are greenish from the presence of ferrous iron and are generally characterized by inelastic cleavage plates.

CRYSTALLOGRAPHY.

The micas have generally been regarded as belonging to the monoclinic system, with approximately hexagonal crystals, but detailed studies have shown, according to T. L. Walker,[8] that probably all the micas except muscovite are really triclinic. Evidence for this conclusion was obtained both by measurement of the angle between the clinopinacoid and the optic axis and by etch figures. These methods yielded similar results in similar minerals. The approximately hexagonal symmetry of the crystals of different micas is indicated by the nearly hexagonal outline observed in many prisms by ruled and A mica and by percussion and pressure figures.

[8] Crystal symmetry of the minerals of the mica group: Am. Jour. Sci., 4th ser., vol. 7, pp. 199–204, 1899.

A percussion figure is readily obtained by striking a plate of mica a sharp blow with a rather blunt punch. The best figures are obtained in sheets 0.25 to 0.50 millimeter thick. A moderately firm background, such as a paper-covered book, is desirable. A percussion figure is a six-rayed star formed by three cracks or cleavages that cross a plate of mica at a common point. In making such percussion figures in mica, part or all of another six-rayed star, the rays of which fall between those of the percussion figure, is occasionally obtained. This is called a pressure figure and is not so readily obtained as a percussion figure. Where complete percussion and pressure figures are obtained together a 12-rayed star is produced.

One of the cracks of a percussion figure is parallel with the clinopinacoid of the mica crystal, and the other two meet each other at angles ranging from 52° 53′ in muscovite to 63° 28′ in phlogopite, as determined by T. L. Walker.[9] In biotite the three cracks meet at angles closely approximating 60°. Walker found that the angle between the two cracks not parallel with the clinopinacoid (χ, fig. 1) ranged from 52° 53′ to 55° 57′ in muscovite from seven different localities. T. H. Holland[10] found that this angle was larger in Indian muscovite when the percussion figure was obtained at higher temperatures. The same mica yielded angles 2½° to 3° larger at 300° C. than at ordinary temperatures. Holland's measurements showed that the angle χ at ordinary temperatures ranged from 53° to 55° in muscovite from four different localities in India. Measurements made by the writer on muscovite from several States of the United States showed that the angle χ ranged from 53½° to 55°.

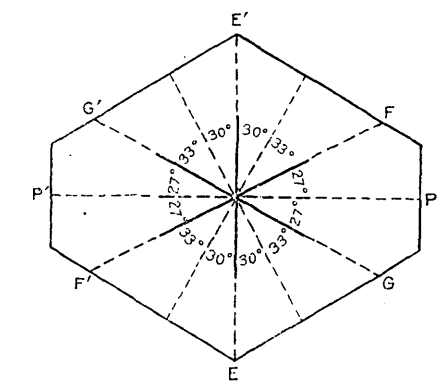


FIGURE 1.—Diagram showing position of rays of the percussion and pressure figures in a crystal of muscovite mica. (After Holland.) See text for explanation.

The cleavages of a percussion figure in mica cut the laminae formed by the perfect basal cleavage at high angles. Rough measurements made on the percussion cleavages showed angles of 60° to 70° with the basal cleavage. The cleavage rays or cracks extend farther from the center of the percussion figure in the lower laminae of the mica than in the upper laminae, or near the surface where the blow is struck. For this reason the best plates for the study of the percussion figures can be obtained by splitting them from the bottom

[9] Percussion figures of mica: Am. Jour. Sci., 4th ser., vol. 2, pp. 5–7, 1896.
[10] Mica deposits of India: India Geol. Survey Mem., vol. 34, p. 21, 1902.

of a sheet of mica after the figure has been made. Thin laminae exhibit sharper figures. The rays of an individual percussion figure range in length from a millimeter or so to 2 centimeters. A cleavage crack can be carried across a sheet of mica by making a series of successive percussion figures along the line of one of the rays. Percussion figures vary greatly, even when obtained in the same sheet of mica and under apparently similar conditions. In some laminae one or more rays are only imperfectly developed or are absent, in others all six rays are prominent, and in a few only three alternating rays occur, radiating from a common point. A cleavage sheet from a mica crystal, with percussion figures, is shown in Plate III, *A*.

A pressure figure, like a percussion figure, is composed of cleavage cracks cutting across the laminae of the mica at wide angles. One of the rays is perpendicular to the clinopinacoid and accordingly perpendicular to the principal ray of the percussion figure. Holland[11] states that the pressure-figure rays form angles of about 60° with each other, but this statement is difficult to confirm, for pressure figures with rays sufficiently distinct to measure closely are rarely obtained. In some of the many specimens of muscovite from the United States experimented on by the writer the rays of the pressure figures were not perfectly straight, and in others those on opposite sides of the center were neither in alinement nor parallel. In one specimen, where the six rays of the pressure figure were obtained, measurements by the writer gave angles of 59°, 60°, and 61°, with an average of 60° between the rays. In other specimens, where only partial pressure figures were obtained, the angles that were measured ranged from 55° to 65°. In a specimen of A mica having the six rays of what was apparently the pressure figure, developed angles of approximately 50°, 60°, and 70° were measured. Some of the rays on opposite sides of the center of this figure were not in alinement.

Most of the pressure figures obtained for examination were combined with percussion figures, the two having a common center. Measurements made on many of these gave results approximating those obtained by Holland[12] with India micas, summarized below and illustrated in figure 1.

1. The principal ray of the percussion figure EE′ lies in the plane of symmetry and at right angles to the optic-axial plane.

2. The principal ray is cut perpendicularly by the ray PP′ of the pressure figure, which lies in the optic-axial plane.

3. The angle κ between the rays FF′ and GG′ averages 53° 55′ (nearly 54°).

4. The remaining angles of the percussion figure are, to the nearest degree, each 63°.

[11] Holland, T. H., op. cit., p. 19.

[12] Holland, T. H., op. cit., pp. 19–20.

5. The rays of the pressure figure intersect one another as nearly as can be measured at angles of 60°.

6. The subordinate rays of the percussion figure meet the subordinate rays of the pressure figure at angles of 93° and 33°.

7. The etch figures produced by the action of hydrofluoric acid or by fused potash are bisected symmetrically by the principal ray EE′ of the percussion figure.

PHYSICAL PROPERTIES.

The first prominent characteristic of the minerals of the mica group is cleavage. All the micas have a pronounced basal cleavage, generally almost perfect, by which they can be split into thin sheets. The true micas yield cleavage sheets that are tough, flexible, and elastic. Other properties possessed in common by the micas are similarity in crystallization, other cleavages or partings called "rulings," brilliancy or high luster, transparency in some varieties, color, comparative softness, and relatively great resistance to the conduction of electricity and heat.

Several of these properties, such as toughness, flexibility, and elasticity of the cleavage sheets combined with transparency in some varieties, nonconductivity of electricity and heat, and brilliancy of the cleavage faces make mica valuable.

Biotite and muscovite are the most common types of mica. Biotite is a dark-colored mica, generally brown to brownish black or green, and is opaque to translucent in all but thin sheets. The folia are flexible and elastic, but less so than those of muscovite. Biotite is commonly found in small plates and crystals as a rock constituent, but some occurs in sheets several inches to a foot wide.

Muscovite is transparent and light-colored when split into thin sheets, but sheets one-sixteenth of an inch or more thick may be colorless, gray, yellow inclining to amber, red, brown, or green. Thin sheets are called "white" mica, but sheets of sufficient thickness to show strong color are spoken of, according to color, as "rum," "ruby," "smoked," or "green" mica. Muscovite occurs both in the form of small scales as a common constituent of many rocks and as large crystals of less widespread but still rather common occurrence.

Phlogopite commonly ranges in color from yellow to brown and black. Sheets less than one-sixteenth of an inch thick may appear amber-yellow to brown, reddish brown, or black. Some of it has a coppery appearance. Phlogopite is generally less transparent than muscovite, owing to the presence of many minute inclusions.

The other varieties of mica will not be considered in this report.

Mica mined for commercial use is commonly found in rough blocks, some of which have irregularly developed crystal faces. The faces are not usually as many as would be required to complete the simplest figure, and their surfaces are generally very rough. A

large part if not all of a block of mica usually has a ragged outline and is without plane surfaces, but fairly well developed hexagonal or rhombic prisms have been observed in crystals of mica weighing hundreds of pounds.

Rough crystals of mica, or "books," as they are called in the Western States, do not split perfectly until the outer shell of etched and sometimes partly crushed mica has been removed by rough splitting or cleaving the large book into sheets an eight of an inch thick or less and trimming the edges with a knife held at a small angle with the cleavage. After the tangled outside edges of the sheets have been removed, further splitting is easy, because the cleavage of mica is nearly perfect. By grinding a wedge-like edge on the sheets and using a thin, sharp knife mica can be readily split into sheets less than a thousandth of an inch thick, and some of the thin splittings prepared in India measure only about a sixteen-hundredth of an inch.

Mica has a number of physical peculiarities due to crystal structure, color, and inclusions, to which miners and dealers have applied certain descriptive terms. Structural peculiarities give "ruled" or "ribbon," "A," "hair-lined," "fishbone" or "herringbone," "feather," "horsetail," "tanglesheet," and "wedge" mica; the different colors give "rum," "ruby," "amber," "white," and "black" mica, though brown, green, and greenish-brown colors are also seen; and inclusions give "specked," "black," and "clay-stained" mica.

Ruled or ribbon mica is formed by more or less clean, sharp parting planes that cut through the crystals at an angle of nearly 67° with the base or cleavage surface. This parting passes entirely through some crystals and extends only part way across the face of others or does not cut through their entire thickness. The trace of the ruling planes corresponds in direction to the rays of the pressure figure in mica. Though a cleavage resembling ruling may be produced by making a series of percussion figures along the line of one of the rays, it is evident that ruling planes do not correspond to the lines of weakness represented by the percussion figure, for the two make angles of 25° to 35° with each other. On the other hand, the ruling planes fall in the same directions as the rays of the pressure figure and probably occur along the lines of weakness represented by them. Plate III, *B*, illustrates ruled or ribbon mica. (See also Pl. VI, 1.) Ruling lines occur more commonly in one series of parallel lines in mica. In some specimens these parting planes extend in two or even in three directions, and their traces on the cleavage planes make angles of about 60° with each other, dividing the mica sheets into small triangular plates. Some large blocks or crystals of mica that are otherwise of excellent quality have been made

practically worthless by extensive ruling. Ruling is so extensive in some mica that it has cut the mineral into thin strips and slivers of hair-like fineness.

In **A** mica two series of lines or striations cross the sheets of mica at an angle of about 60°, generally forming a **V**. A part of a mica crystal exhibiting the **A** structure is shown in Plate IV, *A*. (See also Pl. II; Pl. VI, 2, 3.) The third striation necessary to complete the letter **A** is absent, but the miners have nevertheless called this variety **A** mica. In some pieces these striations are caused by wedge structure in the crystals, and the sheets that have wedged out may or may not be replaced by detached sword-bladelike strips. In other pieces the striations are caused by small folds or crenulations in the sheets of mica. The **A** striations have the same orientation in the sheets as the ruling lines—that is, their position corresponds to the rays of the pressure figure. Ruling is seen in some **A** mica. If the striations are caused by small folds the mica may split across them and the sheets may have some commercial value, though not so high as that of perfect plates; if they are due to the wedging out of sheets, only plates between the **A** lines can be used commercially, and the value of large crystals is thus materially reduced. A crystal of mica in which the striations extend in one direction only is called "hair-lined."

In the "fishbone" or "herringbone" structure, striations with or without ruling and apparently identical with the **A** lines of mica make angles of about 120° with each other and join at a center line or spine. This forms a structure resembling a feather or the skeleton of a fish. Plate IV, *B*, illustrates a block of fishbone or herringbone mica. (See also Pl. VI, 4.) The same variety has been called "horsetail" mica by the miners in Alabama. Mica with fishbone structure has no commercial value as sheet mica but is used as scrap for grinding.

In "tangle-sheet" mica, a name little used, the laminae split well in some places but tear in others. This imperfection is caused by the intergrowth of parts of one sheet with another, and may extend half an inch or more through some crystals, making apparently sound material valueless or nearly valueless as sheet mica.

In "wedge" mica the crystals are thicker on one side than on the other. Wedge structure is common in **A** and fishbone or horsetail mica and occurs also in plate mica. In plate mica the difference in thickness on opposite edges may be greater than half an inch in a crystal 3 inches in diameter. In **A** and fishbone mica the angles of the wedge may be as large as 30°. Plate V, from Bastin, shows a crystal of wedge mica which has also the fishbone structure. Wedge structure is due to an unequal development in the width of the

laminae. Some of the laminae extend across the entire width of the crystal, but others do not, and generally these short laminae are not matched by similar laminae extending from the opposite edge, so that the crystal is thicker on one side than on the other, and not uncommonly wedge-shaped sheets of quartz are included between the laminae of such a crystal.

The words describing the color of mica are self-explanatory, but the miners and dealers ordinarily consider the color of sheets a sixteenth of an inch or more in thickness. Such colors as rum, ruby, and green seen in the thicker sheets practically disappear after the mica has been split into thin sheets. The material is then called "white" mica to distinguish it from Canadian phlogopite or amber mica. By black mica the miners generally mean muscovite specked with magnetite, as described below, but by some miners dark-brown to black biotite is also called "black" mica. Rum, ruby, green, and the lighter-colored micas make the best grades of white mica for glazing. Dark-brown and brownish-green mica has to be split much thinner than rum and light-green mica to gain the desired transparency and is therefore generally classed as "No. 2," even when flawless and clear.

Some muscovite shows variations in color that accord with crystal structure. The variations generally appear in bands that follow the outline of the crystal. Thus, in looking through the mica one may see a dark rum-colored center surrounded by a fringe of light rum or yellow having a hexagonal or rhombic outline; or the center may be light and the border zone dark. (See Pl. VI, 5.) In some sheets there are alternating bands of varying color.

The various kinds of structure found in mica are illustrated in Plate VI. The position of the percussion figure is shown in most of the diagrams.

The pleochroism of muscovite and other transparent micas is strong and may be well observed in small crystals that have prism planes sufficiently smooth to transmit light. Crystals of such mica viewed edgewise are far more transparent than sheets of the same thickness. The color is also very different in these two directions. Some specimens of muscovite show a dark rum color perpendicular to the cleavage and yellowish to greenish yellow parallel with the cleavage.

Muscovite containing inclusions of spots or particles of different-colored minerals between the laminae is called specked or sometimes black mica. Magnetite is the most common inclusion and occurs as black to brown dendritic tufts arranged in definite lines or patterns corresponding to the crystal structure of the mica or

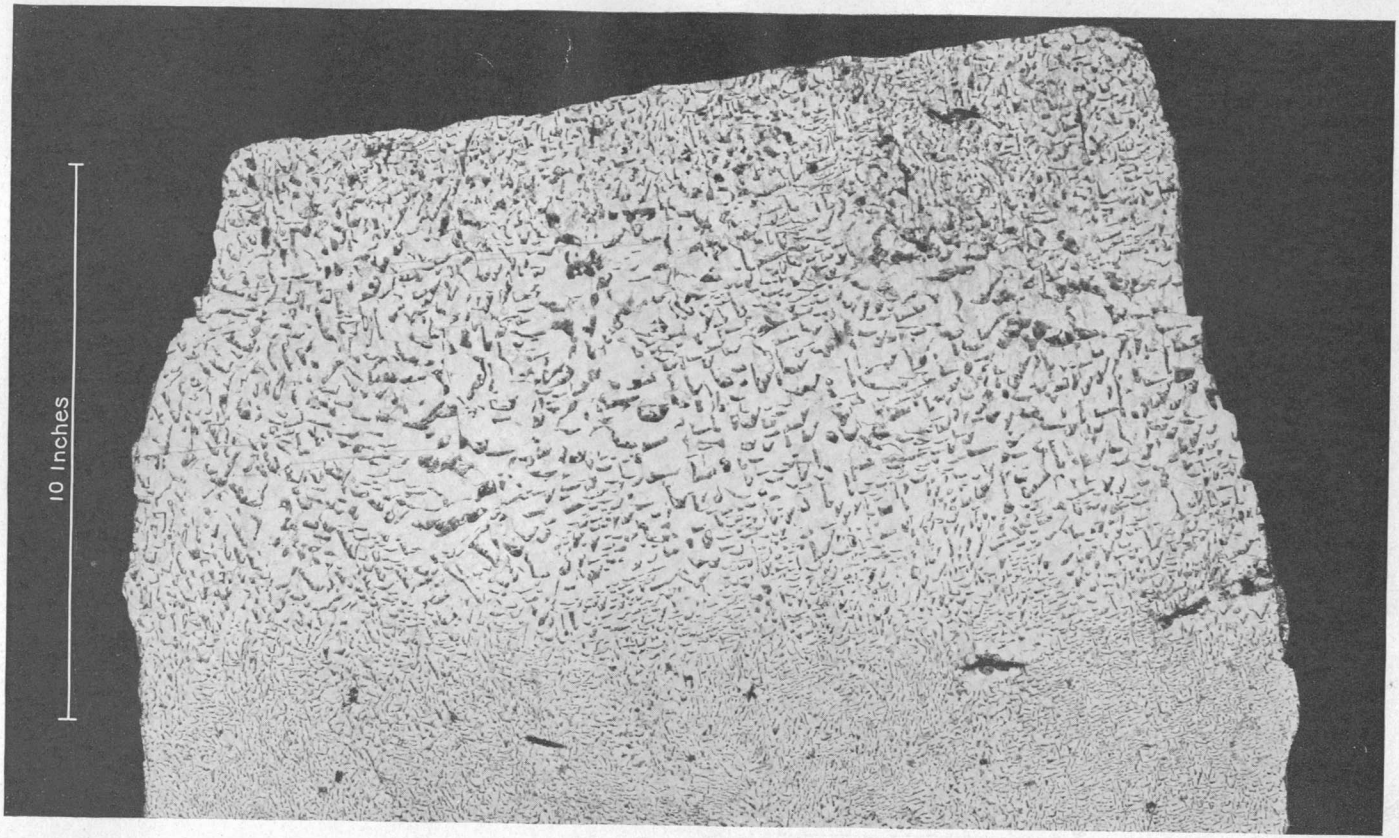
scattered irregularly through the sheets. Plate VII, *A*, shows heavily specked mica and *B*, slightly specked mica. These tufts of magnetite are very thin and rarely penetrate far into a sheet of mica. The dark-brownish color of many of these spots is due to the translucency of the thin films of magnetic iron. Some of the streaks in the mica are parallel to the rays of the percussion figure and others are apparently parallel to the rays of the pressure figure, as shown in figures 6 and 7 of Plate VI.

Each spot owes its dendritic appearance to the arrangement in lines of small particles of magnetite, some of which follow the rays of the percussion figure. From these lines of particles other particles branch off at more or less definite angles. Figure 8 of Plate VI is an enlarged sketch of such a dendrite, being five to ten times the diameter of an ordinary dendrite. That the black dendrites are generally magnetite can be proved by cutting out thin films of mica containing them and testing with a magnet. By decomposition the magnetite is partly or entirely altered to hematite or limonite and the specks become red or yellowish brown. In this way striking patterns in color are produced, which were once thought to be inscriptions made by the aborigines, and which gave rise to the name "hieroglyphic" mica. Still more delicate markings due to the other inclusions also resemble hieroglyphics. A specimen bearing such markings is illustrated in Plate VIII, *A*.

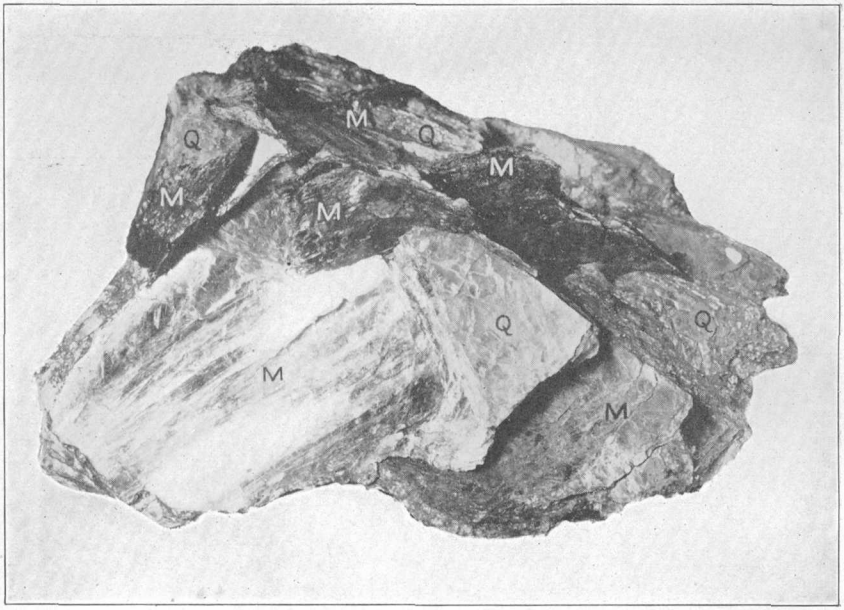
Among other inclusions found in mica are garnets, some of which are in flattened crystals ranging in thickness from that of paper to one-tenth of an inch and reaching a diameter of one-third of an inch. Two small garnets of this kind are shown in Plate VIII, *B*.

Crystals or sheets of biotite may be included in muscovite crystals or vice versa, the two micas generally occurring in parallel intergrowths and having a common cleavage plane. A unique specimen of biotite inclosing a rhombic crystal of muscovite with a common cleavage plane is shown in Plate VIII, *C*. The muscovite crystal narrows down abruptly from a rhomb with a side 1¼ inches long to a rhomb with a side only a quarter of an inch long and a thickness of an eighth of an inch. The percusion figures of the two micas have their principal rays approximately perpendicular to each other and their optic axial planes approximately parallel.

In the zone of surface weathering, especially within a few feet of the surface, mica crystals may be clay stained by the penetration of muddy water between the laminae. The solutions penetrate large areas of crystals and work in between many of the laminae, greatly damaging the value of the mica. The clay staining is generally less marked in mica obtained at some distance from the surface and is absent where mining reaches hard unaltered vein matter.

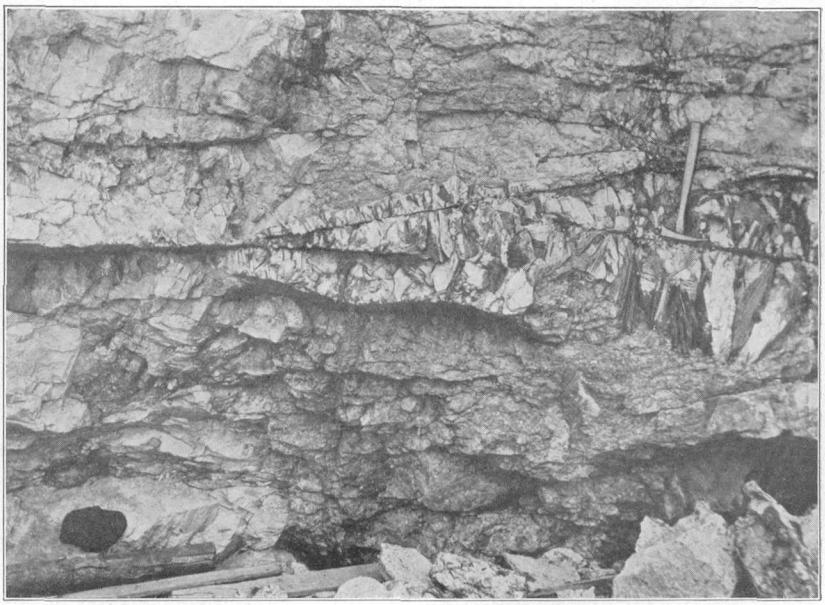


SPECIMEN OF "GRAPHIC GRANITE," A GRAPHIC INTERGROWTH OF MICROCLINE AND QUARTZ.

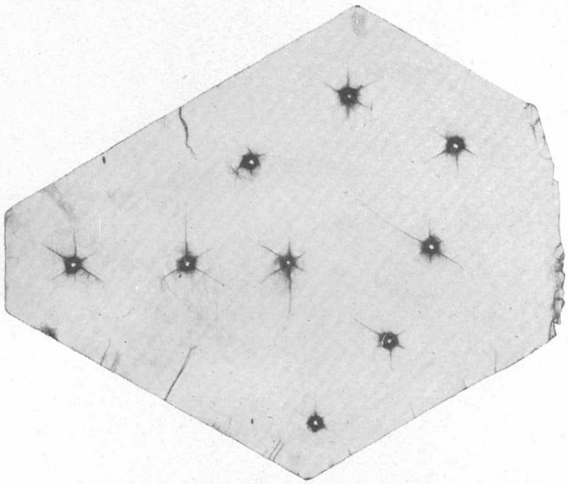


A. MICA "CAPPING."

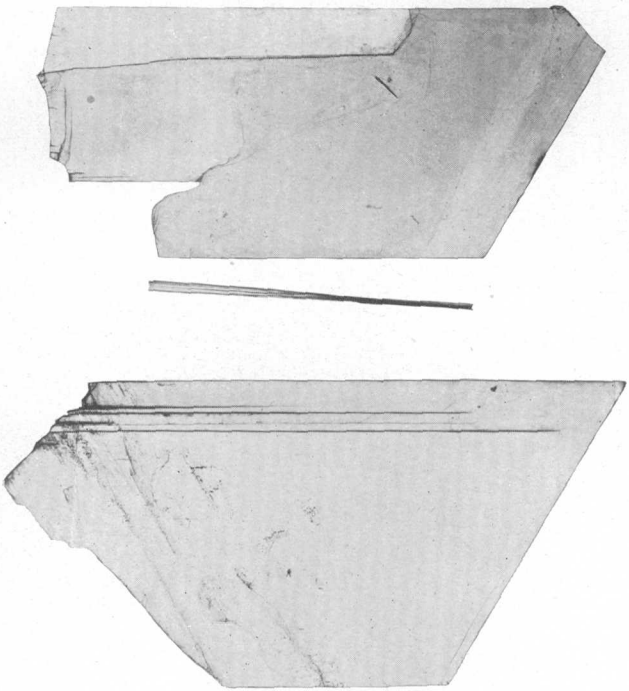
M, mica; Q, quartz.



B. SOLID MICA, CONSISTING OF AGGREGATES OF "WEDGE" AND A MICA.

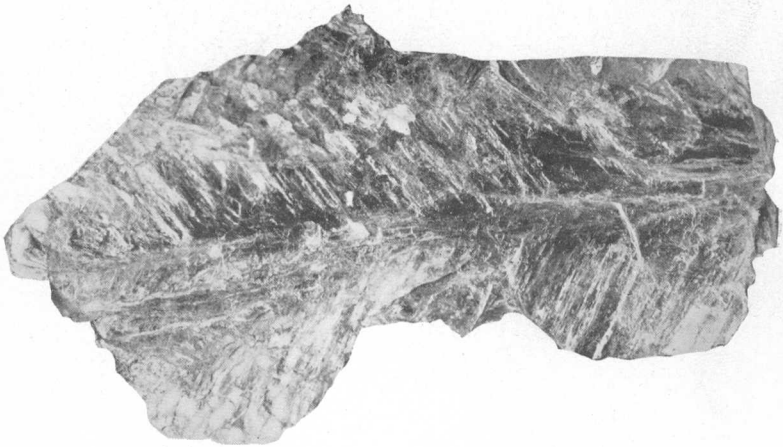


A. CLEAVAGE SHEET FROM MICA CRYSTAL, SHOWING PERCUSSION FIGURES.

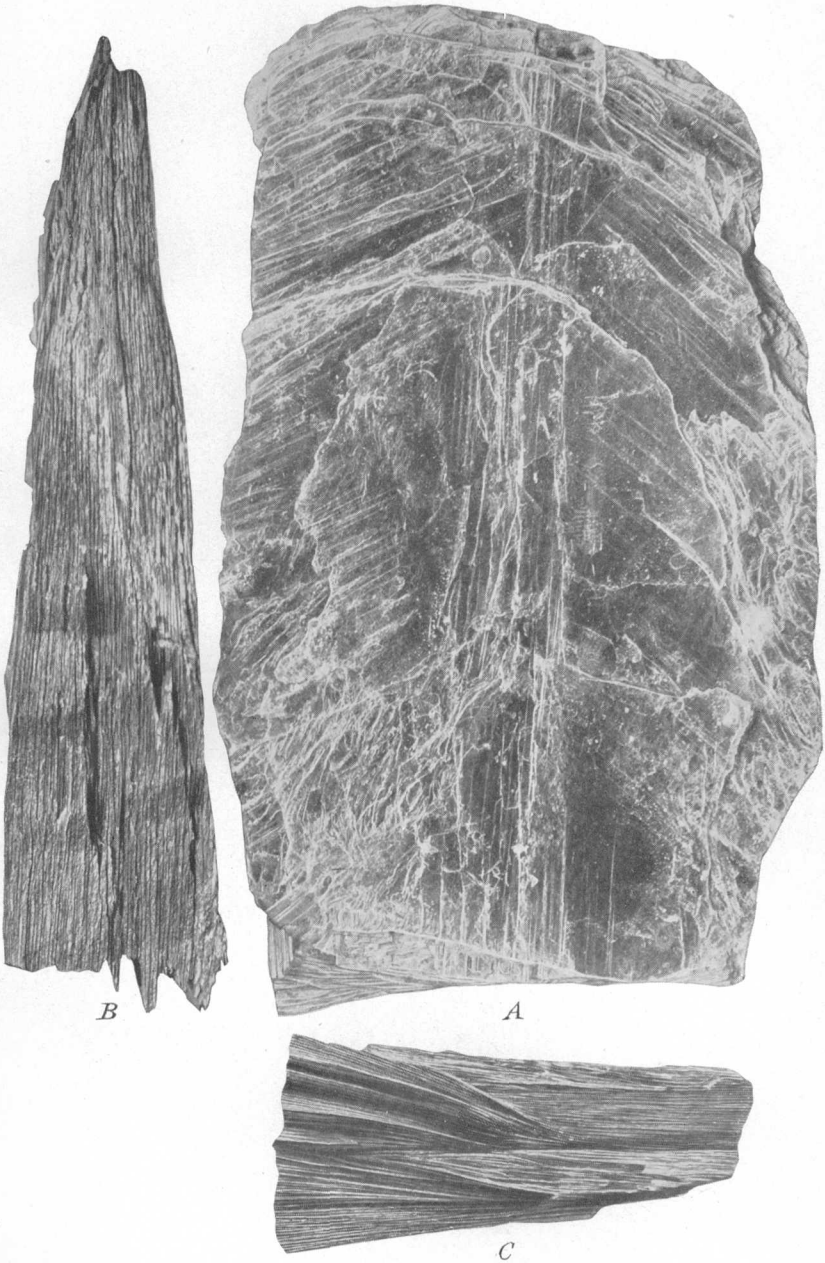


B. SPECIMENS OF "RULED MICA," SOME "RULED" INTO "RIBBONS."

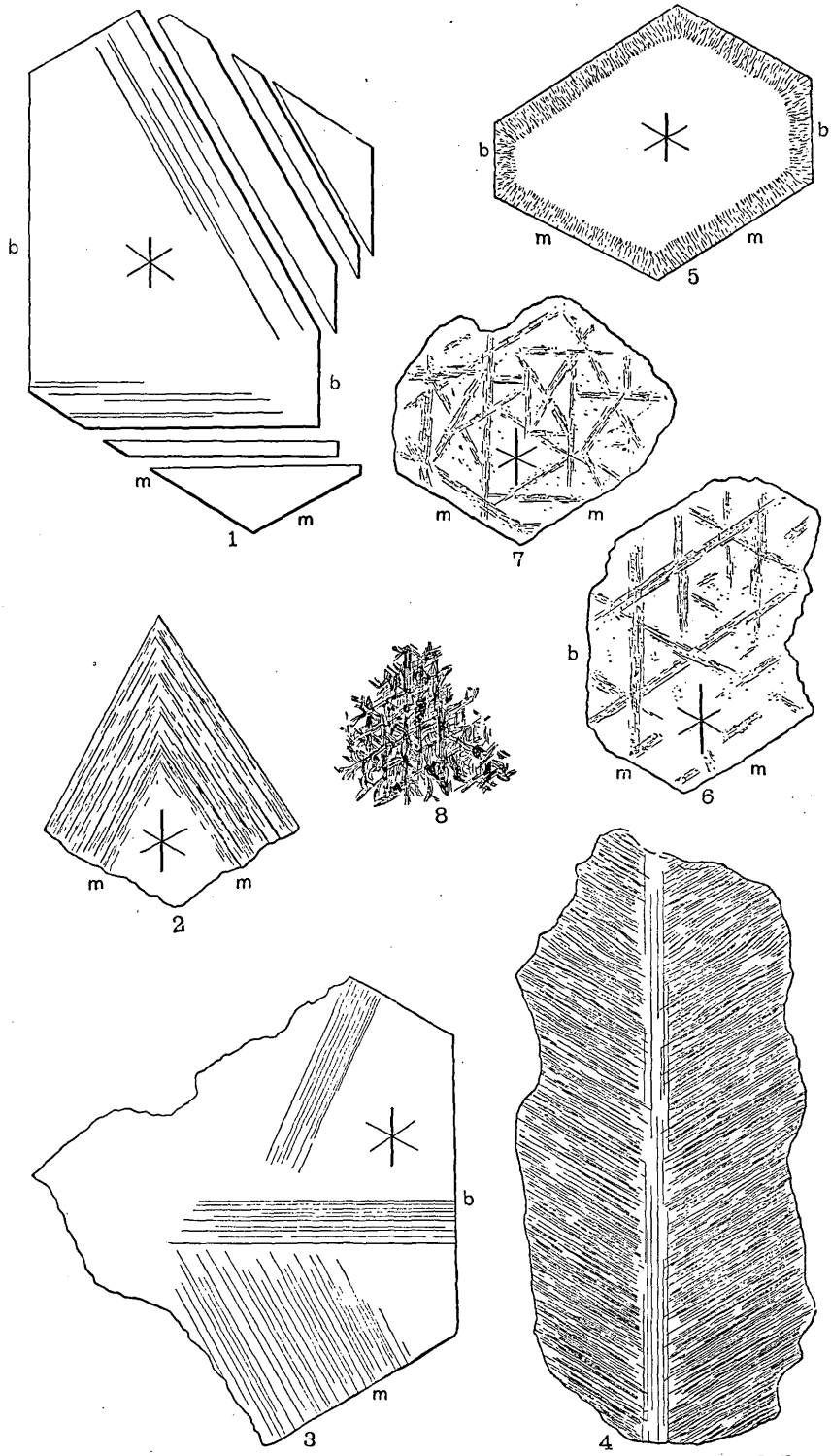
A. FRAGMENT OF CRYSTAL OF MICA SHOWING A STRUCTURE.



B. MICA CRYSTAL SHOWING "FISHBONE" OR "HERRING-BONE" STRUCTURE.

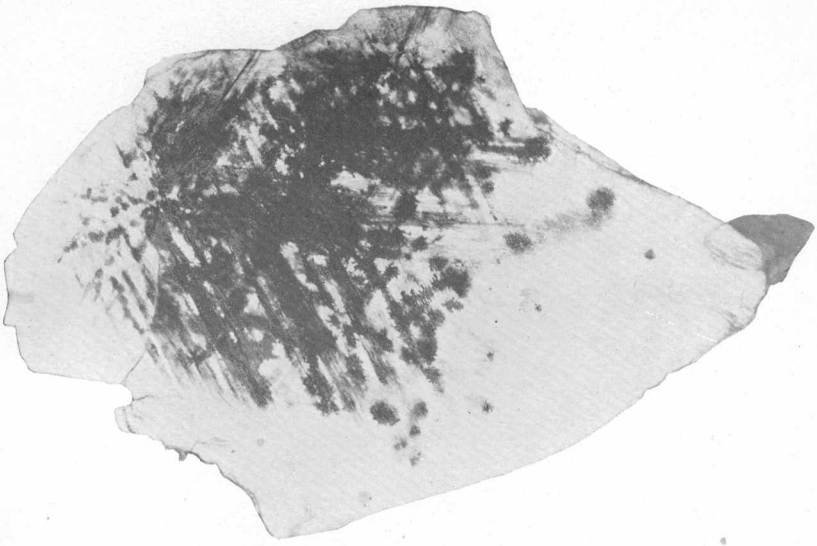


MICA CRYSTALS SHOWING "WEDGE" AND "FISHBONE" STRUCTURE.



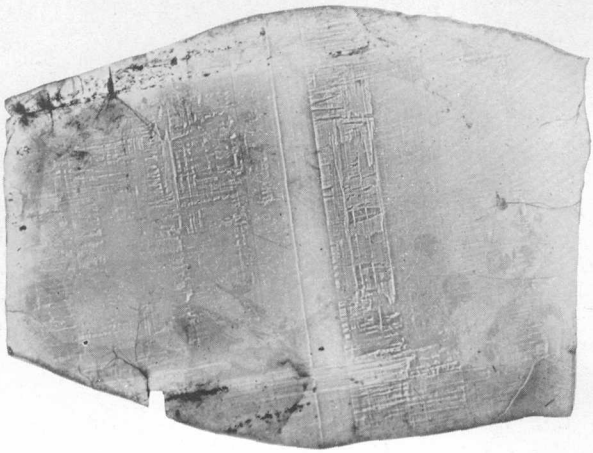
CLEAVAGE PLATES OF MICA SHOWING VARIOUS KINDS OF STRUCTURE.

See text for explanation of numbers. Position of crystal faces shown: b, {010}, clinopinacoid; m, {110}, unit prism. *, percussion figure, vertical line parallel to clinopinacoid.

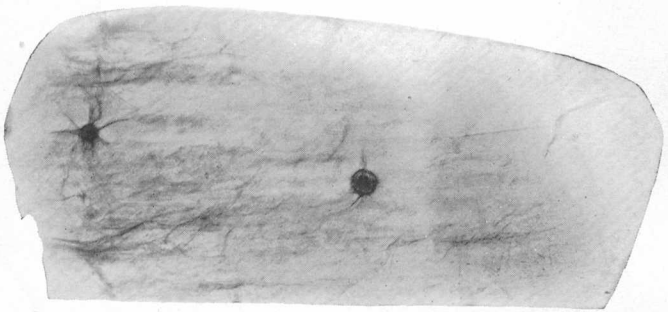


A. MICA HEAVILY "SPECKED" WITH MAGNETITE.

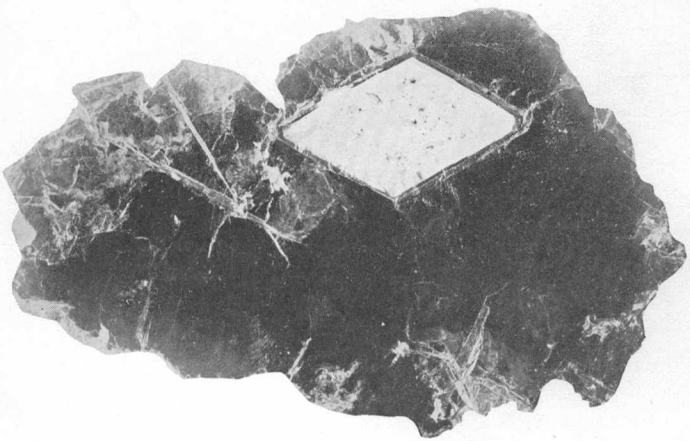
B. MICA SLIGHTLY "SPECKED" WITH MAGNETITE.



A. SHEET OF MICA CONTAINING INCLUSIONS RESEMBLING ANCIENT HIEROGLYPHICS.



B. SHEET OF MICA INCLOSING TWO FLATTENED GARNET CRYSTALS.



C. SHEET OF BIOTITE FROM MITCHELL COUNTY, N. C., INCLOSING A RHOMBIC CRYSTAL OF MUSCOVITE, BOTH HAVING THE SAME CLEAVAGE PLANES.

MICA MINING.

HISTORY.

The ancient Romans are said to have spread a micaceous sand or a disintegrated mica schist over the arena of the Circus Maximus as a decorative material. In India mica has been mined for centuries and was long used in lanterns, for decorative effects, and as a medicine. European countries have used mica for glazing windows for two or three centuries. The aborigines of North America mined mica extensively in the Southern Appalachian States, and it appears to have been used by the mound builders of the Mississippi Valley region for ornamental purposes.

Mica mining in the United States began with the opening of the Ruggles mine, in Grafton County, N. H., about 1803. Other mines afterwards opened in the same State furnished practically all the mica used in the United States until after the middle of the nineteenth century. Mining in New Hampshire was carried on in a desultory way until about 1840, and then more extensively until after 1860. Some of the deposits in Pennsylvania were probably tested shortly after the middle of the century, but definite evidence regarding this can not be obtained.

Mica mining was started on a large scale in North Carolina soon after 1868, and mining in New Hamshire then declined. For many years North Carolina has been the principal producer of mica in the United States. Extensive mica mining has also been carried on intermittently in several other States during the last 40 years, especially in Virginia, South Dakota, New Mexico, and Idaho. No records were kept of the quantity and value of the mica mined in the United States until 1880, and since that time the output has varied considerably, partly because of variations in business condition but since 1885 chiefly because of competition with imported mica. Prior to 1890 the bulk of the mica mined was used in the glazing trade, for which only large sizes were considered suitable. Since then, owing to the great growth in the manufacture of electrical apparatus and machinery, an increasing quantity of mica has been used and smaller patterns have been employed in the glazing trade. During the same period ground mica for wall-paper decoration has utilized much of what had formerly been waste material.

Through 1880 and during a few following years the great demand for large sheet mica was supplied chiefly by the domestic production. After 1885 increased imports of mica from India made inroads on the domestic production, and this competition still continues. In 1890 an ad valorem duty of 35 per cent was placed on imported mica. The tendency of this duty was to prohibit imports of mica

with large bulk and small value, such as small sheet mica and the material then classed as scrap. In 1897 the tariff was changed to 6 cents per pound for unmanufactured mica and 12 cents per pound for cut or trimmed mica, with an additional 20 per cent ad valorem for each. These rates of duty practically made the importation of small sheet and scrap mica impossible, and to meet the growing demand for those sizes domestic mica mining was greatly stimulated. The tariff was changed again in 1909 to 5 and 10 cents per pound for unmanufactured and cut or trimmed mica, respectively, with 20 per cent ad valorem, without apparent effect on the mining industry. The tariff of October 3, 1913, provides for the following duties: Unmanufactured mica valued at not above 15 cents per pound, 25 per cent ad valorem; cut mica, mica splittings, built-up mica, and all manufactures of mica, 30 per cent ad valorem; ground mica, 15 per cent ad valorem.

METHODS.

The occurrence of mica in irregular deposits makes the method of mining it problematic. At a few deposits the pegmatite is in sheetlike bodies that are not badly warped and are persistent for some distance. If the mica content is not extremely variable such deposits can be easily mined by ordinary methods—that is, by regular shafts, adits or tunnels, drifts, and stopes; if the mica content varies greatly stopes and other workings will be less regular. If the pegmatite forks, rolls, is folded, pinches, or bulges out into large masses, the method of mining generally employed is called "groundhogging" or "gophering," in which the workings are very irregular, and waste rock is left to accumulate because it is difficult to remove through the small tunnels and openings.

If the pegmatite occurs in large masses rich enough to be worked for mica regular quarry methods may be used. In the New England mica mines the ore and the waste rock are removed by open quarrying, with derricks and inclined tracks.

Much mica is mined each year in the United States from deposits operated in a small way, without steam engines, pumps, or power drills. Hand power or, at most, horsepower is used in such places to hoist mica, waste, and water from the workings, and drilling is done by hand. Tracks with mine cars may or may not be used.

As a general rule it is best to open a mica prospect by cuts, shafts, or tunnels in the pegmatite along the streak or deposit of mica and also at other places that appear favorable until it has been determined that mica is present in paying quantities. Then only is it safe to develop by vertical shafts to one side of the vein or by long crosscut tunnels from lower levels on a hillside. Few prospects

give evidence on the surface that they will warrant extensive development or large outlay in mining equipment.

In mining care is necessary to avoid drilling through good crystals of mica. Miners using either hand or power drills can generally tell by its clogging when the drill is in mica. Only small charges of dynamite should be used in blasting around a pocket of mica, and black powder is even better, if it can be used.

In some regions, especially in the mountains of the South, work at some of the mines is not carried on systematically nor with proper equipment. Timbering is very sparingly used, and pillars are left only where they are absolutely needed to keep the mine open for the time being. In decomposed formations this type of "ground-hog" working soon becomes dangerous and remains a menace to future development, yet some mines can be worked only by such methods. The deposits may not be rich enough to warrant the expense necessary to equip the mine with proper machinery and timber it carefully and may pay only "good wages" to the lessees.

In some of the mountain regions the mica is found in rather inaccessible places, and all tools and provisions intended for the mines are packed on animals or even on men's shoulders. The mica is carried away by the same method.

Few companies apparently keep records of the yield of mica obtained per ton of rock mined. The deposits vary so greatly in their content of mica that this information does not seem to be of much help to the individual producer, yet such information from many mines, if brought together, would be useful. A yield of 5 to 10 per cent of sheet mica from all the pegmatite mined is considered very good, if the sheets average at least 3 inches square. Few mines will yield over 10 per cent of sheet mica.

PREPARATION OF MICA FOR THE MARKET.

Mica as it is obtained from the mine consists of rough crystals and blocks ranging in diameter from an inch or less to several feet. Before the mica is ready for the trade these crystals have to be cobbed, split, rough trimmed, sorted, cut into patterns, built up into large composite sheets, or ground. In many places these operations are carried out in two or three different plants, owned by as many companies, but some of the better-equipped companies prepare the mica in one plant, built either at the mine or near by.

The rough mica crystals are cobbed and cleaned of adhering quartz, feldspar, or dirt by rapping with hammers. They are then split with wedges or splitting knives into plates one-sixteenth of an inch or less thick. The rough edges are cut off these plates by

knives held at a low angle to the cleavage, and the mica is graded for size and quality. Large quantities are sold in this rough shape, being packed into boxes and graded so that all the mica in a particular box is guaranteed to trim into sheets containing a prescribed number of square inches. Small sheets may be left with rough edges and used for punching into mica disks, washers, and other forms. After being graded the mica is ready for further splitting and trimming into the forms and patterns desired by the trade. It is trimmed with large shears and punches, operated either by hand or by power. If shears are used the mica is cut into the desired form around a templet of wood, metal, or other material laid against it. Mica-punching machines are equipped with dies to punch disks, washers, and all forms of patterns.

The introduction of mica board or built-up mica for electrical manufacture has developed a large demand for "thin splittings." Most of these are made from mica sheets less than 4 inches in diameter. In making "thin splittings" the edges of the plates are first ground on a bevel and then pressed against a flat surface to open the cleavages. The mica is then "thin split" by thin-bladed knives into sheets ranging from one eight-hundredth to one twelve-hundredth of an inch thick, and lots have been received from India averaging in thickness about one sixteen-hundredth of an inch. In the United States "thin splitting" is generally done by girls as piecework.

The "thin splittings" are built up into mica board, flexible mica sheets, and tape. Mica board is built up either with or without tissue paper from several layers of "thin splittings" coated with shellac. It is then made up into sheets measuring 2 by 3 feet and subjected to baking under hydraulic pressure. The required thickness is obtained afterward by sanding and milling machines. Mica board can be cut or punched and treated like sheet mica. When heated it can be bent or rolled into tubes and molded into collars or other forms. If the mica board is to be subjected to a high temperature a siliceous binder is used instead of shellac. Cloth or paper sheets built up with flexible cement and thin splittings are much used, flexible tape being made from these sheets by cutting them into strips.

The rough, small mica and the waste from trimming sheet mica are ground. Two processes, wet grinding and dry grinding, are employed according to the uses to which the ground product is to be put. A. S. Watts's description[13] of a wet-grinding process used in the mountains of the South is quoted below:

[13] Mining and treatment of feldspar and kaolin in the southern Appalachian region: U. S. Bur. Mines Bull. 53, pp. 86–87, 1913.

The method of grinding mica is unique, since the process is shredding rather than abrasion. The process in detail is as follows: The coarse mica is washed by passing it through a revolving cylindrical screen upon which water plays and thus any fine sand is washed away. The washed mica scrap collects in a tank of water and any refuse that floats is carried off by the water which constantly overflows the tank.

The mica-grinding mill into which the mica next goes is a cylindrical wooden vat 3 feet high and approximately 3 feet in diameter, with a wall 6 to 8 inches thick, built of wooden blocks set with the end of the grain toward the inside to present a wearing surface. The grinder is a wooden wheel about 6 inches thick that fits loosely inside the vat. This wheel is built of ordinary plank cut to present as much end grain as possible and spiked together to give the desired thickness. It is attached to a heavy vertical shaft in the center of the vat and is rapidly revolved by steam or water power. The pressure of the wheel on the material in the vat is maintained by a pressure spring from above.

The operation consists of charging the mill with washed scrap mica and adding just enough water to provide the desired lubrication. The wheel is then started and pressed down until it takes a firm hold upon the mica. The friction of the wheel against the mica scrap causes the sheets of mica to be forced between the laminae of adjoining sheets and thus the large blocks and sheets are gradually torn to pieces and reduced to the pulverized mica of commerce. After 8 to 10 hours the mill is emptied, and by a flotation system similar to that used for removing mica from kaolin the fine mica is separated. The coarse mica is returned to the mill and the fine mica is allowed to settle and the water drawn off. The mica is then removed to drying tables where it is spread to dry. After drying it is placed in regular bolting machines similar to those used for bolting flour; the last trace of coarse material is removed and returned to the grinding mill. One such grinding mill will produce from 250 to 400 pounds of 160-mesh mica per day, hence many mills are necessary for a large output.

Some of the locally constructed wet-grinding mills are built like large Chilean mills, but all of the working parts are made of wood—that is, the tub lining and the rolls.

In dry grinding the Raymond pulverizer or a similar machine is generally used. In these machines the mica is crushed by suspended rolls revolving at high speed against a ring in a closed chamber. The ground product is conveyed by air draft to bolters for sizing. One No. 0 Raymond pulverizer will supply two Barnard & Leas bolting machines.

USES.

Mica is generally classed as one of the less useful nonmetallic minerals, but it is really very useful in the electrical manufacturing industry, where it fills a need not supplied by any other substance, and it is of value in the glazing and decorative trades and in the manufacture of lubricants.

Mica was probably used in ancient times for decoration, but in modern times, before the present "electrical age," it was used chiefly for glazing, for which only clear sheets with perfect cleavage are suitable. It was first used in this way in lanterns and windows, but

later it was used in large quantities in stove windows and doors, for which its resistence to heat made it especially desirable. Much is still used in this way, though probably more is now needed for gas-lamp chimneys and lamp shades. It also serves as a substitute for glass in picture frames. Before the method of annealing glass was developed mica was used in the portholes of battleships, because the glass manufactured in the early part of the last century would be shattered by the concussion of the cannon firing. Some mica was used in making spectacles for stone carvers, metal workers, and men around furnaces and smelters. The mica furnished a transparent medium of protection to the eyes and was not liable to be fractured by small chips of flying stone or metal.

Recently mica has been used in making lantern slides.[14] The slides have been prepared by George Palmer, of London, who used a special process to protect the mica from scratching. Lantern-slide "cover glasses" are also similarly prepared, and their use greatly reduces the weight of the slide.

A large quantity of mica is used to make disks for the vibrating membranes of phonographs and telephones. Only mica with the smoothest cleavage and of the highest perfection is suitable for this purpose.

Large quantities of mica split into thin sheets ("thin splittings") are used in the manufacture of "mica board" or built-up mica. This product is applicable to many uses in electrical manufacture, for which natural sheets of mica sufficiently large are costly and difficult to obtain.

In the manufacture of electrical apparatus and machinery mica is used in sheets of various sizes and shapes, including washers and disks, at places in which a noninflammable insulating material is necessary. Thus, properly trimmed sheets are used between the commutator segments of motors and dynamos, for tubes, sheets, and other forms in transformers, and for washers and rings around many bolts and screws requiring insulation. Large disks and washers are used in every arc light and smaller ones in the sockets of incandescent lamps. Flexible mica-covered cloths and tape find varied uses in many pieces of electrical apparatus. The domestic mica is satisfactory for all insulation except for commutators of direct-current motors and for dynamos built up of bars of copper and strips of mica. For this purpose no mica is as satisfactory as the phlogopite or "amber" mica. This mica is of about the same hardness as the copper of the commutator segments, and therefore wears down evenly without causing the motor to spark.

Ground mica is used in largely increasing quantities for the decoration of wall paper, for the manufacture of lubricants, fancy paints,

[14] British Jour. Photography, June 16, 1916, p. 350.

rubber goods, molded mica, and roofing papers, and as covering for steam pipes. Finely ground mica is applied to wall paper to furnish luster and brightness. For this purpose wet-ground mica is the most satisfactory, because, it is claimed, the scales are cleaner and flatter than in the dry-ground product. Ground mica mixed with oil forms a good lubricant for axles and other bearings, and quantities are used for this purpose. For fancy and brocade paints ground mica is mixed with various pigments and serves the purpose of metallic paint. Many rubber goods contain finely ground mica used both as an adulterant and to furnish certain qualities desired in the rubber. Ground mica mixed with shellac or plaster is used in the form of "molded mica" for insulation of trolley wire and for similar supports. Tar and other roofing papers are coated with coarse flakes of "bran" mica to prevent sticking when they are rolled for shipment. Bran mica and coarser grades mixed with other materials furnish good fireproof and heat-retaining coverings for steam pipes and boilers. The value of mica packing for steam pipes and boilers has been shown by experiments.[15] R. Atkinson, mechanical superintendent of the Canadian Pacific Railway, found that the loss of heat resulting from the use of several different kinds of packing material around a 14-inch cube tank in which water had been brought to boiling and then allowed to cool was as follows:

Loss of heat in boiler packed with different heat-retaining materials.

Material.	Loss in 5 hours (°F.).	Temperature at end of 5 hours (°F).
Bare tank	84	128
Asbestos compound	53	159
Magnesia blocks	33¼	178½
Wood logging and air space	33¼	178½
Asbestos and wood	30	182
Mica	20	192

In experiments made by the Grand Trunk Railway on five locomotives protected by different materials, mica covering saved about 92 per cent of the heat radiated from a bare boiler and was about twice as efficient as sectional magnesia block covering.

Rather coarsely ground or "bran" mica is used in the manufacture of concrete facing material to give the effect of a finish of natural rock. This material is prepared in different ways, and various mixtures of other minerals, such as biotite, tourmaline, and hornblende, are used to heighten the effect.

Within the last few years a new mica product called "tung ash," has been placed on the market. The material is bronze-colored and

[15] Mica insulation for steam pipes and boilers: Engineering, London, Feb. 22, 1901.

is obtained by calcining a hydrated biotite mica found 5 miles southeast of Hecla, in the Turret Mountain mining district, Chaffee County, Colo. The mica as mined comes in rather dull brownish-black crystals or plates, which are flexible but inelastic. When heated these crystals expand or exfoliate greatly, and the mica assumes various tints of bronze with metallic luster. Tung ash should find a place for decorative uses.

GRADES.

Mica is graded differently by the different trades using it. The manufacturers using rough sheet mica grade it according to size as extra special, special, Nos. 1, 2, 3, 4, 5, 6, and punch. Extra special is rough sheet mica that will cut into sheets containing more than 48 square inches. No. 1 will trim into sheets containing 24 to 36 square inches. No. 6 includes mica from punch size to material that will cut sheets containing 3 square inches. Punch mica will yield disks 1½ inches in diameter. All mica too small for punching is sold as scrap for grinding.

Good, clear, light-colored sheet mica, with smooth cleavage, is sold as "stove" mica. Strongly colored, discolored, stained, and the rougher grades of mica are classed as "electric." Some of the finest stove mica is used in electrical manufacture. Stove mica is graded as A No. 1, No. 1, A No. 2, and No. 2, according to quality. A No. 1 is the best quality.

PRODUCTION AND IMPORTS.

Mica is of widespread occurrence in the United States. Deposits of commercial value or of promise have been found in 20 or more States. Large productions have been reported from North Carolina, South Dakota, New Hampshire, New Mexico, Idaho, Virginia, Colorado, South Carolina, Alabama, and Georgia. Other States in which mica deposits have been found are Maine, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Wyoming, Montana, Texas, Arizona, Utah, Nevada, and California. The distribution in the different States will be treated in the description of the deposits in those States.

Mica deposits occur in many other countries and have been mined in several of them. The most productive are India, Canada, British East Africa Protectorate, and Brazil. Other countries that have contributed to the world's production or that may do so in the future are South Africa, Ceylon, China, Japan, Argentina, Australia, New Zealand, Norway, and the Philippine Islands.

Only a few of the numerous varieties of mica have so far been used commercially, some of them because of their physical properties and others because they contain certain elements which can be profitably extracted from them, such as vanadium from roscoelite and lithium from lepidolite. This report considers only micas that are valuable because of their physical properties—muscovite, phlogopite, and biotite. Of these varieties muscovite and a very little biotite have been mined in the United States, but no phlogopite deposits of commercial value have been found here, the supply of this variety coming principally from Canada, though a little is received from Ceylon.

Mica produced in the United States, 1880–1921.

Year.	Rough trimmed and cut mica.		Scrap mica.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Short tons.*		
1880	81,669	$127,825	.....	.....	$127,825
1881	100,000	250,000	.....	.....	250,000
1882	100,000	250,000	.....	.....	250,000
1883	114,000	285,000	.....	.....	285,000
1884	147,410	368,525	.....	.....	368,525
1885	92,000	161,000	.....	.....	161,000
1886	40,000	70,000	1,000	$10,000	80,000
1887	70,000	142,250	2,000	15,000	157,250
1888	48,000	70,000	.....	.....	70,000
1889	49,500	50,000	196	2,450	52,450
1890	60,000	75,000	496	6,200	81,500
1891	75,000	100,000	.....	.....	100,000
1892	75,000	100,000	.....	.....	100,000
1893	51,111	80,629	156	8,300	88,929
1894	35,943	43,793	191	8,595	52,388
1895	84,408	50,381	148	5,450	55,831
1896	49,156	65,441	222	1,750	67,191
1897	82,676	80,774	740	14,452	95,226
1898	129,520	103,534	3,999	27,564	131,098
1899	108,570	70,587	1,505	30,878	101,465
1900	456,283	92,758	5,497	55,202	147,960
1901	360,060	98,859	2,171	19,719	118,578
1902	373,266	83,843	1,400	35,006	118,849
1903	619,600	118,088	1,659	25,040	143,128
1904	668,358	109,462	1,096	10,854	120,316
1905	924,875	160,732	1,126	17,856	178,588
1906	1,423,100	252,248	1,489	22,742	274,990
1907	1,060,182	349,311	3,025	42,800	392,111
1908	972,964	234,021	2,417	33,904	267,925
1909	1,809,582	234,482	4,090	46,047	280,529
1910	2,476,190	283,832	4,065	53,265	337,097
1911	1,887,201	310,254	3,512	45,550	355,804
1912	845,483	282,823	3,226	49,073	331,896
1913	1,700,677	353,517	5,322	82,543	436,060
1914	556,933	278,540	3,730	51,416	329,956
1915	553,821	378,259	3,959	50,510	428,769
1916	865,863	524,485	4,433	69,906	594,391
1917	1,276,533	753,874	3,429	52,908	806,782
1918	1,644,200	731,810	2,292	33,130	764,940
1919	1,545,709	483,567	3,258	58,084	541,651
1920	[a] 1,683,480	[a] 546,972	5,723	167,017	713,989
1921	741,841	118,513	2,577	56,849	175,362

[a] Uncut sheet mica only.

Mica imported for consumption in the United States, 1898–1921.

Year.	Sheet.				Ground.		Total.	
	Unmanufactured.[a]		Cut and splittings.[b]					
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1898	877,930	$115,930	78,567	$34,152	.....	.....	956,497	$150,082
1899	1,709,839	233,446	67,293	42,538	.....	.....	1,777,132	275,984
1900	1,892,000	290,872	64,391	28,688	.....	.....	1,956,391	319,560
1901	1,598,722	299,065	78,843	35,989	.....	.....	1,677,565	335,054
1902	2,149,557	419,362	102,299	46,970	.....	.....	2,251,856	466,332
1903	1,355,375	288,783	67,680	29,186	.....	.....	1,423,055	317,969
1904	1,085,343	241,051	61,986	22,663	.....	.....	1,147,329	263,714
1905	1,506,382	352,475	88,188	51,281	.....	.....	1,594,570	403,756
1906	2,984,719	983,981	82,019	58,627	.....	.....	3,066,738	1,042,608
1907	2,226,460	848,098	112,230	77,161	.....	.....	2,338,690	925,259
1908	497,332	224,456	51,041	41,602	.....	.....	548,373	266,058
1909	1,678,482	533,218	168,169	85,595	.....	.....	1,846,651	618,813
1910	1,424,618	460,694	536,905	263,831	(c)	1,298	(c)	725,823
1911	1,087,644	346,477	241,124	155,686	(c)	3,389	(c)	505,552
1912	1,900,500	649,236	88,632	99,737	[d] 343,824	6,611	(c)	755,584
1913	2,047,571	751,092	(c)	191,926	290,757	4,765	(c)	947,783
1914	360,888	168,591	(c)	456,805	404,848	4,088	(c)	629,484
1915	433,822	240,449	(c)	447,962	344,040	3,858	(c)	692,269
1916	703,832	421,856	(c)	646,080	362,000	3,420	(c)	1,071,356
1917	656,391	414,823	(c)	1,014,181	92,963	1,044	(c)	1,430,048
1918	741,429	658,576	(c)	880,906	11,587	1,647	(c)	1,541,129
1919	723,713	726,532	(c)	762,228	62	9	(c)	1,488,769
1920	1,298,537	1,177,943	(c)	2,011,434	.....	.....	(c)	3,189,377
1921	328,444	331,219	(c)	758,521	134,650	2,166	(c)	1,091,906

[a] Essentially trimmed sheets.
[b] Includes the Madras square-shaped uncut sheets.
[c] Quantity not reported.
[d] Figures for quantity cover only last six months of 1912.

DESCRIPTION OF MINES.

ALABAMA.

GENERAL FEATURES.

Some of the mica deposits in Alabama were worked by the aborigines, probably during the general prehistoric period in which mica was mined in North Carolina. These ancient workings are mentioned below in the descriptions of the Curley mine (p. 34), the Miller mine (p. 35), and mine No. 5 of the Great Southern Mica Co. (p. 32). The literature on the mica mines in Alabama is meager, and the details of the history of mining in the State are not easily learned. Residents of the mica region in Randolph County say that some of the mines there were worked about 1885. Other mines were opened in 1893,[16] when the remains of older mines were found near them. Oak trees 12 to 15 inches in diameter were growing on the dumps of these older mines, which may have been worked by earlier white miners or by aborigines.

Considerable work was done from about 1898 to 1900 by Hugh McIndoe around Pinetuckey, in Randolph County. The next period

[16] Eng. and Min. Jour., vol. 56, p. 145, 1893.

of activity in the same region extended from 1906 to 1908, when the Great Southern Mica Co. operated several mines. A few notes on this period have been given by W. F. Prouty [17] and H. D. McCaskey.[18] Since the Great Southern Mica Co. ceased operations mica mining in Alabama has been very intermittent. The largest output made in the State in recent years has come from the vicinity of Pyriton, in Clay County.

Mica deposits have been found in rather widely scattered areas in central eastern Alabama. The most productive deposits are in Randolph, Clay, and Tallapoosa counties, but other deposits have been found in Lee and Coosa counties. Most of these counties are in the Piedmont Plateau, but the western part of Clay County is broken by small mountain ridges. Some of the deposits are in the rolling, less-dissected parts of the plateau at a distance from the rivers; others are in the river valleys, where the relief is considerable.

In Randolph County mica deposits have been opened in a belt extending from a point near the old Micaville post office, on the north-central edge of the county, southward and southwestward down nearly to the forks of Tallapoosa and Little Tallapoosa rivers and across Tallapoosa River toward Lineville. In Clay County the principal deposits are in Shinbone Ridge, northeast of Pyriton, but other deposits have been prospected near Flat Rock and 2 miles south of Lineville. Still others are reported to occur in the Wicker Beat lands, near the southern edge of the county. In Tallapoosa County several deposits that lie 5 to 6 miles northeast of Dadeville have been worked recently. In Lee County prospects have been opened near Opelika and near Auburn. In Coosa County a prospect was opened some years ago near Hissop. These deposits were visited by the writer in the autumn of 1914. Work was in progress only near Pyriton, and it consisted of a test run at the old M. & G. Co.'s mine and of prospecting by J. Warren May. The mines near Dadeville were temporarily closed.

The rocks in the mica region consist of gneisses and schists mapped as crystalline schists by E. A. Smith,[19] and as distinct from certain other schists belonging to the Talladega formation (corresponding to the Ocoee of Arthur Keith), with which they are more or less associated. These crystalline schists are probably the same as the Carolina gneiss mapped by Keith in North Carolina. Large belts of these crystalline schists and parallel belts of the Talladega formation extend northeastward from the boundary of the coastal plain in Chilton, Elmore, Macon, and Russell counties across this part of Alabama into Georgia. The deposits in Lee and Tallapoosa coun-

[17] Mines and Minerals, vol. 28, p. 236, 1907.
[18] Notes on some gold deposits of Alabama: U. S. Geol. Survey Bull. 340, p. 46, 1908.
[19] Geological map of Alabama, Alabama Geol. Survey, 1894.

ties are in the largest area of crystalline schists mapped by Smith, and those in Randolph, Clay, and Coosa counties are in another large belt of the same rock.

The occurrence of the mica-bearing pegmatites in Alabama is very similar to that in other States in the South. The pegmatites occur in sheets, lenticular bodies, and irregular masses of varying thickness and length. They cut the inclosing gneisses and schists both conformably with and across their foliation. Many of the deposits in the less-dissected parts of the plateau have been affected by the general weathering of the rocks of the Piedmont Plateau, and their feldspathic contents are kaolinized to depths of 20 to 50 feet or more. Others in the deeper valleys below the plateau levels contain hard unaltered rock close to the surface.

The sheet mica from most of the deposits in Randolph and Clay counties has a clear rum color and good cleavage. Some of the deposits yield a large proportion of scrap mica, but most of the sheet mica is suitable for use in stoves. The deposits of Tallapoosa and Lee counties yield a slightly cloudy to specked mica, which is suitable chiefly for use in electrical work.

COOSA COUNTY.

JOHN H. THOMAS PROSPECT.

A prospect was opened for mica several years ago on the John H. Thomas place, 1 mile northeast of Hissop, or 10 miles southwest of Kellyton. The work done consisted of a small open cut and a short tunnel (now caved in) in a hillside. The country rock is biotite granite gneiss. Fishbone and A mica were left around the prospect, but sheet mica and a few beryl crystals were reported to have been found. Potash feldspar and massive quartz were the gangue minerals removed.

RANDOLPH COUNTY.

MINES OF THE GREAT SOUTHERN MICA CO.

A group of mica deposits were prospected and worked in Randolph County from about 1906 to 1908 by the Great Southern Mica Co. This company, after making preparations for extensive operations, moved to Asheville, N. C. A trimming plant and grinding mill were erected at Heflin, the railroad shipping point, about 20 miles north of the mines. Four or five deposits were opened in the Pine Tuckey region, and others were prospected several miles to the southwest, on the west side of Tallapoosa River. The company operated energetically for awhile, but was handicapped by much dead work in some of the places opened, by long hauls over poor roads to the railroad, and by a failure to find sufficient mica to keep the

large equipment going. Only part of the workings of this company were visited and these were in bad repair.

Mine No. 1.—Mine No. 1 of the Great Southern Mica Co. is 3¾ miles S. 25° E. of Pinetuckey in a westward-sloping hillside. It was worked by open cuts and shafts with tunnels and drifts running northeastward. The workings were in bad repair when examined, but consisted of a shaft 40 feet deep to water and reported to be more than 100 feet deep, at the northeast end of the workings, and two other shafts open to depths of 30 feet, which were sunk on the "vein" to the southwest. The position of the different workings is shown in figure 2.

The country rock is garnetiferous and kyanitic mica gneiss, which strikes northeast and dips southeast. The pegmatite is nearly conformable with the gneiss but locally cuts across its bedding. It varies in thickness from 18 inches at the southwest end of the workings to more than 8 feet near the middle and to at least 5 feet at the northeast end, where its full thickness is not exposed. The shafts and workings were sunk on an incline running about 70° SE., which probably represents the dip of the pegmatite. The "vein" either forks or is folded over to the southeast near the northeast end of the workings, where the open cut is widest. The formation is semidecomposed near the surface, but 20 feet below it is fairly fresh and hard.

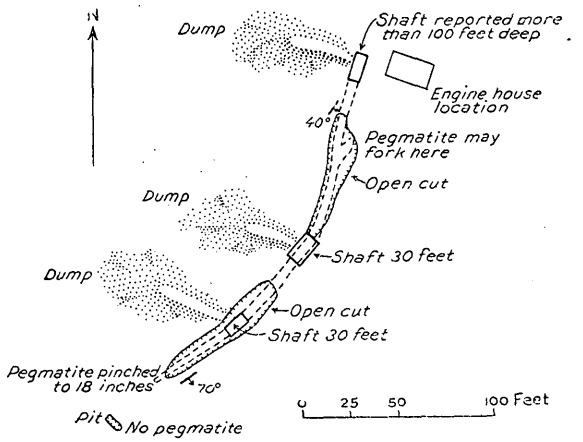


FIGURE 2.—Plan of Mine No. 1 of Great Southern Mica Co., 3¾ miles S. 25° E. of Pinetuckey, Randolph County, Ala.

The feldspar is at least in part of the potash variety, but it does not occur in large masses. Quartz is not especially prominent. Other minerals observed were biotite in plates 2 inches or less in diameter, bluish-green apatite, pink garnet, and black tourmaline. The muscovite mica is of fine quality and has a clear light rum color and excellent cleavage. Nothing could be learned of the quantity of mica the mine yielded.

Mine No. 2.—Mine No. 2 of the Great Southern Mica Co. is 3 miles S. 28° E. of Pinetuckey, in the west brow of a hill. Two shafts were sunk, one vertical and about 30 feet deep and the other 35 feet to the northwest on an incline of about 30° toward the first shaft. Pegma-

tite was followed in both shafts, but the relations to the kyanite mica gneiss could not be learned, as the shafts had caved badly. The principal vein mineral removed was semidecomposed potash feldspar. A little biotite was found and a few grains of pyrite were seen in the rock on the dump. Only small plates of mica had been left around, but these were of clear light rum color. This deposit probably did not yield much mica, for little work was done.

Mine No. 5.—Mine No. 5 of the Great Southern Mica Co. is 2 miles N. 35° E. of Pinetuckey. Here the aborigines dug a large irregular-shaped pit or open cut more than 60 feet across and 5 to 12 feet deep, around the mouth of which they piled the waste rock. The company has sunk numerous shafts with tunnels, open cuts, trenches, and pits, as shown in figure 3. The workings have caved so badly that the formations could not be studied in detail.

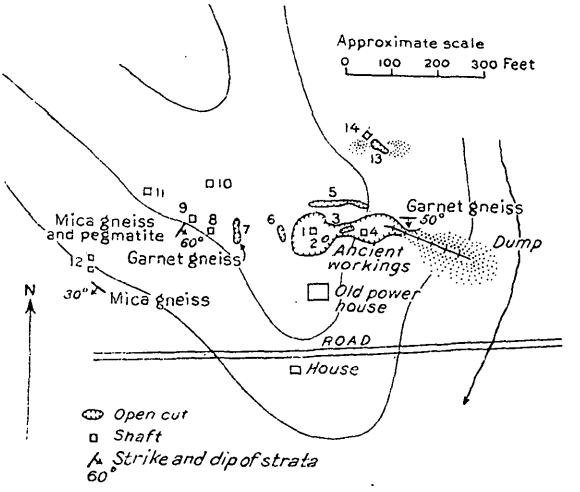


FIGURE 3.—Plan of Mine No. 5 of Great Southern Mica Co., 2 miles N. 35° E. of Pinetuckey, Randolph County, Ala. 1, Shaft 50 feet deep in ancient open cut; 2 and 3, cave-in of underground work between 1 and 4; 4, shaft 30 feet deep in ancient dump; 6, pit in ancient dump; 7, crosscut trench; 8, small pit; 9, inclined shaft, at least 30 feet deep; 10, incline about 20 feet deep; 11, shaft filled within 15 feet of the surface; 12, two shafts filled within 20 feet of the surface, water in one; 13, open cut in ancient dump; 14, shaft 18 feet deep.

The country rock is mica gneiss, kyanitic and highly garnetiferous in places, and the dip and strike differ at different openings. The strike varies from east to west and ranges from N. 60° W. to N. 40° E., and the dip is southerly. Evidently a large deposit of pegmatite was encountered in the ancient workings and in the deeper recent workings. (See 1 to 4, fig. 3.) This deposit has an easterly strike, and the north wall of garnet gneiss is apparently conformable with it. The pegmatite apparently pinches out toward the west, but gneiss was found in the crosscut trench. (See 7, fig. 3.) In the incline shaft (see 9, fig. 3) a pegmatite vein 10 feet thick, conformably inclosed in the gneiss, was tested. The formations at this place strike N. 40° E. and dip 60° SE. Pegmatite was also found in other workings (see 8, 10, 11, 12, and 14, fig. 3), but it seemed to be in disconnected masses.

The formations are decomposed to depths of 20 to 25 feet, below which the pegmatite is hard. This depth was probably the limit to which the aborigines could work. Besides quartz and feldspar the most abundant minerals associated with the mica are biotite and black tourmaline. The mica is of very fine quality and has a clear light rum color and smooth, flat cleavage.

HUGH McINDOE MINES.

Several deposits were prospected or worked by Hugh McIndoe, of Joplin, Mo., from 1898 to 1900. The principal one is a quarter of a mile west of Pinetuckey. Other prospects are about 2 miles N. 40° E. of Pinetuckey, or 300 yards S. 60° E. and 500 yards south of east, respectively, of mine No. 5 of the Great Southern Mica Co.

At the mine near Pinetuckey two shafts (one at least 50 feet deep), several pits, drifts, and inclines were made. The principal inclines extend from the surface east and south into the shafts. As the inclines had caved in it was not possible to reach the deep workings.

The country rock is mica gneiss, which strikes northeast and dips 20° SE. where measured at two places in the incline from the west. Several bodies of pegmatite were cut in the workings and all were approximately conformable with the inclosing gneiss. The exposures of the pegmatite in the workings still open ranged from less than a foot to several feet in thickness. The mica obtained was of fine quality and had a clear light rum color and good cleavage. Mr. Charles Liner, who worked in the mine, states that the veins yielded well.

At the prospect 300 yards southeast of mine No. 5 an irregular open cut 15 feet deep and about 25 feet long was made in a northeasterly direction and an arm was carried from it southeastward about 15 feet. A 35-foot shaft was sunk 15 feet southeast of the open cut. About 30 feet northeast of the open cut is an ancient pit.

The country rock is garnet gneiss, which strikes N. 45° E. and dips 50° SE. It incloses, almost conformably, beds of pegmatite, one of which was worked in the northeast part of the arm run from the open cut and another in its southeast part. This second bed of pegmatite is 10 feet thick and is probably the one encountered in the shaft to the southeast. Smaller streaks of pegmatite fork from the larger ones.

Several prospective pits have been opened about 300 yards east of this open cut, but little could be seen of the formations encountered. The country rock around these prospects is also garnet gneiss. The mica found in all the above prospects has a clear light-rum color and flat cleavage. Only small crystals had been left exposed in the workings or on the dumps.

CURLEY MINE.

The Curley mine is 1¾ miles north by east of Pinetuckey. Remnants of ancient pits and dumps were found near the modern workings made by Horner & Phillips. The workings consist of a good-sized open cut and several pits and shafts. A 50-foot shaft 75 feet southeast of the main workings and a 25-foot tunnel to the north failed to cut the pegmatite.

The country rock is garnet gneiss, which strikes N. 70° E. and dips 45° SE. The pegmatite is about conformable with the bedding of the inclosed gneiss. Only a few feet of the pegmatite is inclosed but it is probably 8 to 10 feet thick. A cross section of the part exposed in the east end of the open cut shows the following from south to north. A 2-foot vein of quartz along the south wall, 2 to 3 feet of kaolinized feldspar carrying mica, and a 3-foot streak of massive mica composed of A, wedge, and fishbone crystals 1 inch to 4 inches across with intermixed quartz. A streak of quartz is inclosed in the middle of the pegmatite in the west end of the cut.

From an examination of the dumps it is evident that some good, clear, light-colored mica with smooth cleavage was obtained. Weathered sheets of such mica 4 to 5 inches across were seen. The massive or solid mica is suitable for grinding, but the ground product could not be marketed until transportation facilities are improved.

PHILLIPS MINE.

The Phillips mine is half a mile southwest of the old Micaville post office and 2½ miles north of Pinetuckey. A dozen or more pits and open cuts and a shaft 50 feet deep were made in an area 20 yards wide by 120 yards long in a N. 30° W. direction. The deep shaft is a few feet north of an open cut at the southeast end of the area. This cut is 50 feet long by 6 to 18 feet wide and 2 to 10 feet deep. All the other workings are smaller.

The country rock is kyanitic and garnetiferous mica gneiss, which strikes east and dips 30° S. as measured in one of the prospects. About 200 yards north of the mine the gneiss strikes N. 10° W. and dips 35° W., which corresponds more nearly with the strike of the pegmatite in the mine workings. Both the gneiss and the pegmatite are decomposed and, as shown by the deep shaft, this decomposition extends as deep as 50 feet in places. Masses of quartz, some of them as much as 6 feet thick, were encountered in the workings. Mica occurs in large masses or bunches of A, wedge, and small ruled crystals along the bodies of quartz. One of these masses exposed is 10 feet thick. They contain variable quantities of quartz and some kaolinized feldspar but will probably average 75 per cent

mica. This material would be suitable only for grinding as scrap mica, and if the deposit were near the railroad it could be worked profitably for that purpose. The largest sheet mica seen would be suitable only for punching. Mr. Charles Liner states that good-sized sheet mica was obtained during mining. The dumps contain a number of tons of scrap mica that could be screened out if better transportation facilities were available.

Another prospect was opened 120 yards S. 20° W. of the shaft. Pegmatite containing small crystals of mica was exposed in this prospect.

MILLER MINES.

Several deposits have been tested or worked on the Miller place, 2½ miles north by west of Pinetuckey. One of these deposits was worked by the aborigines, though remains of more recent work is seen around it. The ancient work consists of an open cut 75 feet long in a northeasterly direction, 40 feet wide, and 10 feet deep, with 8 feet of waste reported in the bottom. The dumps are piled around the edge of the cut, and trees of considerable age are growing in them. In one place an oak tree 2½ feet thick is rooted in the dump. Recent prospects consist of a shaft 45 feet deep in the cut with a drift to the southeast and a pit opened in the southeastern side near the middle of the cut. These workings encountered pegmatite but failed to disclose any considerable body of mica.

An open cut 20 feet across and 5 to 10 feet deep, which was opened about 75 feet northeast of the ancient work, exposed pegmatite that looked promising. Another prospect pit 12 feet deep was opened 100 feet east of the ancient cut. Kaolin and small mica were found at this place.

In a wooded flat or valley bottom about a quarter of a mile southwest of the large ancient working there are several pits and shallow shafts. An exposure of garnet gneiss with interbedded pegmatite in a pit on the southwest side of the workings strikes N. 30° E. and dips 25° SE. The formations exposed in the other openings appeared to lie nearly flat, showing only gentle low folds. In these shallow workings the feldspar of the pegmatite is mostly kaolinized. Weathered crystals of mica 6 inches across were left on the dumps after the last work.

The mica from the openings on the Miller place is all of good quality and has a clear light rum color and flat cleavage.

KNUTT MINE.

The Knutt mine is about 1½ miles north of Pinetuckey. The workings consist of an open cut 30 feet long and a tunnel 30 feet long extending from it N. 70° E. A pit was made 35 feet east and a tun-

nel was driven northwest from a point 100 feet east of the workings, but no vein material was found. Near the modern workings there are ancient pits and dumps covered with vegetation.

The country rock is mica gneiss and is in places garnetiferous. It incloses the pegmatite in approximate conformity with its bedding, both striking about N. 70° E. and dipping 45° SE. The pegmatite occurs in streaks 1 foot to 3 feet thick, which in places bulge out into thicker masses. Thin horses of wall rock are inclosed in the thicker parts. Bunches or pockets of mica occur in the bulges of the pegmatite, especially the knarled masses of A, fishbone, and wedge mica crystals which the local miners call "horsetail" mica. Good sheet mica of clear light rum color was found in the larger beds of pegmatite.

CAMPBELL MINE.

The old Campbell mine, owned by Horner & Phillips, is about 1½ miles west by north of Pinetuckey. This mine was worked about 1885 by several open cuts and pits and is reported to have yielded a quantity of good mica. A trimming plant was erected and 8 or 10 people were employed in splitting and trimming the mica. The country rock is garnet gneiss, which strikes northeast and dips southeast. The pegmatite, which strikes N. 40° E. and dips 20° SE., is probably more than 12 feet thick. It incloses horses of garnet gneiss, one of which had been turned out of the usual parallel relation with the wall rock to a strike of N. 10° W. and a dip of 30° E. The mica is of fine quality and has smooth cleavage and a clear light rum color. Sheets 4 to 6 inches across were seen around the workings.

Other outcrops of pegmatite were observed to the southwest adjoining the old Knopf place.

KNOPF MINE.

Six prospects were examined on the old Knopf place, now belonging to Thomas Morrison and the Wills heirs, about 1½ miles west of Pinetuckey. The prospects are simply pits, most of them rather small, scattered over several acres. The country rock around the prospects is garnet gneiss and mica gneiss. The outcrops observed showed a northeasterly strike and a southeasterly dip. Most of the pegmatites opened are small, ranging in thickness from 1 foot to 2 feet, but one deposit is 6 to 8 feet thick and outcrops for more than 100 feet in a direction N. 10° W. All of the prospects yielded clear light rum-colored mica with good cleavage, but most of it was in small crystals. Mica crystals 5 and 6 inches across were observed in one of the prospects.

C. H. BOYD PROSPECTS.

Several prospects were opened on the land of C. H. Boyd, 2½ miles south of Pinetuckey. Most of these prospects are about half a mile northeast of Mr. Boyd's house; four are on one hill within a few hundred yards of each other, another is about 200 yards southeast and still another is about 400 yards southeast of this hill. The one last indicated was opened by a small cut 15 feet across and a 25-foot shaft a short distance to the south. Here a pegmatite vein about 3 feet thick cuts the kyanitic mica gneiss country rock almost conformably with its bedding—that is, it strikes N. 60° E. and dips 40° SE.

At the other prospects still less work was done and at some of them only pits about 3 feet deep were dug. In the prospect 200 yards southeast of the hill a promising show of mica, with crystals 3 to 4 inches across, was found near the surface in a vein of pegmatite about 3 feet thick. This vein was cut off at a depth of about 8 feet by a slickensided fault. In a prospect at the southwest foot of the hill a 15-foot shaft was sunk to a 3-foot vein of pegmatite cutting kyanitic mica gneiss. A considerable quantity of mica crystals 2 to 3 inches across was taken from this prospect. Among other minerals found were potash feldspar, bluish-black tourmaline, bluish-green apatite in elongated crystals, and pinkish garnets. The other prospects on this bill yielded similar tourmaline and apatite; one of them yielded gray potash feldspar that showed beautiful regular perthitic banding in nearly parallel layers.

From these prospects about 2,000 pounds of the best mica was shipped, leaving 5 or 6 tons of rough mica suitable for scrap and for trimming into sheets measuring 2 by 3 inches and punch sizes. The mica has been obtained from a point near the surface and part is clay-stained from surface weathering. The mica that is not so stained is of good quality and has a clear light rum color and flat cleavage.

LANDERS & AYRES PROSPECT.

A prospect owned by G. V. Landers and J. D. Ayres, of Newell, Ala., was opened on the west side of the public road 1¾ miles south of Pinetuckey. The work consists of an open cut 60 feet long and 2 to 10 feet deep, driven west into the hillside, and a pit about 100 feet to the south in another deposit of pegmatite. The country rock is mica gneiss, which strikes east by north and dips southward. The pegmatite is approximately conformable with the gneiss. It is several feet thick and incloses a vein of massive quartz about 1 foot thick. The largest sheets of mica seen were 3 to 4 inches across. Some of these had the A structure and some contained a few small specks. Most of the flat sheets were clear and rum-colored.

C. L. HOLMES PROSPECT.

Several small prospects have been opened on the land of C. L. Holmes, a little more than 4 miles south by east of Pinetuckey, southwest of the road leading to Rice Mill. The prospects are on the summit and the northeast side of a hill that rises about 200 feet above the valley that the road traverses. The country rock is kyanitic mica gneiss, which strikes N. 30° E. and has a nearly vertical dip. The pegmatite has decomposed badly and is heavily stained with iron oxide near the surface. Coarse, dark-red fractured garnets half an inch to 1½ inches in diameter were seen in one of the prospects. Some small mica that would yield material suitable for punching and some that would cut sheets 2 by 3 inches was taken out of the prospects. This mica has a clear rum color and a smooth flat cleavage, but much of it is clay-stained from the surface weathering of the inclosing pegmatite.

Mica prospects are reported to have been opened on the land of S. A. Creed, about half a mile southeast of the Holmes prospects.

MINES OF RANDOLPH MICA CO.

The Randolph Mica Co. owns three mines near McInnish Ferry, 10 to 11 miles N. 70° E. of Lineville on the east side of Tallapoosa River, and 7½ miles S. 17° W. of Pinetuckey. Douglas Smith, of Wedowee, and Dallas Smith, of Opelika, represent the company and operate the mines. The last work was done in June, 1914. The only working examined is on the road about a quarter of a mile northeast of McInnish Ferry. The other workings are reported to be larger than this, but no guide was available to show them. The company has a plant equipped with punches and trimming shears near one of the other workings. The working examined consists of an open cut 40 feet long, 10 to 12 feet wide, and 15 feet deep driven N. 40° E. through the roadway into a hillside. The cut was later bridged over for the road.

The country rock is kyanite gneiss, which strikes northeast and dips southeast. The relation of the pegmatite to the gneiss is variable. The pegmatite appears to be a blanket ledge, which strikes N. 50° W. and dips 25° SW., outcropping on the hillside below the road. A fork or prong of the pegmatite 3 feet thick cuts through the gneiss vertically to the surface and in mining was followed into the larger underlying mass. The pegmatite includes segregations of quartz, one of which measures 6 feet across. The feldspar is fresh and hard and the crystals of mica are clean and free from clay stains. The largest crystals seen in the pegmatite were 3 to 4 inches across, but sheets 8 by 10 inches are reported to have been obtained from the best of them. Plates of mica shown to the writer by Mr. Dallas

Smith, at Opelika, were several inches across and of the same fine quality as the small crystals at the mine—that is, clear light rum-colored, and having a smooth, flat cleavage.

WILLIAM FOSTER PROSPECT.

The William Foster prospect is 11 miles N. 55° E. of Lineville, west of Tallapoosa River. It was tested by the Great Southern Mica Co., but no regular mining was undertaken. The workings consist of an open cut on the summit of a ridge, another open cut and a tunnel about 100 yards northeast, at the end of the ridge, and a prospect in the hillside north of the first open cut. The open cut on the summit is 40 feet long, extends N. 45° E., and is reported to have been 25 feet deep but is now nearly filled by caving. The tunnel in the end of the ridge extends about 40 feet southwestward into the ridge.

The country rock is kyanitic garnet gneiss, which strikes N. 45° E. and dips 45° SE. At least three bodies of pegmatite were opened in the different prospects. They are approximately, if not entirely, conformable with the bedding of the inclosed gneiss. The pegmatite in the cut on the ridge is 5 to 6 feet thick but pinches down until very thin at the northeast end. A quantity of good mica is reported to have been found here in this prospect. The cut in the end of the ridge exposed a body of pegmatite 2 feet thick. The pegmatite at the entrance to the tunnel is also 2 feet thick, but it pinches down smaller inside. Mica crystals 2 to 3 inches in diameter were seen in these workings. All the mica has a clear light rum color. Other prospects have been opened in the neighborhood.

N. M. McINNISH PROSPECTS.

Two prospects were opened on the land of N. M. McInnish, 10 miles N. 70° E. of Lineville, west of Tallapoosa River. One of these was a quarter of a mile northeast of the house on a hill, and the other was the same distance southeast of the house on the river bank. At the northeast prospect a pit 7 feet deep exposes a pegmatite 6 feet thick with included bands or horses of the gneiss wall rock striking northeast. In the prospect on the river bank another pegmatite outcrops with a northeast strike in the kyanite gneiss country rock. Only small crystals of mica were seen at each prospect, but plates as large as a man's two hands are reported to have been found in the prospect on the river. The small crystals were of clear rum color and had smooth, flat cleavage.

J. B. MOTES PROSPECTS.

The J. B. Motes prospects are 11 miles N. 63° E. of Lineville, west of Tallapoosa River. One prospect is 50 yards east and the other

300 yards west of Mr. Motes's house. At the east prospect there is a 15-foot shaft and a prospect pit 50 feet northeast of it and at the west prospect a pit 6 feet deep. The country rock is kyanitic mica gneiss, which strikes northeast and dips southeast at both prospects. In the east prospect there is a 4-foot "vein" of pegmatite. It contains a quantity of small mica in the part exposed, and one block was seen that weighed 14 pounds and was more than 6 inches thick, but the vein would not yield sheets larger than 2 by 2 inches. A quantity of small mica crystals were thrown out from the west prospect. Black crystals of tourmaline, the largest 2½ inches in diameter, were also found in the pegmatite in this prospect. The mica from both prospects has a clear light rum color and good cleavage.

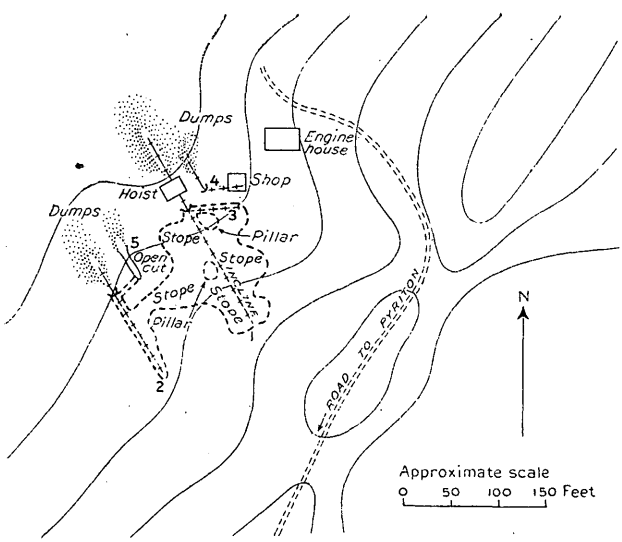


FIGURE 4.—Plan of M. & G. Co.'s mica mine, 2½ miles northeast of Pyriton, Clay County, Ala.: 1–4, Inclines; 5, open cut.

M. & G. CO.'S MINE.

The M. & G. Co.'s mine is about 2½ miles by road northeast of Pyriton. This mine has been worked more systematically and on a larger scale than any other mica mine in Alabama examined by the writer. At the time of visit it was operated under lease by the Producers Mica Co., of Chicago. Since then the ownership of the mine has passed to William L. Halliday, of Chicago.

The mine is on the steep west slope of a narrow part of Shinbone Ridge about 75 feet below the summit. It was equipped with an engine house, shop, hoisting frame, pumps, air drills, tracks, and mine cars and was worked chiefly by inclines and by stopes extending from them. The main central incline (1, fig. 4) is 150 feet deep on a slope of about 30° SE. Incline 2 is 100 feet deep and incline 3 is 40 feet deep. Large stopes were made on each side of the main incline and were connected with smaller stopes by inclines 2 and 3. Pillars were left in the stopes where necessary, but few were required, as the roof does not cave badly. At the time of visit the bottom of incline 3 was used as a sump from which to pump for the upper mine workings. Incline 4 was sunk 30 feet deep, but no stop-

ing was done from it. At 5 an open cut was made and a short incline extended from the inner end down to the mouth of the main incline.

The country rock is metamorphic schist and gneiss. Both were removed in mining where dead wall rock had to be cut. These rocks are dark gray to grayish black when fresh. One specimen collected on the dump is fine porphyritic schist containing a groundmass of quartz, biotite, and muscovite, inclosing phenocrysts of quartz, feldspar, and greenish muscovite 3 to 6 millimeters across. This specimen contains scattered small grains of a sulphide, probably pyrite, and a little graphite around some of the phenocrysts. Another specimen of similar rock has "pyrite suns" one-half to one centimeter in width along a joint-plane surface. Another specimen is lighter colored and coarser grained, muscovite forming most of the phenocrysts. This specimen contains many crystalline graphite scales.

The schist and gneiss strike N. 45° E. and dip 30° SE. The pegmatite is conformable with the bedding of the inclosing rock. It ranges from 2 feet thick at incline 4 to 8 feet thick at a depth of 125 feet on the main incline. A streak or bed of schist ranging from a few inches to 2 feet thick is inclosed in the pegmatite parallel with its walls. The formations are rather regular in strike and dip, so that little difficulty has been experienced in following the "vein." The pegmatite is rather fine grained. In places it is partly banded, especially near the walls. The crystals of feldspar range in thickness from less than 1 inch to 4 inches and include both plagioclase and microcline. Minute pink garnets in scattered grains and bunches more than an inch thick occur in places in the pegmatite.

The mica from this mine is of the finest quality, having a clear rum color and a smooth, flat cleavage. At the time of examination rough crystals 4 to 6 inches across formed the bulk of the output, but some large blocks are found. As these crystals are of good quality and have clean edges the waste from trimming them would be very small. A short time before the examination a block weighing 130 pounds and measuring 14 by 16 inches across the cleavage was found in the bottom of the main incline. This block would have yielded a number of 4 by 6 inch sheets of perfect quality. The Producers Mica Co. is reported to have taken out 27,000 pounds of rough crystal mica in November, 1914.

Another mine, the McNamara, has been developed on a fairly large scale about a mile west of the M. & G. Co.'s mine and it is reported to be on a promising deposit with a well-defined vein somewhat like that of the M. & G. Co.'s mine, but it was not examined.

Other mica prospects have been taken up in the same general region in Clay County by the Southern Mica Co., of Birmingham, Ala. These prospects are on the properties of W. D. Dye, J. W. Hunter, J. W. Smith, and J. W. Brown. None of them was visited, but Mr. George H. Clark, a mining engineer, reported them favorably to the company.

Other prospects occur in the same region. One of these, owned by I. W. Ray, of Pyriton, is about half a mile northeast of the M. & G. Co.'s mine. Small prospects were observed along the road half a mile to the southwest.

J. WARREN MAY MINE.

J. Warren May, of Quenelda, Ala., opened a mica deposit near Flat Rock, about half a mile southeast of Pyriton, in the east side of a small steep valley. Two shafts, one 30 and the other 18 feet deep, 60 feet to the northeast, were opened at the time of examination. The country rock is mica gneiss, which strikes N. 45° E. and dips 60° SE. The pegmatite veins are conformable with the gneiss. In the 30-foot shaft there are two parallel pegmatites, one 2 to 3 inches thick and the other 1 foot thick separated by 1 foot of gneiss. In the 18-foot shaft the pegmatite is more than 3 feet thick at the surface and just 3 feet thick at the bottom. It incloses small streaks or horses of gneiss parallel with its walls. Mica was found in all the veins of pegmatite, even in the 2-inch vein. Most of the mica taken out at the time of examination was small but had a clear rum color and smooth, flat cleavage. Mica crystals 6 to 8 inches across are reported to have been taken out of the 3-foot pegmatite.

GIBBS LUBRICATING CO.

Several prospects were tested by the Gibbs Lubricating Co., of Lineville. One of these is 2 miles S. 15° E. of Lineville, along the property line of G. E. Moore and S. M. Cotney, and the other is near Flat Rock, half a mile southeast of Pyriton, on the land of J. S. Robertson. In the prospects near Flat Rock several pits and a shaft 30 feet deep were very irregularly made in soft earthy formations. The country rock is interbedded hornblende gneiss and mica gneiss, which has been decomposed to soft saprolite near the workings. The pegmatite is approximately conformable with the bedding of the gneiss, striking northeast and dipping southeast. It is large, probably more than 10 feet thick, but the whole thickness is not exposed. The feldspar has thoroughly kaolinized. Quartz occurs in large segregations, one of which is 3 feet thick where exposed. A streak of mica crystals lies next to the quartz. Only small mica that would cut into sheets 1 to 2 inches square was seen, but it was of clear rum color and good cleavage.

At the prospect 2 miles south of Lineville 2 shafts were sunk about 20 feet deep and 35 feet apart. These developed a mass of pegmatite with an irregular east and west strike and nearly vertical dip. The pegmatite incloses an irregular-shaped vein of quartz parallel with its walls. Bunches and scattered pockets of mica occur next to the quartz vein. Most of these pockets of mica consist of A, wedge, and bunched mica, but a little clear flat rum-colored mica is found also.

TALLAPOOSA COUNTY.

MINES OF TALLAPOOSA MICA CO.

In 1915 the Tallapoosa Mica Co. took over the operation of three mines which had been worked by N. L. Baxter, of Dadeville, Ala. Two of these mines were worked during 1914 by Mr. Baxter and were visited by the writer at a time of temporary idleness. These are the Nelson Ware mine and the Berry mine and are described below.

NELSON WARE MINE.

The Ware mine is 6⅓ miles N. 37° E. of Dadeville, in a small but prominent hill. More than 30 prospect pits and shafts with irregular tunnels and underground workings have been made. The country rock is kyanitic mica gneiss. The pegmatite forms a large part of the summit of the hill and measures more than 100 yards north and south and 75 feet east and west. At the time of examination the deepest shafts were about 35 feet and the feldspar of the pegmatite is kaolinized to that depth. The workings are grouped about an outcrop of massive quartz, about 80 yards long and 50 feet wide, which forms the summit of the hill. The relations between the pegmatite and inclosing gneiss were not well exposed.

Most of the mica is scattered through the feldspathic content of the pegmatite in bunches or pockets and in single crystals that lie close to the quartz, but part of it occurs in the quartz and along the gneiss wall rock. Some of the pockets are evidently large, for much mica was removed from small workings. At the time of examination 15 to 20 tons of mica had been mined and was held ready for shipping. This rough mica should have yielded at least 2 tons of sheet mica and the rest should have been suitable for grinding. Much of the mica suitable for sheets would have trimmed to 2 by 3 inches, a fair proportion to 3 by 4 inches, and some larger than 4 by 6 inches. The mica is dark greenish-brown and is somewhat clouded with minute black specks of magnetite and small thin plates of pale-green mica or chlorite. Some of the mica might be classed as of inferior stove grade, but the bulk of it is best adapted to electrical uses.

MRS. I. T. BERRY'S MINE.

Three deposits of mica were opened on the property of Mrs. I. T. Berry, 5½ miles N. 30° E. of Dadeville. The principal one is about 100 yards northwest of the house in a field; the next in importance is on the main road about 200 yards northeast of the first deposit; and the third, of doubtful value, is on the east side of the road about 50 yards northeast of the house. At the principal deposit 5 shafts were sunk, and underground workings were extended from them. The underground workings are very irregular, and as the owner was installing a gasoline engine preparatory to more regular operation at the time of visit the mine was idle and many of the workings could not be examined.

The country rock is kyanite gneiss and has a general north to northeast strike and an east to southeast dip but is locally nearly horizontal. The pegmatite is at least 8 feet thick and appears to be in part conformable with the inclosing gneiss. In one exposure it has a dip of 30° E. The pegmatite and inclosing gneiss are decomposed and soft except where greisen-like masses of quartz and mica have resisted weathering. In some places the mica is bunched thick in the pegmatite and in others there are only scattered crystals. The mica has a greenish-brown color and part is specked. Some of it occurs in sheets of good size, and the largest crystals seen would yield sheets 4 by 5 inches. A quantity of scrap mica was scattered over the dumps and probably several tons could be screened out.

At the prospect on the west side of the main road there was a 20-foot shaft, from the bottom of which an incline extended northeastward under the road. A large deposit of decomposed pegmatite in kyanitic mica gneiss was encountered. About a ton of solid thick blocks of rough mica had been left out. Most of it was small and would yield chiefly punch and scrap material.

LOUIS TAYLOR PROSPECT.

A little prospecting was done on the property of Louis Taylor, 7 miles N. 40° E. of Dadeville. At one place there was an 18-foot shaft from which a short drift was run to the east. The shaft was sunk in decomposed kyanitic mica gneiss and the drift cut pegmatite, which was also decomposed. About 2 tons of rough mica, most of it scrap but some of it in sheets suitable for punching, had been left on the dump. This mica has a brownish to rum color and most of it contains a few small specks, though some is clear.

McCRAY PROSPECTS.

Two prospects were opened on the McCray place 5 miles N. 25° E. of Dadeville. Both are on the west side of the main road; one about

125 yards northwest of the house on a knoll and the other about a quarter of a mile northeast of the house. Both prospects are associated with the large outcrops of massive quartz. The prospect that makes the best showing lies northwest of the house, where a large deposit of quartz crops out, extending N. 20° W. along the summit of the knoll. The blocks and boulders of quartz cover an area about 225 feet long and 30 to 40 feet wide. A few boulders of opaque pale-rose quartz were observed in this outcrop. Mica was found in decomposed feldspathic material at both ends of the quartz outcrop, but the best showing was in an 18-foot shaft and in two pits at the southeast end, where partly clay-stained mica crystals 8 inches across were found. This mica has a dark-green color and is heavily specked with small black and red oxides of iron between the laminae. The mica splits well and has soft, flexible sheets.

Only a little mica was found in the two pits made near the quartz in the northeast prospect.

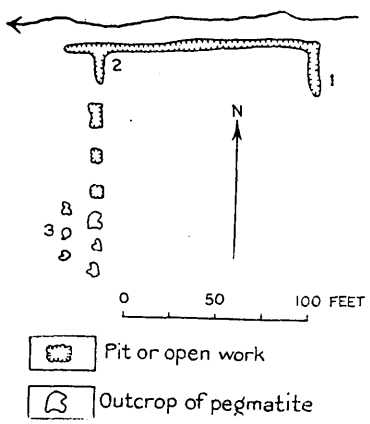


FIGURE 5.—Plan of T. H. Clower mica prospect, 2½ miles north of Opelika, Lee County, Ala.

T. H. CLOWER PROSPECT.

A prospect was opened on the land of T. H. Clower, 2½ miles north of Opelika. Much dead work was done and further prospecting would be required to prove the value of the deposits. A long trench was cut along the south side of a branch with two arms or trenches projecting from it to the south. Two other small prospect pits were made south of the west arm.

The country rock is fine-grained biotite gneiss or graywacke with interbedded coarse mica schist. The strike of these beds is chiefly north and the dip is west, but locally they lie nearly horizontal. About 15 feet of pegmatite having a maximum thickness of 7 feet is exposed in the east cut. (See 1, fig. 5.) The pegmatite pinches out toward the south and pitches under the biotite gneiss toward the north. It contains quartz segregations, one of which where exposed is 2 feet thick, and potash feldspar crystals several inches across. Mica crystals 5 inches in diameter were also observed in the pegmatite.

In the west cut, at 2, a regular vein of pegmatite about 5 feet thick has been opened. This vein has been traced by pits and outcrops more than 100 feet up the hill to the south. In places it con-

tains a quantity of small mica crystals bunched together and but little intermixed with quartz or feldspar. This material would yield mica suitable for grinding. No pegmatite was found in the long trench between 1 and 2. At 3 another row of pegmatite outcrops indicate a third vein, but these may be part of the same vein as those south of 2, brought to the surface by folding. The pegmatite in most of the openings and outcrops is hard and but little decomposed.

About 4,000 pounds of rough mica, which would yield possibly 10 per cent of sheet ranging from punch size to 3 by 4 inches, was taken from the openings. The mica would be suitable for electrical uses, but because of a slight clouding, due to inclusions, it would yield only an inferior grade of stove mica.

YARBOROUGH, SMITH, AND NEIGHBOR PROSPECT.

A small prospect was opened by F. L. Yarborough and Dallas Smith, of Opelika, and R. Neighbor, of Auburn, 2½ miles N. 10° E. of Auburn. The prospect consisted of a pit 8 by 12 feet and 6 feet deep. The country rock is decomposed, coarse biotite, schist, or gneiss, which incloses lenses of pegmatite about conformable with its bedding. The gneiss strikes N. 45° W. and dips 35° NE. A lens-shaped mass of pegmatite was opened by the prospect, but a thickness of only 6 inches was exposed in the bottom of the pit at the time of examination. This mass of pegmatite was reported to have been several feet thick near the surface. In places there was no feldspar in the pegmatite, which at this prospect was composed of intermixed coarse muscovite mica and quartz. This mixture graded into the coarse biotite schist wall rock. A surprisingly large quantity of mica was taken out of the prospect, some of the crystals of which measured 7 to 8 inches across and would yield plates 2 by 3 and 3 by 3 inches. The mica is partly specked and slightly clouded with fine, light-colored inclusions. These inclusions appear to be large numbers of minute blisters, each one showing Newton interference rings. The mica splits well but is somewhat brittle.

A prospect yielding mica of a similar quality was opened on the land of Mr. R. Neighbor, half a mile northwest of the Yarborough, Smith, and Neighbor prospect.

ARIZONA.

The occurrence of mica in Arizona has been known for many years. In 1884 F. W. Clarke[20] reported that it was known but not worked. Occasional inquiries about mica have been received from Arizona by the Geological Survey, but no valuable deposits have been reported. During 1914 Dr. Burt Ogburn, of Phoenix, sent in speci-

[20] Mica: U. S. Geol. Survey Mineral Resources, 1883–84, pp. 906–912, 1885.

mens found near Buckeye, Maricopa County, in the mountains on the south side of Gila River. The rough sheets of this mica measure 4 to 5 inches across but have been so much crushed that none of them would yield material larger than punch size. This mica has a clear yellowish-green color where it is free from surface clay stains.

The mica belt in the Virgin Range, in southern Nevada, is said to extend north by east from Nevada into Arizona, but there has been no report of the opening of any prospect on the Arizona side.

Specimens of the sericite schist variety of muscovite found in that region were sent to the Geological Survey by Sterling C. Lines, of Glendale, Ariz. This variety is very similar to the sericite schist from the region around Jasper, Ga., described by S. L. Galpin.[21] The Georgia sericite schist has been used, after crushing and bolting, for some of the purposes to which ground mica is applied. Industrial companies have experimented with the Georgia material in an effort to discover a source of both potash and aluminum, and a partial analysis of the Arizona sericite schist was made with this object in view by A. A. Chambers, of the United States Geological Survey, with the result shown below.

Partial analysis of sericite schist from Glendale, Ariz.

[A. A. Chambers, analyst.]

	Per cent.
SiO_2	46.10
Al_2O_3 (+TiO_2, P_2O_5, etc.)	36.34
Total iron	2.48
Na_2O	2.11
K_2O	10.01

This analysis corresponds rather closely with that of the Georgia rock, both containing over 10 per cent of potash and 34 per cent of alumina.

The schist has a silvery, greenish-gray color, is foliated and has a crinkled structure. A number of the cleavage surfaces show small ripple-like folds in two directions. Some of the specimens have a few flattened lenses of quartz lying parallel with the schistosity; others, probably from the border of the bed of pure sericite schist, contain rather numerous phenocrysts of both quartz and feldspar with the sericite wrapped around them.

CALIFORNIA.

GENERAL FEATURES.

So far as can be learned the only serious attempt to mine mica in California was made by the Mount Alamo Mining Co., at a place in

[21] A preliminary report on the feldspar and mica deposits of Georgia: Georgia Geol. Survey Bull. 30, pp. 153–155, 1915.

Ventura County, from 1902 to 1904. Prospects have been found at other places, and according to reports a little mining was attempted at some of them.

F. W. Clarke[22] in 1884 mentioned the occurrence of mica deposits near Gold Lake, Pluma County; in the Ivanpah district, San Bernardino County; near Susanville, Lassen County; near Tehachapi Pass, Kern County; in the Salmon Mountains, Siskiyou County; and in Eldorado County. The deposits of the Salmon Mountains were tested in 1885 but without good results.

A deposit was reported as being tested on the land of George Simmons, 6 miles west of California Hot Springs,[23] Tulare County, in 1903. In 1902 mica deposits were reported 6 miles east of Soledad,[24] Monterey County. According to the lithologic map compiled by G. A. Waring,[25] the rock formations 6 miles east of Soledad are of comparatively recent age, chiefly Cretaceous or Tertiary, in which one would not expect to find mica deposits. The same map shows an area of granitic rocks including gneisses and schists, in which mica-bearing pegmatites might occur, within 6 miles west of Soledad.

According to the State mineralogists[26] 50 tons of mica was produced in California in each of the years 1902, 1903, and 1904, worth $2,500, $3,800, and $3,000, respectively. Much of this mica probably came from the Mount Alamo Mining Co.'s mine in Ventura County.

VENTURA COUNTY.

MOUNT ALAMO MINING CO.

The work of the Mount Alamo Mining Co. has been briefly described, in part anonymously and in part by the mine superintendent, A. J. Hoskins.[27] The mine is on Piru Creek, nearly 60 miles south of Bakersfield and the same distance west of Lancaster, the shipping point. Mount Alamo, or Alamo Mountain, from which the company took its name, is in Ventura County 12 miles S. 20° W. of the corner of Los Angeles, Ventura, and Kern counties. Work was stopped in 1905, and the mine has since been idle. The work is said to have been carried to a depth of 200 feet on a large body of pegmatite inclosed between a mica schist hanging wall and a granite footwall. The mica was shipped to the company's plant in West Berkeley, Calif., and there prepared for use in electrical work. The mine yielded chiefly scrap mica suitable for grinding. A

[22] Op. cit., p. 907, 1885.
[23] Eng. and Min. Jour., vol. 75, p. 496, 1903.
[24] Idem, vol. 74, p. 559, 1902.
[25] Springs of California: U. S. Geol. Survey Water-Supply Paper 338, 1915.
[26] Mineral production of California in 1902, 1903, and 1904: California State Min. Bur. Bulls. 29, 39, and 41.
[27] Min. and Sci. Press, vol. 90, p. 69, 1905.

quantity of small sheet mica was obtained, part of which was thin split and built up into mica board. Some good sheet mica was also mined, yielding plates ranging from 2 by 3 to 4 by 10 inches.

COLORADO.

GENERAL FEATURES.

Deposits of mica have been found in many parts of Colorado. Some of them have only been prospected and others have been worked on a fairly large scale. The deposits are widely scattered, occurring in areas of older gneisses and schists extending along the front ranges of the Rocky Mountains from Larimer County to Fremont County and westward into Routt, Lake, and Chaffee counties. A few deposits occur in isolated outcrops of older rocks, such as those near Grand Junction, in Mesa County.

Some of the occurrences have been known for many years. Albert Williams[28] mentions mica deposits in Boulder, Jefferson, and Fremont counties in 1882. The following localities are mentioned by J. A. Holmes[29] in 1899:

> In Colorado mica deposits have been examined at the following points: (1) Near Floyds Station, on the Union Pacific, Denver & Gulf Railroad, 5 miles east of Idaho Springs; (2) at the Terrill mica mine, 18 miles west-northwest of Golden, on the Blackhawk road, where the dike is 60 feet wide and shows considerable quantities of fairly good mica, and the Scheller mine in the same region, 8 or 9 miles west-northwest of Golden; (3) the Beers mica mine (Princess lode), on Soda Creek, 3 miles south of Idaho Springs, where a slightly specked but otherwise good mica occurs in an 8-foot dike; (4) the Mi Wot mica mine, in the Central mining district, some 15 miles northwest of Boulder, where the dike has a width of 50 to 60 feet, and in portions of it mica of fair quality is abundant; (5) the Pearl mica mine, 9 miles southwest of Leadville and on the north slope of Mount Massive; (6) the Snavley mine, 9 miles northwest of Cripple Creek; (7) High Creek mine, 4 miles southwest of High Park, in the Cripple Creek district.
>
> At the two last-named localities a considerable quantity of mica has been exposed but is extensively ruled and in irregular wedge-shaped blocks. At the other localities mentioned the mica shows less ruling, though the feature is fairly common at all these places, but at each of them the indications for successful mining operations are sufficiently favorable to warrant more extensive developments.

The mica deposits of Colorado have yielded good sheet mica of merchantable sizes, but a study of the different deposits described below leads the writer to believe that as a whole they yield an unusually large proportion of scrap mica. Some of the deposits yield mica suitable only for grinding and others yield but a small propor-

[28] Mica: U. S. Geol. Survey Mineral Resources, 1882, pp. 583–584, 1883.

[29] Mica deposits in the United States: U. S. Geol. Survey Twentieth Ann. Rept., pt. 6 (cont.), p. 707, 1899.

tion of sheet mica and none of large size. Several of the deposits have produced sheet mica of good quality and large size. The large yield of scrap mica from the Colorado mines has led to the building of grinding mills in many places in the State, some near the mines and others in towns or cities. Few of the mills are now in operation, and a large part of the mica produced in Colorado is shipped to Chicago or eastern points.

CHAFFEE COUNTY.

A hydrated form of biotite mica found about 5 miles southeastward of Hecla, in the Turret mining district, has been used in the industries during the last few years. The material is mined and handled under the name of tung ash by the Denver Mining & Manufacturing Co. By calcining the mica as it comes from the mines and then crushing and sizing, a ground product with a rich golden-bronze to silver color and metallic luster is obtained. This is suitable for various decorative purposes. Because of the expansion and exfoliation the mica undergoes when calcined, a little of the crude product will make a large quantity of the calcined product. The finished tung ash is light, and a small quantity will spread over a large surface.

According to Mr. W. W. Kirby, secretary of the company, the mica is found in veins that lie between gray granite and hard black schist and that reach in places a thickness of 4 feet. It occurs in shoots about 40 feet long, very much like ores in metalliferous veins, and forms solid masses of crystals, the largest 2 or 3 inches in diameter, bunched together at different angles. In the parts between the ore shoots a similar variety of mica forms about 50 per cent of the filling. The mica is greenish to brownish black. The folia are flexible and inelastic. When heated they swell and exfoliate very much like vermiculite. The laminae of the calcined product are sufficiently separated and brittle to break down into a fine scaly product, which exhibits the colors and luster already mentioned.

FREMONT COUNTY.

More mining for mica has been done in Fremont County than in any other county in Colorado. The principal mines in this county are those that work deposits in the Micanite region, about 25 miles northwest of Canon City. Other deposits have been worked in the dissected plateau north of the Royal Gorge and within 2 miles of the rim, 7 or 8 miles by road northwest of Canon City. One of these deposits, the Mica Hill mine, yields only scrap mica for grinding but is of interest because of the abundance of this material. Another prospect of this kind is the Wild Rose claim, 6 miles north of Texas Creek.

The deposits have been prospected or worked at different times, but mica mining in Fremont County was most active from about 1904 to 1907. During this period the United States Mica Co., of Chicago, Ill., operated the mines of the Micanite region, and the Canon City Mica Mining & Mills Co. operated the Mica Hill mine. The United States Mica Co. had an elaborate trimming plant and a dry grinding mill near the mines. The Canon City Mining & Mills Co. had a dry grinding mill and an experimental plant in Canon City to develop uses for the product. None of the mines were in operation in 1908 and 1913.

MICANITE REGION.

MINES OF UNITED STATES MICA CO.

Location of mines.—The mines of the United States Mica Co. are on the east side of Mac Gulch, a tributary of Currant Creek, about 2 miles south of the Park County line and about 25 miles northwest of Canon City. The Micanite post office was formerly near the mines but is now 3 miles east of it, on West Fork of Wilson Creek. The deposits are in rough, mountainous country at elevations of 7,900 to 8,400 feet above sea level. The names and present owners of all the claims could not be learned. The old Micanite post office and mica shops are in the gulch, and the position of the different workings examined can be described with respect to them. The most northerly working is about three-quarters of a mile north of the shops, in the steep east wall of the gulch, probably 300 feet above the bottom. In the following descriptions this working will be called the North mine. Mine No. 8 of the United States Mica Co., at the time of examination claimed by Thomas Pennington and Luther Seymour under the name Climax, is about 250 yards east of south of the North mine, in less broken country, near the summit of the ridge. Another working, which will be called the East mine in the description below, is nearly a quarter of a mile east of the Climax or No. 8, on the west side of a small gulch tributary to Mac Gulch. Another deposit was opened by the United States Mica Co. on the summit of the narrow ridge east of the shops, about two-thirds of a mile south of the Climax working. This will be called the South mine. Two prospects have been opened by F. L. Rowe, of Micanite, one about 150 yards south of the South mine on the point of the ridge, and the other a quarter of a mile to the southeast, in the east side of the gulch. Still other prospects are reported to have been opened in the region by the United States Mica Co.

North mine.—The North mine was worked by an open cut and tunnels in a northerly direction along the steep mountain side. Crosscuts and pits were made on the west or lower side. The open

cut is about 100 feet long and of irregular shape. It has a depth of 25 feet in places, but caving of the walls has filled parts of it. The dumps on the mountain side are large.

The country rock immediately around the mine is composed of biotite schist and gneiss with streaks of muscovite schist having a porphyritic texture due to inclusions of small feldspar crystals. The formation strikes about north and dips 35° W. The pegmatite body is probably 30 feet thick and of irregular shape. It cuts the gneiss with an irregular but low dip. The component minerals of the pegmatite are in some places segregated into irregular masses and in others they occur in the usual mixture. Along the west side of the open cut there is a mass of quartz at least 20 feet thick and probably 50 feet long. This quartz is chiefly white, but in places it is pale pink. The pegmatite was richest in mica on the east side of the quartz, but pockets of mica were also mined along the west side and to the north of it. Both pink orthoclase and white albite or other plagioclase feldspar were observed in the pegmatite. Beryl and apatite were noted as accessory minerals. Fragments of opaque bluish-green beryl crystals 5 inches in diameter were found on the dump. Two badly fractured crystals of apatite, about 12 and 18 inches across, were seen in the massive quartz. The crystals were opaque and contained both green and pink apatite. Most of the mica left around the mine was wedge, fishbone, and small plates suitable chiefly for grinding.

Climax claim or mine No. 8.—The Climax claim or working No. 8 of the United States Mica Co. was worked by three open cuts with connecting tunnels, some smaller cuts or pits, and a tunnel at a lower level. The workings fall within an area about 100 feet long from north to south and 50 feet wide, and their positions are shown in the rough sketch (fig. 6).

The lower tunnel is about 15 feet below the level of the floor of the larger open cuts (1 and 2 in the figure). It is about 60 feet long and branches at the end as shown. Open cuts 1 and 2 are from 10 to 15 feet deep and are connected with No. 3, which is at a little greater elevation, by an inclined tunnel or raise.

The country rock is diorite gneiss with streaks of biotite schist and gneiss. The pegmatite dike is probably 25 feet thick and cuts the inclosing gneiss irregularly. In the open cuts it appears to dip 15°–20° E., but the lower contact exposed in the end of the tunnel is irregular and rolling, as shown in figure 6. The pegmatite is coarse grained and has an irregular texture. Parts of it consist of the normal mixture of feldspar, quartz, and mica, but other parts contain large crystals and segregations of these and other minerals. Quartz occurs in masses 10 feet across, feldspar in crystals a yard

through, and mica in blocks weighing 50 pounds or more. Imperfect crystals of mica 18 inches across and 6 to 8 inches thick and masses of wedge-shaped crystals 2 feet across had been left exposed in the face of the pegmatite in the open cuts. An unusual feature of this pegmatite, one without economic value, is the inclusion of cordierite crystals or masses, some nearly a yard across, in various stages of alteration. This cordierite occurs in contact with all three minerals of the pegmatite—that is, the feldspar, quartz, and mica. Part of it is fresh and glassy and has a gray to dark violet-blue color in thin pieces. Much of the cordierite has altered to muscovite (often called pinite) and some has been only partly altered. Alteration has taken

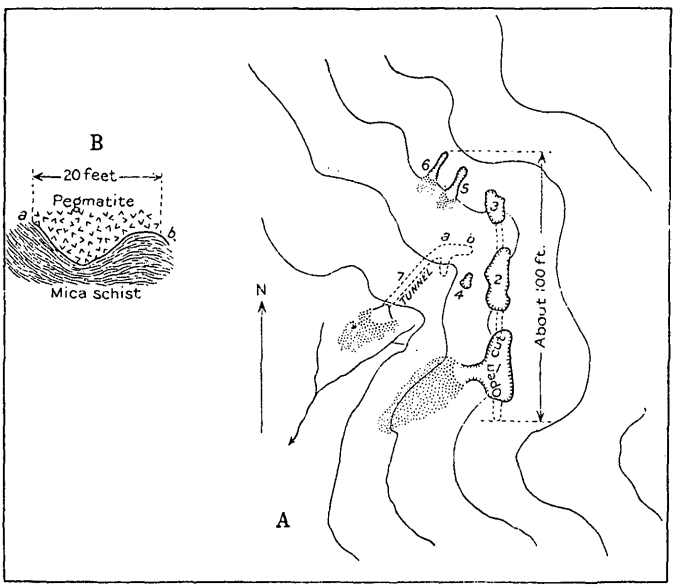


FIGURE 6.—Plan and cross section of Climax mica claim or working No. 8 of United States Mica Co., 25 miles northwest of Canon City, Fremont County, Colo. A, Plan of workings; B, cross section in end of tunnel; 1, 2, 3, open cuts; 4, 5, 6, small cuts or pits; 7, tunnel.

place along numerous parallel cleavage planes, and the surfaces of these planes are heavily coated with mica. The effect of these numerous cleavages with their reflection from mica-coated surfaces in the glassy cordierite is striking. In some places entire cordierite crystals have altered to masses of brownish-stained mica which still preserve the prominent cleavage planes of the cordierite as thin layers of mica schist with smaller crystals of mica developed between them. Green apatite was found in some of the pegmatite in crystals as much as 2 inches in diameter.

The product of this mine would include both sheet mica and scrap mica for grinding. Many of the large mica crystals have been

badly ruled and others have imperfections, such as the A structure and hair lines. Some of the sheet mica is partly specked with thin films of magnetite between the laminae. Rough sheets of mica several inches across were seen around the mine, and a specimen was picked from the pegmatite that would cut into clear sheets 2 by 5 inches. There would be a large proportion of scrap mica in trimming the sheet mica, and this with the masses of wedge-shaped mica crystal would form an important part of the output of the mine.

East mine.—The East mine was worked by a short tunnel and several small open cuts in an easterly direction down a spur on the east side of a ridge of moderately steep slope. The country rock is coarse biotite granite containing pink or red feldspar. The pegmatite dike is large and is composed of dark-red coarse feldspar crystals and irregular quartz masses with bunches of pockets of small wedge-shaped mica crystals. No mica of sufficient size to cut into sheets was seen at the time of examination, but the wedge-

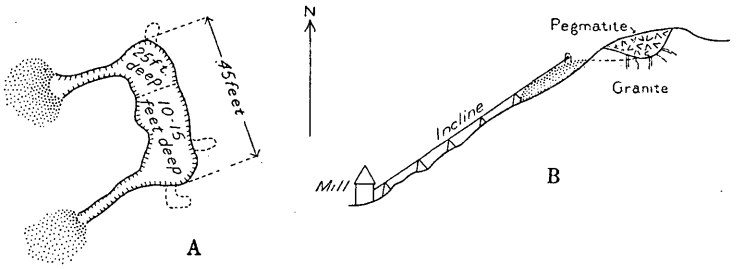


FIGURE 7.—Plan and cross section of South mine of United States Mica Co., 25 miles northwest of Canon City, Fremont County, Colo. A, plan; B, cross section, looking north.

shaped crystals would be suitable for grinding. Biotite mica, a little green apatite, and small fragments of feldspar with bright-green copper stains were seen in the pegmatite or on the dump.

South mine.—The South mine was worked by an open cut with short tunnels near the summit and along the west side of a small knob on a ridge. The open cut is about 45 feet long in a north-northwest direction, 15 to 20 feet wide, and 10 to 25 feet deep. Cross-cut trenches were made at each end of the open cut to the hillside on the west for the removal of waste and ore, as shown in figure 7, *a*. An inclined track connected the mine with a grinding mill in the valley a couple of hundred feet below.

The country rock is coarse biotite granite, characterized by pink feldspar and an abundance of biotite. The pegmatite consists of the unusual mixture of quartz and feldspar with mica unevenly distributed through it. The feldspar is dark-pink or red orthoclase or microcline. The pegmatite mass is large and irregular in shape and has streaks of pegmatite and aplite from 2 inches to more than a

foot thick extending from it into the granite below, as shown in the section in figure 7. The pegmatite apparently forms a large bulge or body cropping out at the present surface and surrounded by granite below and on the sides. There seem to be transitional phases between the pegmatite and aplite, and the streaks of these rocks may represent feed channels for the main body of pegmatite or may be offshoots from that mass.

Most of the mica obtained from this mine was small and in wedge-shaped crystals suitable only for grinding. Evidently a large pocket was found, but this was exhausted and considerable exploration work was done in search of other pockets. A little biotite mica was associated with the muscovite mica in this mine.

ROWE MINE.

At the north working of the F. L. Rowe mine an open cut was driven about 35 feet S. 80° E. into the side of the ridge, with a short tunnel and an 18-foot raise to a small open cut above. The biotite granite country rock is cut by two streaks of pegmatite, the upper one 10 feet thick and the lower about 25 feet thick. The west contact of the lower pegmatite strikes N. 25° W. and dips irregularly eastward. The pegmatite masses have a very uneven texture and contain segregations of both quartz and dark-pink feldspar 3 to 4 feet across. The mica occurs chiefly in wedge-shaped and ruled crystals suitable only for grinding as scrap. Some of it is specked. Several tons of mica was left around the workings.

The other prospect of F. L. Rowe, a quarter of a mile to the southeast, was not examined.

ROYAL GORGE REGION.

Mica Hill.—Mica Hill is about 7 miles, by fairly good wagon road, northwest of Canon City and about 2 miles north of the rim of the Royal Gorge. It is an oval hill that rises about 150 feet above the road in the valley on the south. The summit is formed by a mass of pegmatite about 100 feet thick and two or three times as long. The pegmatite and the hill have an east by north elongation, corresponding roughly with the average strike of the country rock, which is crumpled biotite gneiss with an east-northeast strike and a high northerly dip. There are masses of granite and diorite in the vicinity. About 200 yards east of Mica Hill is a similar hill, formed by the outcrop of a mass of pegmatite, in which lithia mica (lepidolite), pink and green tourmaline crystals, and fremontite[30] have been found. The pegmatite of Mica Hill is composed of large

[30] Schaller, W. T., The amblygonite group of minerals—fremontite (=natramblygonite): U. S. Geol. Survey Bull. 610, pp. 141–142, 1916.

masses of feldspar and quartz, graphically intergrown in places, and of irregular masses and streaks of solid mica. The masses and streaks of mica occur in massive feldspar and range in thickness from 2 to 10 feet. The mica is in the form of wedge-shaped blocks having fishbone structure and in twisted plates bunched together at all angles. In places a little biotite or black mica is mixed through the white mica, so that it is necessary to hand-cob part of the material after crushing before grinding. The solid mica is plentiful in the better exposures, and 200 tons is reported to have been obtained from a small opening in the south face of the hill near the summit. A supply sufficient to keep a grinding mill in operation for many months is exposed in the working faces and outcrops of the pegmatite. In small openings lower down rough crystals of beryl from an inch to a foot in diameter and columbite in masses weighing 2 or 3 pounds, were found.

Other prospects and mines were opened near the edge of the Royal Gorge about half a mile west of the point where visitors view the gorge from its rim. These prospects were not examined.

TEXAS CREEK REGION.

Wild Rose claim.—The Wild Rose claim was located by J. D. Endicott, of Canon City, both for its mica and rose quartz. It is in the steep west wall of East Gulch, about one-third of a mile from its junction with Echo Canyon nearly 6 miles north of Texas Creek. Transportation facilities were poor when the claim was visited, part of the distance to the railroad at Texas Creek being covered by a trail. The deposit is 300 or 400 feet above the bottom of the gulch and consists of a large mass of pegmatite that crops out in a northerly direction along the mountain side and reaches in places a height of 25 feet. The pegmatite is inclosed in contorted mica and cyanite or fibrolite gneiss and schist in which hornblende schist streaks are also included. The most prominent feature of this deposit is a large segregation of quartz, which outcrops for a distance of 150 feet and reaches a height of 20 feet. Most of the quartz is white to pink, but some has a fairly deep rose color and is suitable for gems. The mica occurs in irregular streaks containing solid masses of twisted and wedge-shaped crystals. These streaks vary from 1 foot to more than 6 feet in thickness and occur in both quartz and feldspar. The solid mica at this time does not appear to include any biotite and is therefore well adapted to grinding without other preparation than crushing. The claim has not been worked commercially, but the solid mica should not be difficult to mine as long as the streaks or masses hold out, and these would supply the demand of an ordinary grinding mill for a considerable time.

JEFFERSON COUNTY.

LOCATION OF DEPOSITS.

Mica has been mined or prospected at several places in Jefferson County. Two deposits southwest of Morrison were examined—the Bigger mine, about 9 miles southwest of Morrison, and the Thomas mine, about 12 miles west-southwest of Littleton. These mines are in rough mountain country a few miles west of the first foothills scarp of the Rocky Mountains. According to F. W. Clarke [31] a mica mine was opened on Turkey Creek in 1884. This was probably the Bigger mine, which is reported to have been first opened about that time in search of tin ore. No tin ore was found, but a deposit of mica was proved.

BIGGER MINE.

The Bigger mine is on the south side of a tributary of Turkey Creek at the edge of a broken plateau about 7,100 feet above sea level. It is about half a mile from a good road along Turkey Creek to Morrison. A passable wagon road could be made to the mine at small expense. The developments consist of a deep shaft with a tunnel from the hillside to an upper level, an open cut northwest of the shaft, and an irregular set of "ground-hog" workings southeast of the shaft. The shaft is reported to be 80 feet deep but is filled with water to within 30 feet of the surface. The tunnel from the hillside on the northeast is about 50 feet long and only about 15 feet below the surface. It has caved in badly. Other short tunnels were made from the shaft at this level. The open cut to the northwest is about 35 feet long and 10 feet deep. The "ground-hog" workings are about 100 feet southeast of the shaft and consist of an irregular-shaped open cut about 20 feet deep with short drifts and rooms.

The country rock is chiefly diorite cut by reddish granite. The pegmatite crops out in a large bed that is nearly horizontal or has a slight southerly dip. This bed forms a small scarp along the edge of the valley and is therefore in a very favorable position for development by open work or tunnels. The lower contact of the pegmatite is concealed by soil and vegetation, but the bed must be at least 25 feet thick. The shaft cut through pegmatite into the underlying diorite, but at what depth could not be determined. The pegmatite has an exceedingly variable texture, and in places the segregations of the different component minerals are large. Masses of pink orthoclase or microcline feldspar, 8 feet thick, composed of several large crystals and irregular segregations of quartz, some with a pale rose tint, of similar size, were encountered in the workings.

[31] Mica: U. S. Geol. Survey Mineral Resources, 1884, pp. 906–912, 1885.

Mica occurs in large aggregations or deposits of wedge, A, ruled, and fishbone crystals. These deposits are irregular in shape and range from 1 foot to 8 or 10 feet in thickness and 15 to 20 feet in length. They both occur among the large masses of feldspar and quartz. Beryl crystals are abundant and probably more than 2 tons are in sight on the dumps and in the workings. The beryl crystals seen were opaque and ranged from 4 to 18 inches in diameter. Black tourmaline was found in a small pit east of the main workings, but most of the small quantity of muscovite mica discovered was associated with biotite mica.

The mica from the Bigger mine is practically all suitable only for grinding. A little small-sheet or punch mica might be cut from some of the crystals, but that would be a very small proportion of the production. Scrap mica can be mined in a nearly pure form, which would not require much cleaning before shipping or grinding. As long as such large pockets of mica as were exposed in the workings at the time of examination could be found, scrap mica could be mined cheaply.

THOMAS MINE.

The Thomas mica mine is in the steep slope of the west side of a tributary of Deer Creek, about 1½ miles southeast of the Bigger mine. It has been worked by an open cut 15 to 30 feet wide, extending for a height or distance of about 50 feet in a N. 60° W. direction up the hill, with two short tunnels and a room stoped out near the bottom of the cut. A small cleaning mill had been erected near the lower tunnel.

The country rock is schistose diorite cut by reddish granite. The pegmatite and the inclosing diorite have been partly decomposed. Sufficient work had not been done to expose the attitude of the pegmatite toward the inclosing rock. One contact between pegmatite and country rock had a strike of N. 30° E. and a dip of 70° SE. The schistosity of the inclosing diorite strikes N. 60° W. and has a vertical to high northeast dip. Much of the pegmatite has a rather fine, even grain, but some is very coarse and variable in texture, with large feldspar crystals, masses of quartz, and bunches of mica. The mica obtained is chiefly small, owing to the excessive ruling of the larger crystals. Some punch and small-sheet mica could be mined, but the principal returns would be obtained from the scrap mica. The quality of some of the small-sheet mica is excellent, the color being a clear rum and the cleavage perfect. Among other minerals observed in the pegmatite were numerous opaque red garnets and a little apatite.

Apparently scrap mica was rather plentiful in parts of the pegmatite. Much of the pegmatite was crushed in the upper part of

the mill, and the product was distributed by gravity over coarse sieves below, where the mica was separated from it.

LARIMER COUNTY.

BUCKHORN MINE.

Considerable work was done several years ago by the Buckhorn Mica Mining & Milling Co. on a deposit about 17 miles in an air line S. 75° W. of Fort Collins, on North Fork of Buckhorn Creek. This deposit, which was discovered in 1884, lies in an oval hill whose longer diameter extends N. 65° E. and is about 200 feet higher than the camp and mill, which are a quarter of a mile north of it in the valley below. The camp is about 8,000 feet above sea level. Fires have damaged much of the timber, but sufficient is left on the mountains for use in mining. A fair road was built from the mine to Masonville, about 12 miles to the southeast, but the bridges and some of the grades were in bad repair at the time of examination, in 1913.

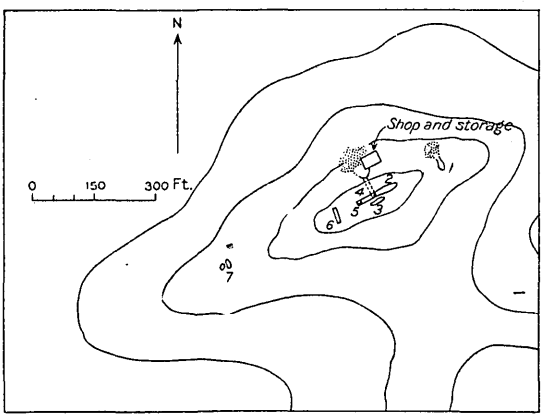


FIGURE 8.—Plan of workings of Buckhorn Mica Mining & Milling Co., 17 miles S. 75° W. of Fort Collins, Larimer County, Colo.

The mine was worked by open cuts, two shafts, drifts, trenches, and pits in a N. 65° E. direction along the summit of the hill. The position of the workings is shown in figure 8, in which 1 is a crosscut trench or open cut; 2 an open cut 90 feet long, 10 feet wide, and 2 to 15 feet deep; 3 an open cut 20 feet long and 8 feet deep; 4 a shaft (now boarded up) in the end of a crosscut tunnel; 5 a shaft filled with water within 25 feet of the surface; 6 a crosscut trench 20 feet long and 3 feet deep; and 7 two prospect pits. Drifts were made from the interior shaft (4) on the vein. It was not possible to see much of the underground workings, but the size of the dump indicates that they were rather extensive.

The country rock is chiefly quartz-biotite schist. The pegmatite is approximately conformable with the foliation of the schist, striking about N. 65° E. and having a nearly vertical dip. The contact between the two rocks is sharp. The pegmatite varies in thickness from about 9 feet in the open cut marked 1 to 20 feet in the other open cuts, 2 and 3, and about 10 feet in the prospect pits, 7. It is a

variable mixture of gray quartz, albite feldspar, pink orthoclase or microcline feldspar, mica, and a few accessory minerals such as beryl and black tourmaline. The mica occurs in bunches or pockets, some of them several feet thick, in which there is not much gangue mineral, and in separate crystals distributed irregularly through the pegmatite. The pockets are filled chiefly with wedge, **A**, fishbone, and ruled mica in crystals ranging from those of small size to some several inches across. In some of the **A** mica thin plates of albite were observed between the laminae. Blocks of light-greenish compact massive mica have been thrown on the dumps. This is composed almost entirely of mica in scales of various sizes, some minute and some one-eighth of an inch in diameter, with but few impurities intermixed. Pale-greenish to white beryl crystals several inches across were observed in the pegmatite in the open cut. In places black stains of manganese oxide have penetrated into the seams in the pegmatite. The mica-quartz schist wall rock in one place has been strongly metamorphosed by the pegmatite, and much small black tourmaline has been deposited in the bedding planes and through the layers of schist.

The mica from this mine is light green, but very little of it is suitable for sheets. It is of a good grade for grinding for wall-paper decoration, because of its light color and brilliancy. Possibly the fine compact variety mentioned above would be suitable for grinding and might be found in large quantity. No rich pockets of mica were left exposed in the workings, and little idea could be formed as to the yield to be expected. Several tons of good scrap mica had been left on the storage floor of the shop at the mine and several tons more in the bins at the mill.

The mill erected on the property was operated by steam engine and was equipped with dry-grinding machinery. The mica was ground with a Raymond patent pulverizer No. 0 and conveyed to a Barnard & Leas bolter by air draft from a rotary blower. The capacity of the mill was limited by that of the bolter to 1½ tons a day. The pulverizer could have supplied two or more bolters.

Another mica prospect was opened by Parkson & Kitchen about a quarter of a mile west of the Buckhorn mine. The work consisted of an open cut on a bulge of pegmatite nearly 30 feet across. The pegmatite has a northwesterly strike and is inclosed in biotite gneiss. An irregular streak or pocket of mica, about 6 feet thick, extended across the pegmatite in a northeasterly direction. Green and yellow opaque beryl ranging from thin films to crystals 2½ inches in diameter were found. Orange-colored and yellow ocherous stains of uranium were seen in a few pieces of pegmatite on the dump. These were reported to surround small cores of a heavy black mineral,

which might be pitchblende. The mica obtained resembles that of the Buckhorn mine and is practically all suitable only for grinding.

MESA COUNTY.

A deposit of mica was located some time prior to 1895 in Ladder Canyon, Mesa County, 8 miles south of Grand Junction, Colo. The deposit is said to have been discovered by Benton Cannon, but is now held by S. A. Grady, of Grand Junction. The locality was reached in 1911 by trail only, though a road was once made up the canyon within half a mile of it. The trail leaves the Grand Junction road and enters the canyon about a mile north of the prospect. This part of Ladder Canyon is from 200 to 300 feet deep.

The development consists of a short tunnel about 10 feet long and an open cut about 25 feet long in the side of the canyon. The deposit occurs in a dome of pre-Cambrian rocks exposed in the bottom and lower walls of the canyon. Red sandstone, probably of Carboniferous age, overlies the dome and forms the country rock of the region, even outcropping in the bottom of the canyon one-third of a mile farther north. Near the mica prospect the older rock outcrop to a height of 100 feet in the canyon walls. They consist of biotite and muscovite schist and gneiss cut by pegmatite. The pegmatite is more than 200 feet wide in the bottom of the canyon and is thinner at the top of the exposure. Apparently it is at the top of an anticline whose axis strikes nearly east and west. The main anticline has smaller folds upon it and the pegmatite exhibits these irregularities. The minerals of the pegmatite are segregated in large masses. The feldspar is chiefly the potassium variety and has a pinkish or flesh color. It occurs in an irregular mass or streak more than 10 feet thick in the interior of the pegmatite and grades into material containing considerable quartz or with the composition of ordinary pegmatite. A large segregation of massive quartz, the thickness of which is not exposed, lies below the feldspar mass, and more massive quartz overlies it. A few blocks of translucent rose-colored quartz were observed in the bottom of the canyon, but the quartz is too pale for use as gem material. The upper part of the pegmatite outcrop is concealed by talus from the overlying red standstone.

The mica occurs principally along the contact between the feldspar and quartz masses, where it forms an almost continuous streak across the face of the pegmatite outcrop. (See fig. 9.) The mica streak ranges from 1 foot to 3 feet in thickness and is composed of nearly solid masses of mica crystals. These crystals range from less than 1 inch to more than 1 foot in length and are more commonly arranged in tufts and radiating groups. In places quartz, feldspar, and black tourmaline are associated with the mica. Rosettes of radiated mica

crystals cover the south wall of the open cut for a space 12 feet long by 8 feet high. The mica in the face of this cut is shown in Plate IX, *A*. The exposure here gives an impression of a very thick mica streak, but an examination shows that the cut has opened the "vein" along its wall. The full thickness of the streak of mica is not exposed but is probably 3 feet or more. The mica crystals are much ruled and broken and nearly all have either the A, wedge, or herringbone structure. It is probable that the entire yield of mica from this deposit will be suitable for grinding only, and that little if any mica valuable for cutting into sheets will be obtained. The quantity of scrap mica for grinding that can be mined near the surface is considerable.

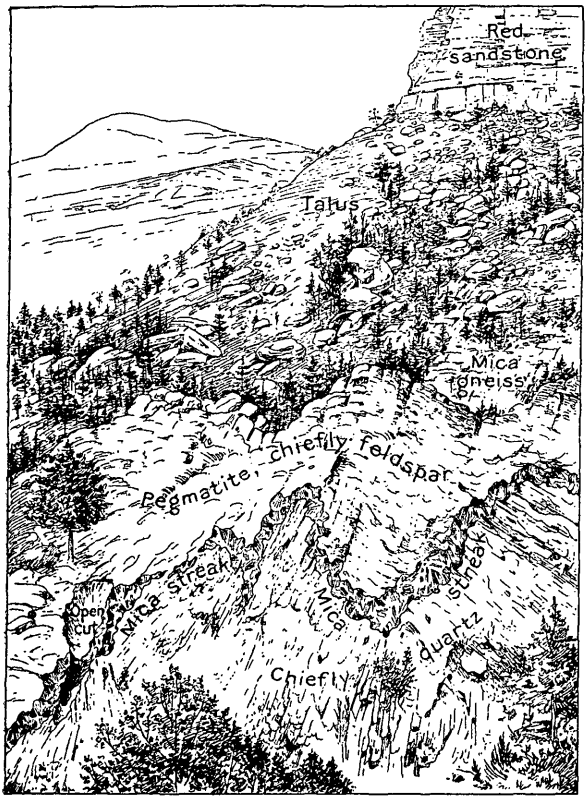
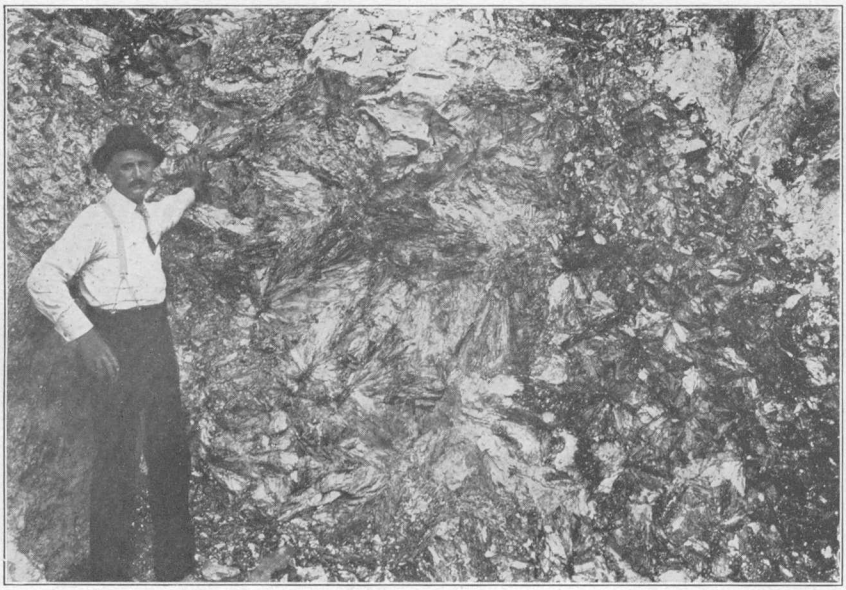


FIGURE 9.—Outcrop of irregular streak of mica between quartz and feldspar in S. A. Grady claim, Mesa County, Colo.

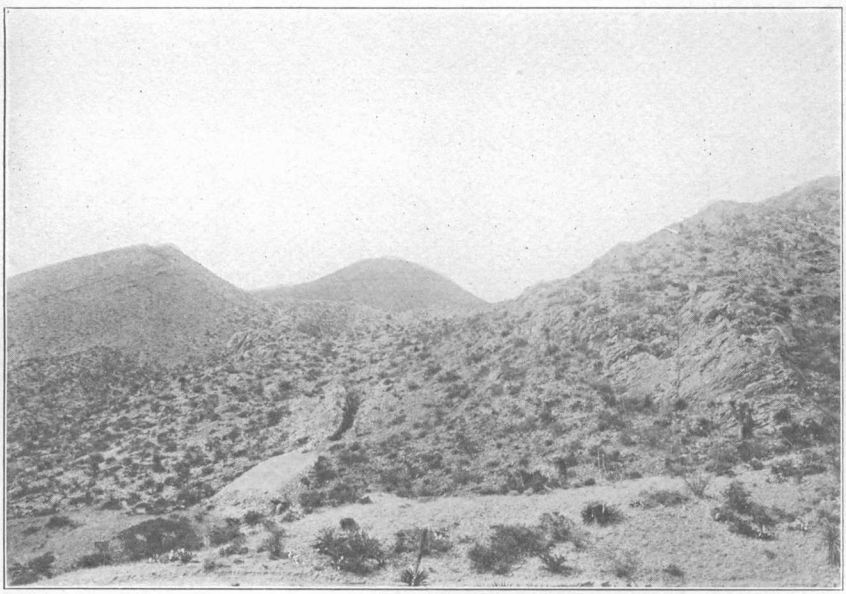
CONNECTICUT.

GENERAL FEATURES.

Mica of rather inferior quality has been obtained in variable quantities as a by-product from some of the quarries operated for feldspar and gems in Middlesex, Hartford, and New Haven counties, Conn., and sheet mica of good quality has been found at the Roebling mine near Merryall, Litchfield County. Undesirable features that are common in the mica of Connecticut are the widespread development of the A, wedge, and tangle-sheet structure, ruling, hardness, and brittleness of the plate. The mica is saved at the feldspar quarries, and after a stock has accumulated most of it is sold in bulk in the rough at the market price for scrap mica. The principal quarries of Middlesex, Hartford, and New Haven counties have been described



A. MASS OF SOLID MICA EXPOSED IN OPEN CUT AT GRADY MICA MINE, MESA COUNTY, COLO.



B. VIEW NORTHWARD TOWARD OPEN CUT IN PEGMATITE INCLOSED IN MICA GNEISS, TEXAS MICA CO., CULBERSON COUNTY, TEX.

Hills capped with sedimentary rock in background.

BLOCK OF SOLID MICA BLASTED LOOSE FROM PEGMATITE AT GEORGE ROEBLING MICA MINE, LITCHFIELD COUNTY, CONN.

by E. S. Bastin,[32] and the following descriptions of the deposits in those counties are abstracted from his report supplemented by notes made by the writer regarding the Gillette and Strickland quarries, in Middlesex County.

LITCHFIELD COUNTY.

GEORGE ROEBLING MINE.

A mine was operated for mica and feldspar near Merryall, Litchfield County, between the years 1880 and 1900, in which gem beryl

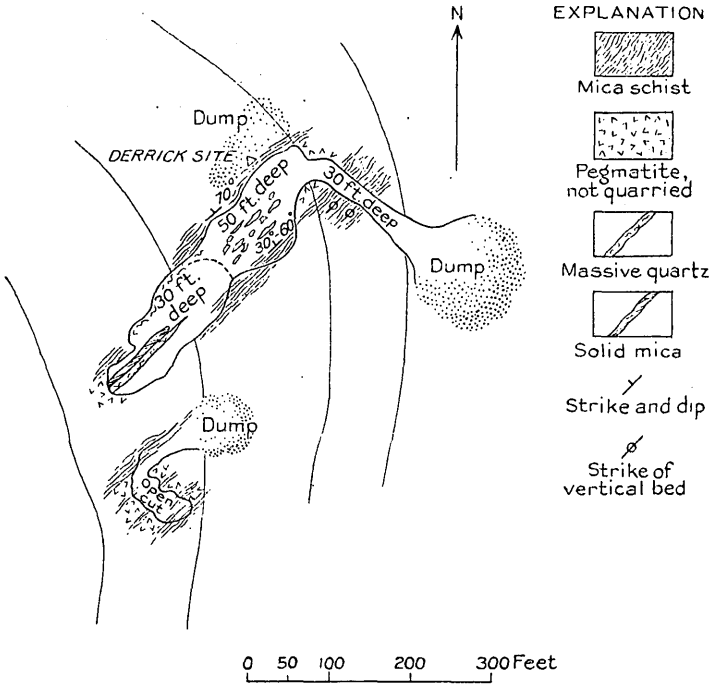


FIGURE 10.—Plan of George Roebling mica, feldspar, and beryl mine near Merryall, Litchfield County, Conn., showing part of geology.

proved to be a valuable by-product. The beryl has been mentioned by George F. Kunz[33] in reports on precious stones in 1885, 1892, 1898, and 1899. The mine has been idle since 1900, and in 1914 the workings were covered with vegetation. The mine was formerly owned by S. L. Wilson and George Roebling, but is now held solely by Mr. Roebling, of Northville. An examination of the deposits was made by the writer in October, 1914, at which time the following notes were taken:

[32] Economic geology of the feldspar deposits of the United States: U. S. Geol. Survey Bull. 420, pp. 41–53, 1910.

[33] Precious stones: U. S. Geol. Survey Mineral Resources, 1885, 1892, 1898, and 1899.

The deposit is 5½ miles N. 12° W. of New Milford, or 3 miles east of Kent, a station on the New York, New Haven & Hartford Railroad. The workings consist of a main cut about 120 yards long driven southwestward into a hillside and a smaller cut (see fig. 10) about 100 feet south of it. The main cut ranges from 10 to 50 feet in depth and 30 to 40 feet wide in the northeast half. The northwest wall overhangs the workings, and the southeast wall dips northwestward at varying angles. A little tunnel work has been carried on along the hanging wall. The open cut was originally 65 feet deep toward the northeast end, but this part has been partly filled up by the caving of wall rock. The smaller cut is about 70 feet long across the formations and is reached through an entrance in the hillside on the northeast. (See fig. 10.)

The country rock is biotite schist or gneiss, highly schistose near the vein, and has been mapped as Berkshire schist by Rice, Gregory, and Robinson.[34] Through error this was reported as Becket gneiss by the writer in a former description of this mine.[35] The Becket gneiss contact as mapped lies only 100 or 200 feet east of the mine. Immediately around the mine the schist has a northeast strike and a vertical to high northwest dip. The vein rock is pegmatite, which ranges from 20 to 40 feet thick in the main cut. In the smaller cut the pegmatite is thicker but contains inclusions of schist. In the main cut the pegmatite strikes about parallel with the country rock, but to the northwest it cuts across the schistosity of the country rock with a lower dip. The pegmatite pinches and swells in different parts, and is reported to have been thinner near the bottom of the cut than at the surface. The texture of the pegmatite is extremely coarse grained. Gray quartz occurs in large massive streaks several feet in thickness and lies roughly parallel with the walls of the pegamtite; orthoclase feldspar in crystals and masses several feet across; and mica in bunches and pockets in different parts of the vein. The best mica and feldspar are reported to have come from the northeast half of the open cut, and the best beryl from the southwest half. Near the southwest end of the cut there are outcrops of quartz streaks 2 to 3 feet thick and masses of "solid mica" of even greater thickness, one of which is 50 feet long. This "solid mica" is composed of rough A and wedge-shaped crystals 1 inch to 4 inches across, bunched closely together, and mixed with a little quartz and feldspar. One block of "solid mica" of irregular shape blasted loose from this vein measured 4 feet thick and 8 feet long. (See Pl. X.) Such mica would be valuable only as scrap for grind-

[34] Rice, W. N., Gregory, H. E., and Robinson, H. H., Preliminary geological map of Connecticut: Connecticut Geol. and Nat. Hist. Survey Bull. 7, 1907.

[35] Sterrett, D. B., Precious stones: U. S. Geol. Survey Mineral Resources, 1914, p. 313, 1916.

ing, but probably 50 tons are in sight. The mica from the northeast end of the cut yielded clear sheets several inches across, which were suitable for glazing. Large quantities of potash feldspar were sold to pottery manufacturers, and the amount realized from their sale paid most of the expenses of mining. Among associated minerals are a few dark-red opaque crystals of garnet, a little biotite-mica, and black tourmaline.

Many crystals of beryl, some of them more than a foot in diameter, have been found in the quarry. In four years $17,000 worth of gem beryl is reported to have been sold. Mr. Roebling still has a few specimens showing the quality of the gem material obtained from the mine.

This deposit of pegmatite or another in the same lead has been traced for several hundred yards across the hill southwest of the mine, and at a few small openings large, pure crystals of orthoclase-feldspar were seen.

Other feldspar quarries have been worked in the county but did not yield so much mica as the Roebling mine. During 1915 a specimen of mica was received at the United States Geological Survey from D. J. Emmons, of Canaan, near the north edge of the county. This crystal measured only about 3 inches across and had a clean, sharp, rhombic crystal outline. The color was clear light purplish brown with a narrow light-yellowish border parallel with the faces. The specimen was too small to have value, but the quality was such as to encourage further prospecting for larger sheets. Mr. Emmons carried on a little prospecting in 1915 and removed more than a ton of mica, of which 200 or 300 pounds might be classed as rough sheet mica.

MIDDLESEX COUNTY.

F. E. STRICKLAND QUARRY.

The quarry of F. E. Strickland is about 2½ miles northeast of Portland, in the west side of Collins Hill. At the time of examination, in October, 1914, it was operated by Mr. Strickland under lease to the Eureka Mining & Operating Co., of Trenton, N. J., all the spar, quartz, and mica going to the company. The gems and other minerals were retained by Mr. Strickland. The quarry consists of two adjoining open cuts with north and south elongation, parallel, and connected at the north end. The east cut is about 300 feet long, 65 feet wide, and 10 to 40 feet deep. The west cut is about 200 feet long, 50 feet wide, and 25 feet deep. A crosscut leads out to the hillside at the north end of the west cut. (See fig. 11.)

The country rock is muscovite-biotite schist and contains much black tourmaline near the pegmatite. It probably belongs to the Bolton schist as mapped by Rice, Gregory, and Robinson,[36] but close to the contact there is a mass of Glastonbury granite gneiss. The schist has a general north strike and a dip of about 20° W. It has been warped, however, to correspond approximately with the contact of the pegmatite, which is a large, irregular, semibedded deposit both parallel with and cutting the schist in different parts. In the east deposit the outcrop was an elongated dome pitching under the schist at each end. This body of pegmatite joins the one forming the west deposit under the surface where the two open cuts join at the north end. The geologic relations are shown in figure 11.

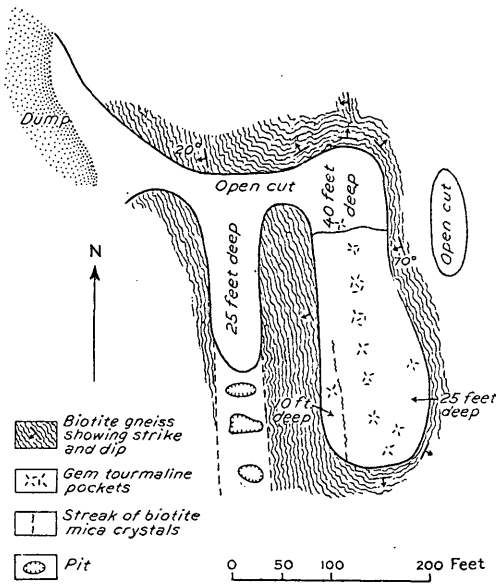


FIGURE 11.—Plan of Strickland feldspar, mica, and gem quarry, 2¾ miles northeast of Portland, Conn., showing geology.

The pegmatite is coarse grained and contains large bodies of graphic granite, potash feldspar crystals 2 or 3 feet across, irregular quartz segregations several feet thick, and bunches or streaks of mica crystals. Cavities or pockets with crystal-lined walls are irregularly distributed in parts of the quarry, especially in the east working. These pockets range from one of small size up to one reported to be 4 feet long, 1½ feet wide, and 1½ feet high. Some of them have yielded tourmaline gems of fine quality and specimen minerals of interest. The gem-bearing pockets were found near the middle and in the south half of the east quarry. Work in this part of the quarry has been temporarily abandoned, but a good working face 20 feet high has been made across the north end of the cut preparatory to removing the spar. Mr. Strickland expects to find more gem pockets when this block of pegmatite is quarried.

Among other minerals adjoining and lining the walls of the pockets are coarse, flat albite or clevelandite crystals, granular lepidolite, rough quartz crystals, greenish muscovite crystals, and a little beryl.

[36] Rice, W. N., Gregory, H. E., and Robinson, H. H., Preliminary geological map of Connecticut: Connecticut Geol. and Nat. Hist. Survey Bull. 7, 1917.

Much of the beryl is opaque and yellowish green, but in one pocket an irregularly shaped fragment of transparent pale salmon-pink beryl was found. It is 2½ inches long and 1 inch thick, with an exceedingly rough honeycombed and drusy surface. It is evidently the remnant of a much larger crystal, most of which has been dissolved, leaving only a part with a rough etched surface. Portions of this would cut into small gems. In some of the pockets there are mossy tuffs or coatings of minute short hairlike tourmaline crystals of dull greenish-gray color. Some of these coatings cover a couple of square inches of the surface of albite crystals and make exceedingly delicate, pretty specimens. Gem tourmalines of fine greenish-blue, bluish-green, and nearly grass-green color have been obtained from some of the pockets.

Among other minerals found in the quarry are muscovite and biotite mica, columbite, and a few garnets. The mucsovite occurs in plates as wide as 12 inches but most of it does not have good cleavage. It is yellowish green, and where the cleavage is good the mica is suitable for the glazing trade. The bulk of the crystals are so injured by A lines and tangle-sheet structure as to be suitable only as scrap for grinding. The mica is saved during quarrying and sold at intervals as scrap, but that suitable for sheets is doubtless sorted out by the purchaser.

GILLETTE OR HADDAM NECK QUARRY.

The M. P. Gillette or old Haddam Neck quarry is 1 mile N. 22° E. of Haddam, near the east bank of Connecticut River. It is one of the oldest quarries in Connecticut and has been worked for gem and specimen minerals as well as for feldspar. Mica was obtained as a by-product. The deposit has not been worked for several years, and the pits were partly filled with water and overgrown with vegetation at the time of visit in 1914. The quarry consists of one large, irregularly shaped open cut about 300 feet long in a north and south direction and 100 feet wide at the widest part, which joins a smaller open cut on the west about 150 feet long in a north and south direction and 35 feet wide. These quarries range from 20 to 30 feet deep and have crosscuts leading out to two large dumps on the river side. One cut extends west from the west quarry and the other west from the south end of the east quarry. According to Bastin the west quarry was worked chiefly for tourmalines and specimen minerals. The east quarry was worked chiefly for feldspar, but also yielded mica, gem tourmalines, and specimen minerals. The shape of the workings and the general geologic relations are shown in figure 12.

The country rock is dark-gray muscovite-biotite schist or gneiss, mapped as Monson granite gneiss by Rice, Gregory, and Robinson.[37] The gneiss strikes about north and dips vertically. The pegmatite is large and is divided into several streaks by large inclusions or horses of schist. In the north end of the quarries there are three beds of pegmatite having a total thickness of about 100 feet in a width of 150 feet. In the middle of the quarry on the south side the schist unconformably overlies a rounded boss of pegmatite. This boss pitches to the south and on the north side of the quarry outcrops as a bed nearly 50 feet thick conformably between schist walls. The pegmatite contains large masses of graphic granite, potash feldspar crystals 1 to 3 feet across, generally with a little intermixed albite, muscovite, black and green tourmaline, and pockets or cavities lined with crystals. Some of the mica crystals measure more than 1 foot across and are 6 inches thick, but do not split well because of the presence of wedge, A, and tangle-sheet structures. At the time of examination some mica crystals were found that measured more than 8 inches across, but they were rendered unfit for anything but grinding by tangle-sheet structure and by the presence of many small green tourmaline crystals and needles both parallel with and penetrating the laminae in many directions. A few good mica crystals of yellowish-brown color which would trim into sheets 2 by 2 inches were seen.

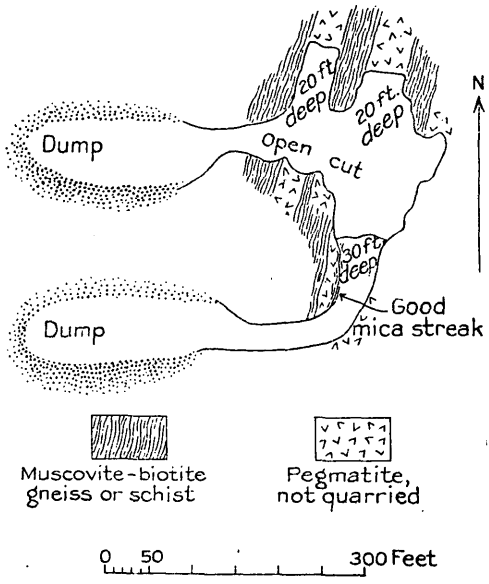


FIGURE 12.—Plan of Gillette or Haddam Neck feldspar and gem quarry, 1 mile N. 22° E. of Haddam, Conn., on east bank of Connecticut River, showing geology.

The feldspar shipped to the pottery manufacturers is said to have been chiefly graphic granite or irregular intergrowths of feldspar and quartz with smaller quantities of nearly pure feldspar.

Most of the gems and specimen minerals are found in pockets or cavities. Bastin[38] describes the gem pockets in the east cut as

[37] Rice, W. N., Gregory, H. E., and Robinson, H. H., Preliminary geological map of Connecticut: Connecticut Geol. and Nat. Hist. Survey Bull. 7, 1907.

[38] Economic geology of the feldspar deposits of the United States: U. S. Geol. Survey Bull. 420, pp. 48–49, 1910.

averaging 8 or 10 inches in diameter, though there are many smaller ones only 2 to 3 inches. They are distributed very irregularly through the mass of pegmatite. Lepidolite in finely granular masses, pale-green albite, and small crystals of green tourmaline are abundant near many of the pockets. Muscovite surrounded by a border of lepidolite, or in parallel growth with lepidolite, is also of common occurrence near the pockets. In this as in most other gem-bearing pegmatites, the crystals of tourmaline are seldom in their original positions on the walls of the cavities but lie embedded in a sandlike mass of quartz fragments, cookeite, and other decomposition products at the bottom of the pockets. They are mainly grass-green to olive-green but become nearly colorless toward the tip. The exact apex of some of the crystals is pink and many of them show very perfect terminations. Gem tourmaline is not so abundant here that it would pay to work the mine for this alone. Most of the gems found in mining for feldspar were marketed irregularly through local collectors.

ANDREWS QUARRY.

The Andrews quarry is about 2½ miles south of South Glastonbury and about half a mile south of the Middlesex-Hartford county line. It is a large quarry with a working face 25 feet high. Graphic granite is the principal material shipped for pottery manufacture. Some mica is found, but it is nearly all in crystals less than 3 inches in diameter and is suitable only for grinding. Other minerals found in the quarry are small red garnets, black tourmaline, and biotite-mica.

JOSEPH HALBERG QUARRIES.

Two quarries have been opened on the land of Joseph Halberg, a little over 1½ miles southeast of Middle Haddam, but they were not in operation when visited in 1914. Bastin called one of them, 100 yards south of the house, the Eureka Mining & Operating Co.'s quarry, after the company operating it at that time. Besides feldspar for making pottery this quarry contains muscovite and biotite mica and pockets carrying gem tourmaline. The mica occurs in blocks from 4 to 5 inches across, a few measuring 8 inches, all of which was sold as scrap for grinding.

The other quarry, opened after Bastin's visit, is about 50 yards northeast of the house. A small quantity of scrap mica was removed during the quarrying for feldspar.

HARTFORT COUNTY.

ROARING BROOK QUARRY.

A quarry was worked for feldspar on the south side of Roaring Brook valley, half a mile east of South Glastonbury. The quarry

is in a pegmatite mass intruded into nearly horizontal mica schist, probably of the Bolton schist formation. Microcline feldspar occurs in pure bodies as wide as 3 feet and quartz in opaque milky-white masses. Mica has been found in crystals from 4 to 6 inches across and 6 inches thick. Most of the crystals are so badly ruled or crumpled that they are suitable only for scrap. Other minerals of the pegmatite are biotite and garnet.

EAST GLASTONBURY QUARRY.

The East Glastonbury quarry is 2½ miles northeast of South Glastonbury on the farm of Frank G. Curtis. The quarry has been worked to obtain feldspar for the manufacture of abrasive soaps. A nearly vertical dike of pegmatite cuts across biotite granite gneiss. The pegmatite contains cream-colored microcline feldspar in pure masses from 2 to 3 feet across. Quartz is not found here in large masses. Mica is fairly plentiful but most of it is in crystals less than 3 inches across. A few crystals measure 5 or 6 inches. Most of the mica is in wedge-shaped or twinned crystals and is suitable only for grinding.

WIARDA AND HOWE QUARRIES.

A little mica, chiefly in small crystals, is found in the feldspar quarries of the John C. Wiarda Co., 1¼ miles south of South Glastonbury, and of Lewis W. Howe, 2 miles south of South Glastonbury. Most of this mica is in wedge-shaped crystals or has the A structure so strongly developed that it is suitable only for grinding.

NEW HAVEN COUNTY.

SOUTHFORD QUARRY.

The Southford quarry is about 1¾ miles south of the station bearing that name. It is worked by the Bridgeport Wood Finishing Co. for quartz but yields some feldspar and mica. Quartz makes up a larger proportion of the rock than usual in the pegmatites of Connecticut. Mica is rather plentiful. It occurs chiefly in bladelike or spearhead-shaped crystals. Some of these crystals are 1½ feet long and 6 inches across. No sheet mica is obtained, and all the product is sold as scrap for grinding.

GEORGIA.

GENERAL FEATURES.

Mica-bearing pegmatites have been found in 20 or more counties of Georgia. A small amount of test work has been done at many of the prospects, but mining has been carried on at a few places only

and has never become a regular industry. The distribution of the deposits and the occurrence of the mica have been described in detail by S. L. Galpin.[39] Much of the information given below has been abstracted from Galpin's report, but a few of the mine descriptions have been prepared in part or wholly from notes made by the writer during brief visits to the deposits in 1908 and 1914.

Galpin considers the following the only counties likely to become producers of mica: Carroll, Cherokee, Elbert, Hall, Hart, Henry, Lumpkin, Meriwether, Monroe, Oconee, Paulding, Pickens, Rabun, Talbot, Troup, Union and Upson. Of these, the deposits of Cherokee, Elbert, Hart, Lumpkin, Rabun, and Union are the most promising. Most of the deposits are in the Piedmont Plateau region, but a few are in the rough mountain section in the northeastern part of the State, especially those in Lumpkin, Rabun, and Union counties.

The deposits are associated chiefly with pre-Cambrian rocks (the Carolina gneiss and the Roan gneiss of Keith), but a few deposits in Pickens County are with rocks of later age, probably Cambrian. Granitic rocks are present in many of the regions where mica deposits occur. Some are early or pre-Cambrian intrusions and others are of later or post-Cambrian age. The location of the deposits and the general geology of the mica region are given in the accompanying map, reproduced from S. L. Galpin's report by permission of Dr. S. W. McCallie, State geologist of Georgia. (See Pl. XI.)

The surface rock over most of the region has been deeply weathered and fairly fresh outcrops of pegmatite and the inclosing rocks are found only where the valleys have been cut through the mantle of residual soil. In the uplands the outcrops of pegmatite are marked by kaolin (white where not discolored by other products of weathering) containing more or less clay-stained mica and blocks or boulders of quartz scattered over the surface. When the upland deposits are opened weathering extends to varying depths, even exceeding 50 feet.

CARROLL COUNTY.

Crystals of mica 4 to 6 inches across have been found in a 10-foot body of pegmatite on the land of J. A. Potate, 1⅛ miles north of Temple. The vein outcrops for 150 yards across a small gully. The feldspar has been kaolinized, and the mica has been rather badly ruled. Deposits 1 mile to 3 miles northwest of Burwell were also examined, some of which contained mica plates 3 by 4 inches.

[39] A preliminary report on the feldspar and mica deposits of Georgia: Georgia Geol. Survey Bull. 30, 1915.

CHEROKEE COUNTY.

The principal mica deposits of Cherokee County occur in a belt about 3 miles wide that enters the southern border of the county west of Woodstock and extends northeastward through the Hollysprings-Toonigh region to and beyond Hickory Flat to Lathantown. Starting in the southwestern part of the belt, deposits belonging to the following persons were examined by the writer: De Lay brothers, M. M. Cole, J. B. Wheeler, and W. J. Cook. Mr. Galpin also examined the property of J. D. Hillhouse, the old Dean mica mine, and prospects near Lathantown, all of which are described elsewhere in this bulletin.

DE LAY PROSPECT.

About 100 pounds of mica was taken out of a pit on the land of the De Lay brothers, 3 miles west of Woodstock. The pit was only 4 feet deep and was made in one of three outcrops in a field. Much of this mica had the **A** structure and part was specked. Good sheets could be cut from the material between the **A** lines, where the cleavage was smooth in some of the crystals. The largest crystals seen with the **A** structure were 8 to 10 inches long and one of them would have yielded plates $1\frac{1}{2}$ by 4 inches. The mica occurs in pockets along the side of a quartz vein in a pegmatite several feet thick. The pegmatite is inclosed in mica gneiss that has a northeast strike.

OLD DEAN MICA MINE.

The old Dean mica mine, about $3\frac{1}{2}$ miles northwest of Woodstock, has not been worked since 1889. It is now owned by C. W. Flentke, of Evansville, Ind. The mica obtained from this mine is reported to have been ground on the property. The mine was worked chiefly through two open cuts, one extending across the formation into a hillside and entering another about 75 feet long, 30 feet wide, and 25 feet deep, which follows the "mica lead." A short tunnel extends northeastward from the bottom of the cut. Two masses of pegmatite striking N. 40° E. and dipping southeast were exposed in the cut. One of these masses 3 to 4 feet thick, which lies along the west side of the working face, contains partly decomposed feldspar, a little quartz, and mica in crystals as much as 3 to 4 inches across. The mica crystals occur in a streak about a foot thick along the hanging wall, where they form possibly 20 to 25 per cent of the rock. The crystals are ruled and have been badly stained with clay. The other mass of pegmatite, which is more than 10 feet southeast of the first, is 10 feet thick in the bottom but pinches toward the top of the cut. The feldspar content of this pegmatite has been kaolinized. A streak about 2 feet thick near the hanging wall carries mica crys-

MAP OF NORTHERN GEORGIA SHOWING LOCATION OF MICA AND FELDSPAR DEPOSITS

After S. L. Galpin

Scale 1:600000

10 0 10 20 30 40 Miles

10 0 10 20 30 40 50 Kilometers

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

tals, none of which as exposed measured more than 3 inches across. Galpin describes as "mica conglomerate" a mixture of mica and quartz from which a little feldspar has been dissolved in smaller pegmatites on the hill above the mine. This material would probably be called "mica capping" in the mica regions of North Carolina.

J. D. HILLHOUSE MINE.

Galpin mentions several prospects opened on the J. D. Hillhouse place, 1⅛ miles west by north of Toonigh. The prospects are on or near the crest of a low ridge. Several bodies of pegmatites were opened within a belt 100 yards wide. At least one of these bodies is 8 to 12 feet thick, but the others are thinner. Mica crystals measuring 3 or 4 inches across were found in irregular streaks along the walls of some of the masses of pegmatites. The mica has good cleavage but is specked with magnetite. The feldspar of the pegmatites has been almost entirely kaolinized.

M. M. COLE PROSPECTS.

Mica prospects have been opened on the M. M. Cole place, 1½ miles N. 25° W. of Toonigh. Most of the work was done by Charles Makepeace, of Ball Ground, Ga. The prospects occur in a series of outcrops of pegmatite within a distance of about 350 yards in a direction N. 30° E. along the summit and east side of a ridge. The relief between the ridge and the stream to the southeast is about 50 feet. The largest working is at the northeast end of the outcrops in the hillside, a few feet above the stream, where two tunnels 30 feet apart were driven west into the hillside and curved in the shape of a horseshoe so as to meet each other at a distance of about 50 feet. The country rock is mica gneiss. The pegmatite cuts the gneiss irregularly, branching from a large deposit on the southwest side into smaller streaks in the workings. The mica was found rather irregularly in bunches or pockets in the decomposed pegmatite.

Most of the mica is specked, some rather heavily, with thin films of magnetite between the laminae. The cleavage is good, and a little clear mica is obtained by splitting many of the crystals. Several tons of mica suitable for small sheets, punch, and scrap was left on the dump.

J. B. WHEELER PROSPECT.

Several prospect pits and a shaft were opened about 1890 on the land of J. B. Wheeler, 2 miles east of Holly Springs. The pits fall within a distance of 75 feet in a N. 35° E. direction. The shaft is 25 feet deep and lies southeast of the line of pits and the pegmatite. The country rock is mica gneiss which strikes about northeast and

dips almost vertically. The body of pegmatite is approximately conformable with the gneiss and is 6 or more feet thick. Little could be seen in the workings, but on the dump weathered mica ranging from minute scales to crystals 5 or 6 inches in diameter were seen. The mica is clear and light in color.

In a field a quarter of a mile west of this prospect many A and wedge shaped crystals of mica were plowed up.

COOK MINE.

The W. J. Cook mine is 8 miles S. 80° E. of Canton, or a little more than 2 miles south by west of Orange. The mine was worked by the Pittsburgh Mica Mining Co. in 1907, Mr. Cook acting as superintendent, but later the property passed to Mr. Cook. The equipment consisted of a 25-horsepower gasolene engine and a dynamo to generate current for mine use, a hoist operated by a 7-horsepower electric motor, mine cars, and track, and electric lights. The workings consist of an incline reported to be 150 feet deep, a drift extending from the incline 70 feet long in a N. 30° E. direction at about the 30-foot level, an interior shaft 30 feet deep on the southeast side of the drift, an incline 20 feet deep at the northeast end of the drift, an upraise connecting with a shaft from the surface and used as an air shaft, a shaft 22 feet deep connected with the 70-foot drift by a short incline, short drifts from this shaft at a depth of about 15 feet, and two surface pits. The position of the different workings are shown in figure 13. The interior shaft and the incline below the 70-foot drift were filled with water at the time of examination. The mouth of the incline had caved in, and entrance to the workings was made through the 22-foot shaft.

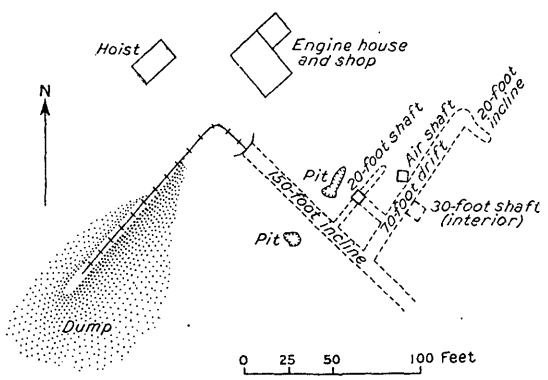


FIGURE 13.—Plan of W. J. Cook mine, 8 miles S. 80° E. of Canton, Cherokee County, Ga.

The country rock is mica gneiss cut by pegmatite and pegmatitic granite. The pegmatite bodies are approximately conformable with the inclosing gneiss but cut across it in places. The formations strike about northeast and dip 45° SE. The pegmatite is somewhat irregular in shape and branches out from the main mass. It varies in thickness from less than a foot in some of its branches to 8 or 10 feet where opened by the pits and the 22-foot shaft. The "vein" was much thinner in the 70-foot drift than above and ranged from

a few inches to 3 feet. The pegmatite was richest in mica in the upper workings and did not yield much at the 70-foot drift or lower. The deep incline yielded practically no mica but was sunk chiefly in the mica gneiss country rock. The feldspar of the pegmatite is kaolinized in the upper workings but was only slightly altered below the 70-foot drift.

Pegmatitic quartz containing a few boulders of pegmatitic granite and pegmatite, both carrying mica crystals ranging from a fraction of an inch to 2 inches in diameter, are scattered over the surface of the ridge for a distance of about 300 yards to the northeast. None of these pegmatite outcrops have been tested for mica.

Mr. Cook states that about 4,500 pounds of mica trimmed into sizes ranging from punch to 5 by 7 inches was shipped to Pittsburgh. Several tons of scrap and mica suitable for punching or small sheets was left at the mine. The mica is rum-colored, and part of it contains numerous small specks. The cleavage is smooth and flat.

Other mica prospects have been found in Cherokee County but have not proved promising when opened. At one of these, on the David Bennett place, several miles west of Nelson, Galpin found a pegmatite 1 foot to 4 feet thick exposed in several shallow pits and trenches along a ridge. The pegmatite follows the ridge and strikes N. 40° E. No recent work had been done, but a little mica was found in the pegmatite and around the workings. It is of good quality, but the largest seen would not trim to sheets of more than 2 by 4 inches.

ELBERT COUNTY.

CHAPMAN MINE.

The mica deposits of Elbert County occur chiefly in the northeastern part. Prospecting and mining have been carried on during several periods at the J. E. Chapman place near the junction of Rocky Branch and Coldwater creeks, the most extensive work being done in 1907 and in 1910. At the main working a drift was run 200 feet diagonally into the hillside to connect with a crosscut tunnel. The pegmatite and inclosing mica gneiss strike northeast and dip almost vertically. The "vein" is about 7 feet thick and has been rather strongly weathered. About 15 tons of mica is reported to have been shipped. Sheets left around the mine have a good cleavage but are rather heavily specked.

About a quarter of a mile north of the main working an open cut exposes a large pegmatite inclosing irregular quartz segregations. Masses of wedge, A, and herringbone mica are thickly packed around the bodies of quartz. No sheet mica was observed by Galpin at this prospect.

HALL COUNTY.

HOPE MINE.

The George M. Hope mine is about 1½ miles west by north of Gainesville. The following description and sketch map are reproduced from a report by S. L. Galpin, supplemented by a few notes taken by the writer during a brief visit in November, 1914. The workings consist of numerous pits, cuts, shafts, tunnels, and inclines extending from a branch on the south for more than 100 yards northward along the west side of a small hollow. Most of them have caved in badly, so that the formations were exposed in only a few places. The position of the workings is shown in figure 14.

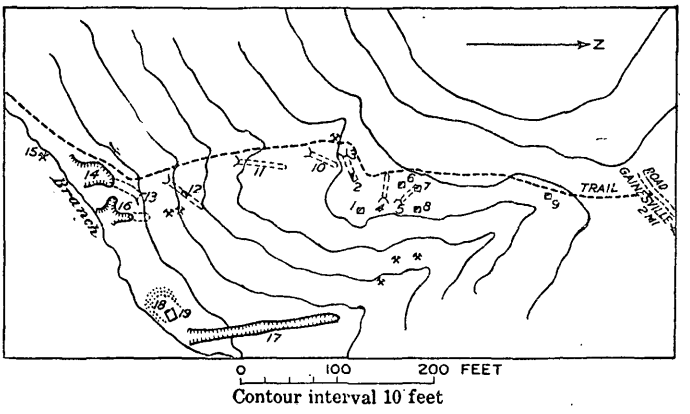


FIGURE 14.—Sketch map of Hope mica mine near Gainesville, Hall County, Ga. (After S. L. Galpin.) 1, Shaft 120 feet deep; 2, shaft badly caved; 3, incline to shaft; 4 and 5, 20 to 30-foot inclines; 6, 7, 8, and 9, shafts; 10, 40-foot incline; 11, 60-foot incline; 12, 40-foot tunnel exposing 12-foot kaolinized pegmatite; 13, partly caved incline extending to open cut, 14; 15, recent prospect; 16, open cut and tunnel; 17, long open cut; 18, dump; 19, storage house; crossed hammers, minor prospects.

The country rock is coarse mica schist, garnetiferous in places, with a few streaks of inclosed hornblende gneiss. The strike in the vicinity of the mine ranges from due north to N. 30° W. and the dip from 25° to 50° west and southwest. Several pegmatites have been opened in mining. Three mentioned by Galpin are in part conformable with the inclosing schist and in part cut across its foliation. They range in thickness from a foot or two to 16 feet. In the incline at 5 (see fig. 14) the pegmatite is about 5 feet thick and carries a good mica content. At 13 the pegmatite is about 8 feet thick, but the mica content of that exposed at the time of examination was low. Most of the feldspar in the upper workings was kaolinized, but nearly fresh potash feldspar occurs near the level of the branch. An analysis of feldspar from the prospect at 15, by Edgar Everhart, showed 10.02 per cent potash, 1.25 per cent soda, 21 per cent alumina, 1.2 per cent

ferric oxide, and 59.87 per cent silica. The mica has smooth cleavage and a clear light rum color. Only small sheets and scrap were seen around the mine, but good sizes are reported to have been found. Galpin suggests that possibly the kaolin associated with the mica might be profitably washed and says that a good location for a washing plant can be found.

None of the mica deposits in the counties mentioned below have been visited by the writer, and all information regarding them has been abstracted from S. L. Galpin's report.

HART COUNTY.

The following mica deposits in Hart County have been described by Galpin:

CRAFT PROSPECT.

A prospect shaft 12 feet deep was opened on the J. W. Craft farm in the southeastern part of the county. The pegmatite is nearly 8 feet thick and incloses several quartz streaks or veins. About 2 tons of rough thumb-trimmed mica was reported to have been taken from the prospect. A quantity of A and partly clay-stained mica was left around the pit. Other prospects have been opened on adjoining farms.

HEATON PROSPECTS.

Two prospects on separate bodies of pegmatites about 200 yards apart have been opened on the J. S. Heaton farm, 1 mile south of Hartwell. Clay-stained mica of good quality and with good cleavage was found in both prospects.

HAILEY PROSPECT.

Mica-bearing pegmatite outcrops at several places on the J. A. Hailey estate, 3½ miles southwest of Hartwell. Mica ranging from thin films to plates 3 by 5 inches are scattered over a field in line with one of the larger outcrops. A few beryl crystals have also been found on this place.

HODGES PROSPECT.

Several small open cuts and pits were made on the W. L. Hodges farm, 1 mile north of Hartwell. Mica of good quality but in small sheets was found in decomposed pegmatite.

EVANS PROSPECT.

Two prospects were opened on the B. W. Evans place. Very little mica had been left around one of these prospects near the public road, but a quantity of small mica and clay-stained sheets was found around the other one.

PARHAM PROSPECT.

A little prospecting on the Earl Parham place, 5 miles northeast of Hartwell, exposed two thin flat-lying bodies of pegmatite. The upper one of these bodies contains a mass or pocket of tangled herringbone mica, some of the crystals of which are 10 inches long, and a little good-splitting mica.

WILLIAMSON PROSPECTS.

Three pits and two hillside trenches have been opened on the J. B. Williamson place, 2½ miles south of Air Line. The country rock is staurolite and garnet schist. A body of pegmatite 3 to 15 feet thick cuts it with a strike of about N. 70° E. and a dip of 60° SE. The mica occurs along the hanging wall but is so badly weathered that probably no use can be found for any material taken above the water level.

MORRIS PROSPECT.

T. E. Morris has prospected for mica on the Tribble place, the mineral rights of which he holds, 2½ miles north of Air Line. Several hundred pounds of clear rum-colored mica with good cleavage but somewhat clay stained was obtained from a 15-foot trench on a thin pegmatite.

Other prospects are known, especially within 5 miles of Hartwell, but extensive clay staining of all mica mined above water level in Hart County has materially affected its commercial value.

LUMPKIN AND UNION COUNTIES.

LOCATION OF DEPOSITS.

A number of deposits of pegmatites have been prospected or worked for mica in the Tworun and Yahoola districts of Lumpkin County and in the Gaddistown district, adjoining them on the north in Union County. The deposits are on both sides and along the summit of the Blue Ridge Mountains, the crest of which forms the boundary line between the two counties. Some of the deposits were briefly described by the writer in 1908,[40] but a more complete description of the region and mines has been given by Galpin, from whose report the following descriptions have been taken, supplemented by notes of the writer. The mines are from 8 to 15 miles north and northwest of Dahlonega, and the location of the deposits is shown in figure 15 (reproduced with slight changes from Galpin's report). Eight or more of these deposits were worked by the Pitner Mica Co. between 1898 and 1908, but little work has been done since that time.

[40] Sterrett, D. B., Mica: U. S. Geol. Survey Mineral Resources, 1908, pt. 2, pp. 743–754, 1909.

SAIN MINE.

The Sain mine of the Pitner Mica Co. is about 2⅓ miles south of Cooper Gap and about 1 mile northwest of the old Tworun post office. It was opened by a 60-foot incline equipped with a hand hoist. The country rock is mica gneiss interbedded with a little hornblende gneiss. The body of pegmatite seen by the writer is very irregular in shape and is reported to range from 2 to 10 feet in thickness. It carries horses or inclusions of the mica gneiss and

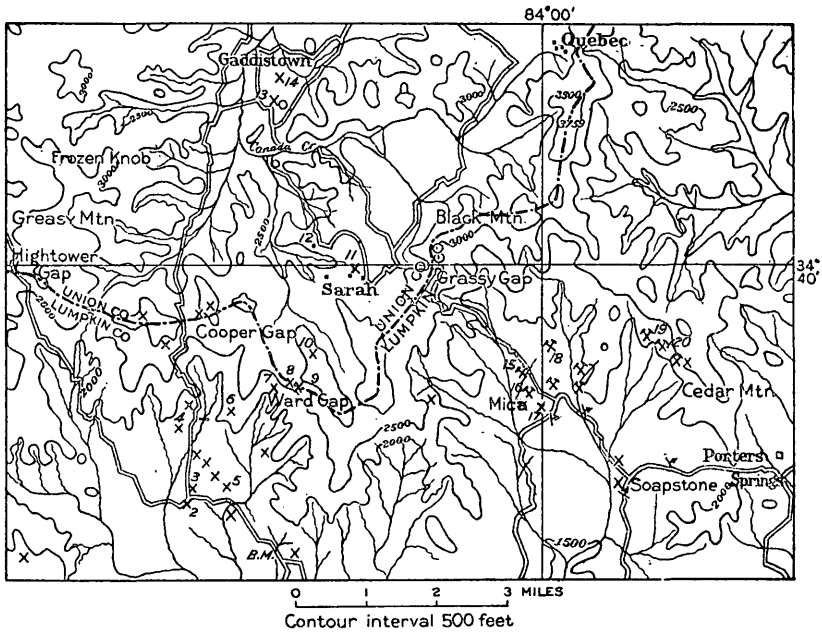


FIGURE 15.—Sketch map of parts of Lumpkin and Union counties, Ga., showing the location of the principal mica mines and prospects. Topography taken from U. S. Geol. Survey maps of Ellijay and Dahlonega quadrangles. 1, Jones Creek prospect; 2, Sain mine; 3, Williams mine; 4, Ward mine; 5, Masters or Geddes mine; 5-A, Graham mine; 6, Henry Lee mine; 7, Eph Lee mine; 8, Ward Gap mine; 9, Green Vein mine; 10, Long Mountain mine; 11, William Gooch mine; 12, mica mill; 13, Thomason prospect; 14, Gooch mine; 15, Scott mine; 16 and 17, Cassity prospect; 18, Caldwell prospect; 19, Wash Walker or Big mine; 20, Wess Walker mine. Other less important or unnamed prospects and mines are represented by crosses.

hornblende gneiss. Several tons of mica was found in pockets within a few feet of the surface. Some of the crystals were 15 to 18 inches across but were cut into smaller plates by ruling. The mica has a rum color but is clay stained from surface weathering.

WILLIAMS MINE.

The Williams mine of the Pitner Mica Co. is about 250 yards northeast of the Sain mine. It was opened by an incline 120 feet deep with a hand hoist, skips, drills, and other equipment. The

country rock is mica gneiss which strikes northeast and dips southwest. Galpin found a mass of pegmatite, 6 to 15 feet thick, striking N. 10°–20° E. and dipping southwestward when the mine was cleaned out in 1913. The portion of the "vein" examined by the writer in 1908 appeared to strike northwest and dip 20° NE., cutting across the bedding of the gneiss. The vein is composed of partly decomposed feldspar through which are scattered lenslike masses of quartz. Mica crystals occur along the feldspar-quartz contacts wholly or partly inclosed in either mineral. Vugs found in some of the quartz lenses contain smoky and clear quartz crystals, and Mr. L. M. Richard, of Stamford, Tex., found a colorless topaz crystal in a cavity in a mica crystal during 1913. Mica crystals as much as 18 inches across were seen in 1908, and Galpin mentions one more than 2½ feet across exposed in the roof of the incline. The mica is strongly ruled, and much of it is in A-shaped crystals. The thicker sheets have a greenish cast.

WARD MINE.

The Ward mine is about 2 miles south of Cooper Gap 300 yards west of the road to Dahlonega. It was opened by a trench 40 feet long with tunnels, now badly caved in, at each end and a short incline on the "vein" near the southwest end of the trench. A small pegmatite with a 60° SE. dip was poorly exposed in the workings. Only small mica was left around the prospect, but this was of good quality.

MASTERS OR GADDIS MINE.

The Masters or Gaddis mine of the Pitner Mica Co. is a little more than half a mile east of the Sain mine. It was worked by a 40-foot open cut, a 40-foot shaft, and a 20-foot incline. A tunnel at a lower level has caved in. The country rock is kyanitic mica gneiss with variable strike and dip. The pegmatite occurs in lenses, more or less connected, and ranges in thickness from a few inches to several feet. The main lead of lenses has been traced northeast for about 75 yards. Branch "veins" or lenses of pegmatite occur on the northwest side of the main lead and contain some good mica. Sheet mica and a quantity of ruled and A mica were obtained from the workings.

GRAHAM MINE.

The Graham mine is about one-fifth of a mile south of the Masters or Gaddis mine. The pegmatite has a strike of N. 60° E. and a vertical to southeast dip. It contains a quartz streak or lens 30 feet long and from a fraction of an inch to 2 feet thick parallel to its strike. The pegmatite is 10 feet thick where exposed in one opening. A branch streak of pegmatite to the northwest is exposed at this point.

HENRY LEE MINE.

The Henry Lee mine is in a prominent mountain ridge or spur extending south from the Blue Ridge between Cooper Gap and Ward Gap. It was worked by a Mr. Ashley from 1903 to 1906, but is now owned by the Roland Lumber Co. Large dumps were thrown out, but little could be seen of the workings or formations at the time of Galpin's visit. The mine is reported to have yielded a large quantity of mica, the best of which was ribbon mica measuring 4 by 10 inches.

EPH LEE MINE.

The Eph Lee mine is a little north of the crest of the Blue Ridge and about three-eighths of a mile northwest of Ward Gap. The workings consist of an irregular-shaped pit from which a tunnel has been driven 40 feet to the northeast along the strike of the pegmatite. The country rock is granitic mica gneiss strongly folded and contorted. The pegmatite cuts the gneiss near the axis of one of the folds. It is 6 inches to 3 or 4 feet thick and incloses quartz veins or stringers. Small mica crystals 2 to 3 inches across are plentiful, and a few crystals 6 to 8 inches across are reported to have been found. The mica has a rum color, but much of it is **A** or has been crushed.

WARD GAP MINE.

This mine is in Ward Gap close to the Lumpkin-Union county line. The workings consist of an irregular open cut, with a crooked incline extending a few feet into the south wall. The pegmatite is at least 6 feet thick and cuts the mica gneiss country rock unconformably. It contains both granular quartz and small lenses and masses of quartz. The mica is associated with the quartz masses. It is rum-colored to smoky brown, and a rather large proportion is of the **A** variety. Mr. J. L. Ingram, who operated the mine for the Pitner Mica Co., reports that he removed about 3 tons of rough sheet mica and much scrap mica, some of which was ground at the company's mill, about 2 miles northeast of the mine. Mining cost about 50 cents a 100 pounds for scrap and about 75 cents a 100 pounds for rough sheet for trimming. A day's work yielded from 100 to 600 pounds of mica.

GREEN VEIN MINE.

The Green Vein mine is in the south side of the Blue Ridge Mountains about three-eighths of a mile southeast of Ward Gap. As seen by the writer it was opened by a cut 20 feet deep and 40 feet back into the mountain side. Galpin mentions two other pits probably below this. The country rock is mica gneiss with a northerly strike and 30° E. dip. The mass of pegmatite, ranging from 1 foot

to 5 feet in thickness, cuts across the country rock with the same strike and a nearly vertical dip. The "vein" contains both granular and massive quartz segregations. Only small mica was seen. This has a strong green color in thick sheets but is practically colorless when split into thin sheets. Galpin states that the color seems to be due, in part at least, to inclusions of darker mica, probably biotite. Four tons of thumb-trimmed and a quantity of scrap mica are reported to have been taken from the Green Vein mine.

LONG MOUNTAIN MINE.

The Long Mountain mine of the Pitner Mica Co., is a little west of the summit of Long Mountain and about two-thirds of a mile northeast of Ward Gap. It was opened by a trench 25 feet long, now badly caved in. A pegmatite 4 feet thick was exposed striking N. 20° E. and dipping southeast. The "vein" consists of kaolinized feldspar, quartz, and a little mica. Much A mica was left on the dumps, but 5 or 6 tons of rough-trimming mica of good quality is reported to have been obtained in a few days' work.

THOMASON MINE.

The Thomason mine is about a mile east of Gaddistown. It was worked by an open cut and a short incline on a pegmatite about 2 feet thick. The vein strikes N. 20° W. and dips 45° NE. Only A mica suitable for grinding was found.

MATT GOOCH MINE.

The Matt Gooch mine is about a quarter of a mile north of the Thomason mine. It was opened by a trench and a tunnel 50 feet long on a pegmatite 3 to 6 feet thick. The pegmatite has a north strike and low west dip. It contains irregular quartz masses and segregations with which the mica is associated. The mica has a dark color, and part of it is specked with magnetite.

OLD SCOTT MINE.

The Old Scott mica mine of the Pitner Mica Co. is 10½ miles north of Dahlonega and 30 yards west of the road leading to Grassy Gap. It has been worked intermittently for more than 30 years. The workings consist of a large open pit with entry trench and several short inclines on the dip of the "vein." The pegmatite is 6 feet thick and contains irregular quartz segregations. Both A and clear, flat, splitting mica were mined. Other prospects were tested by the Pitner Mica Co. on the Cassity and Caldwell farms south and northeast of the Old Scott mine.

WASH WALKER OR BIG MINE.

The Wash Walker or Big mine of the Pitner Mica Co. is a little more than 2½ miles northwest of Porter Springs. Two nearly parallel drifts only a few feet apart and at slightly different levels were made on two pegmatites that join a short distance to the southwest. The pegmatites strike northeast and dip southeast, cutting the bedding of the gneiss, which strikes west of north and dips northeast. Mica of good quality and some of the A variety were found.

J. W. WALKER PROSPECTS.

Two prospects have been opened on the J. W. Walker place, 2½ miles northwest of Porter Springs. One is a quarter of a mile north of the Walker house and the other is a quarter of a mile east of the house. At the north prospect the pegmatite cuts biotite-mica gneiss unconformably. It ranges from 3 to 15 feet thick and incloses a quartz mass in the thickest part. The mica came from around the quartz segregation. Two men working 2 weeks mined 4,000 pounds of mica from this deposit.

At the east prospect a 3-foot pegmatite was opened by a drift 35 feet long. The pegmatite cuts the foliation of the gneiss with a strike of N. 20° E. and is banded with feldspar streaks along the walls and quartz with mica in the middle. The quartz contains open cavities or vugs. Both A and sheet mica were obtained.

A mica prospect was opened by B. E. Dyer near Tower, Union County, in 1908, by a tunnel driven 125 feet into a hillside. Promising samples of clay-stained mica crystals 8 to 10 inches across were obtained.

PAULDING COUNTY.

Mica prospects have been opened on the land of Dr. E. W. Dean, three-eighths of a mile southwest of Hiram, on the property of M. J. Petty, a quarter of a mile northeast of the Dean prospect, and on the Turner farm, 5 miles north of Dallas. At the Dean prospect a quantity of clay-stained mica was left on the dumps, some of it clear sheet material but a large part of it has the A structure. Some of the sheets were 6 to 8 inches across. At the Petty prospect a pegmatite inclosing quartz lenses was opened by a 60-foot trench. Most of the mica seen was small and of the A variety. At the Turner prospect the work was directed about large quartz masses. Some A mica had been left on the surface.

PICKENS COUNTY.

Mica of probable value has been found in pegmatites and in the form of sericite schist in Pickens County. The mica-bearing pegma-

tites occur chiefly in two belts, one 5 miles west of Nelson and the other 2 miles east of Nelson. In the belt west of Nelson prospects were opened on the F. M. Cagle farm, 5 miles west of Nelson, and on the Marion Davis farm, 4½ miles south by west of Jasper. Trimmed sheets of good quality measuring 4 by 10 inches are reported to have been obtained from the Cagle prospect. At the Davis prospect the showing is better for feldspar than for mica. Prospects were opened on the Burgess Fowler and John Freeman farms, 2 miles west of Nelson, a number of years ago. A ton or more of mica still remains around the pits. Most of it is badly weathered, but some of the crystals measure 6 to 8 inches across.

A sericite schist of remarkable purity has been found on several properties about 5 miles southwest of Jasper. It has been described by Oliver B. Hopkins[41] and S. L. Galpin, and additional notes have been supplied to the State geologist, Dr. S. W. McCallie, by Henderson Hallman, of Atlanta. Prospects have been tested on the property of Gabriel Martin, 5½ miles southwest of Jasper; on that of J. W. Alfred, adjoining it on the east; on that of W. K. Padgett, 1 mile northwest of the Martin land; and on that of William Richards, north of the Alfred property. The deposits consist of beds or layers 2 to 10 feet thick interbedded with or grading into quartz sericite schist of less purity.

The sericite schist is a silvery greenish-gray rock with rather close texture and fine slaty to schistose cleavage. It can be cut and sawed very much like talc, and at first was sold as talc. In its purer phases it is composed almost entirely of fine, flat scales of muscovite or sericite mica. The cleavage planes show two sets of fine folds of different intensity, crossing each other at large angles. Analyses made by the Geological Survey of Georgia show a composition quite similar to that of muscovite, one analysis indicating about the following percentage: SiO_2, 46.75; Al_2O_3, 34.94; total iron oxides, 3.04; K_2O, 10.31; H_2O, 3.18.

The rock crushes rather easily, breaking down into fine mica scales resembling ground mica, and it is reported that a quantity has been tried as a substitute for ground mica in the manufacture of wall paper, rubber and electrical goods, and for tire lubrication. Because of its high potash content (more than 10 per cent) experiments have been conducted with a view to using the sericite schist as a source of potash. Some of the processes of extraction are designed to save the alumina at the same time.

[41] Asbestos, talc, and soapstone deposits of Georgia: Georgia Geol. Survey Bull. 29, p. 304, 1914.

RABUN COUNTY.

The best mica deposits in Rabun County have been found in a belt passing 6 to 10 miles east of Clayton. A number of these have been described by Galpin, from whose report the following descriptions have been abstracted:

McCRACKEN MINE.

The McCracken mine is 12 miles southeast of Clayton in lot 67, fourth district. It was worked by a number of pits, shallow shafts, and trenchlike open cuts. Some of the workings expose a coarse-grained pegmatite 4 to 6 feet wide, striking N. 5° E., dipping 80° E., and composed of pinkish feldspar, quartz, and greenish muscovite mica. The mica is clean and free from injurious structures.

TUNNEL MINE.

The tunnel mine is about 9 miles east of Clayton, near the top of the divide between Hicks and Warwoman creeks and not far from the southern entrance of a tunnel which the Blue Ridge Railroad Co. started a number of years ago. The workings consist of an open cut 100 feet long, 20 feet wide, and 30 feet deep. The country rock is hornblende gneiss. The pegmatite body cuts northward across the country rock and dips 53° E. It is 12 to 16 feet thick and coarse-grained through the main mass, but it consists of a finer-grained mixture of quartz and mica for a thickness of 3 feet along the hanging wall. The coarse-grained portion of the pegmatite is composed of partly kaolinized feldspar, graphic granite, quartz masses, and mica in irregular streaks through the decomposed feldspar. The mica is clear in thin sheets but of dark rum color in thicker sheets, some having the A structure.

BECK MINE.

The Beck mine was examined by the writer in 1907. It was opened by a cut about 100 feet long and 10 to 15 feet deep with three entries from the downhill side. The country rock is mica gneiss, which strikes N. 70° E. and dips 25° N. Small inclusions of hornblende gneiss occur in the mica gneiss, and the mica gneiss has local variations of dip and strike around these inclusions. The body of pegmatite is 6 to 12 feet thick and cuts northward across the gneiss. A streak of massive quartz is inclosed in the pegmatite, and fragments of rough quartz crystals were thrown on the dump. A number of mica crystals 6 to 8 inches across were seen on the dump and in the pegmatite. Most of the mica is of the A variety, but good sheets could be cut from some of the crystals between the A lines. Bluish, bluish-green, and yellowish-green beryl crystals were found.

Some of these measure several inches across and, though badly flawed, contained small clear portions. Masses of potash feldspar a foot across were seen in the walls of the cut.

KELL MINE.

The Kell mine is about 12 miles by road or trail east by north of Clayton. It was opened by a cut 60 feet long and 16 feet wide at the southwest base of a steep ridge a few feet above a small stream. The pegmatite has a maximum thickness of 24 feet, 8 to 12 feet of which along the hanging wall is very coarse grained. Masses of rose quartz and mica occur in this portion. The rest of the vein is finer textured. Good sheet mica is reported to have been found, and a quantity of A mica, which was not shipped.

Other prospects have been opened in this belt, especially in the region of Pine Mountain, where only a small amount of work was done, near Dillards, and at Mountain City.

TALBOT COUNTY.

Mica prospects have been opened on the old Martin place, 6 miles east of Woodland on the Thomaston road, in Talbot County. Several barrels of sheet mica is reported to have been shipped, and only scrap mica was left around the workings.

TROUP COUNTY.

Mica-bearing pegmatites are rather plentiful in the northwestern half of Troup County. Some of the deposits 2 to 5 miles northwest of La Grange are reported to have yielded good specimens of mica. A crystal 3 by 5½ inches was found on the Virgil E. Davis farm, 3½ miles west of La Grange.

UPSON COUNTY.

Mica-bearing pegmatite occurs from 1 mile to 3 miles south and southeast of Thomaston and 3 miles west of Kenzie near the E. E. Thompson house, in the northern part of Upson County. On the Thompson property weathered sheets of mica 4 to 10 inches across are found loose in the surface soils. This mica is clear and of good quality except for surface weathering.

IDAHO.

LATAH COUNTY.

MICA DEPOSITS.

Deposits of mica have been found in several counties of Idaho, but only those of Latah County have been developed extensively. These

were examined in 1910, and the conditions of the workings are described below as they were at that time. More recently the Producers Mica Co., of Chicago, has worked some of the properties, especially the Muscovite mine, on a large scale. Heavy shipments of mica have been made to the company's plant in Chicago where the mineral has been prepared for the market.

The deposits examined lie in a belt about 2 miles wide that extends north and south for several miles in T. 41 N., R. 2 W., from 3 to 6 miles north of Avon. They lie at elevations of 3,400 to 4,700 feet above sea level, along the top and to the west of a high mountain ridge extending south from the Thatuna Hills. The principal properties are the Muscovite claim, about 5 miles north of Avon, in sec. 22; the Levi Anderson mine, about 4 miles north of Avon, in secs. 22 and 27; the Maybe mine, about 1 mile southwest of the Muscovite claim, in sec. 22; and the Luella mine of the Western Mica Co., about 1½ miles southwest of the Muscovite, in sec. 21. Other claims are owned by Alexander Munro and David Peterson, in sec. 15. In order from south to north along the ridge the mines are the Levi Anderson claim, the Muscovite, Atlas, Violet, and Morning Star claims, and the Sunshine claim of David Peterson. The Maybe and Luella mines are in the valley to the west of this ridge. The location of the different deposits is shown in figure 16. At the time of the writer's visit the Muscovite was the only mine in operation; it had been idle a few years and was being cleaned out preparatory to mining. The elevations given were determined by barometric measurement.

The mica deposits occur in an area of highly schistose metamorphic rocks of pre-Cambrian age. Muscovite and biotite schists and gneiss, in which quartz is generally a prominent constituent, are the principal types of rock in the region. Bands of the gneiss at some places contain crystals of black tourmaline, especially in places near large bodies of pegmatite. The schistosity of the gneiss and schist of this region strikes roughly north and south and dips from 50° W. to vertical. Masses of pegmatite cut the gneiss and schist and are at many places entirely conformable with the schistosity and at others only in part or not at all. Some of the bodies of pegmatite crop out continuously for several hundred yards with few variations in thickness or direction. Others have smaller outcrops. At some places the bodies of pegmatite bulge or swell into chimney-like deposits and contain rich deposits of mica. The gneiss and schist apparently contain more pegmatite in the valley west of the high mountain ridge than in the ridge itself. The miners say that the deposits along the top of the mountain are on the same ledge of pegmatite, but this has not been proved. There may be separate sheets of pegmatite that

do not connect, though they may be nearly in line with one another or may overlap. Even if a single body of pegmatite should prove so persistent as to extend over several claims, its content of mica is variable and at some places it contains none.

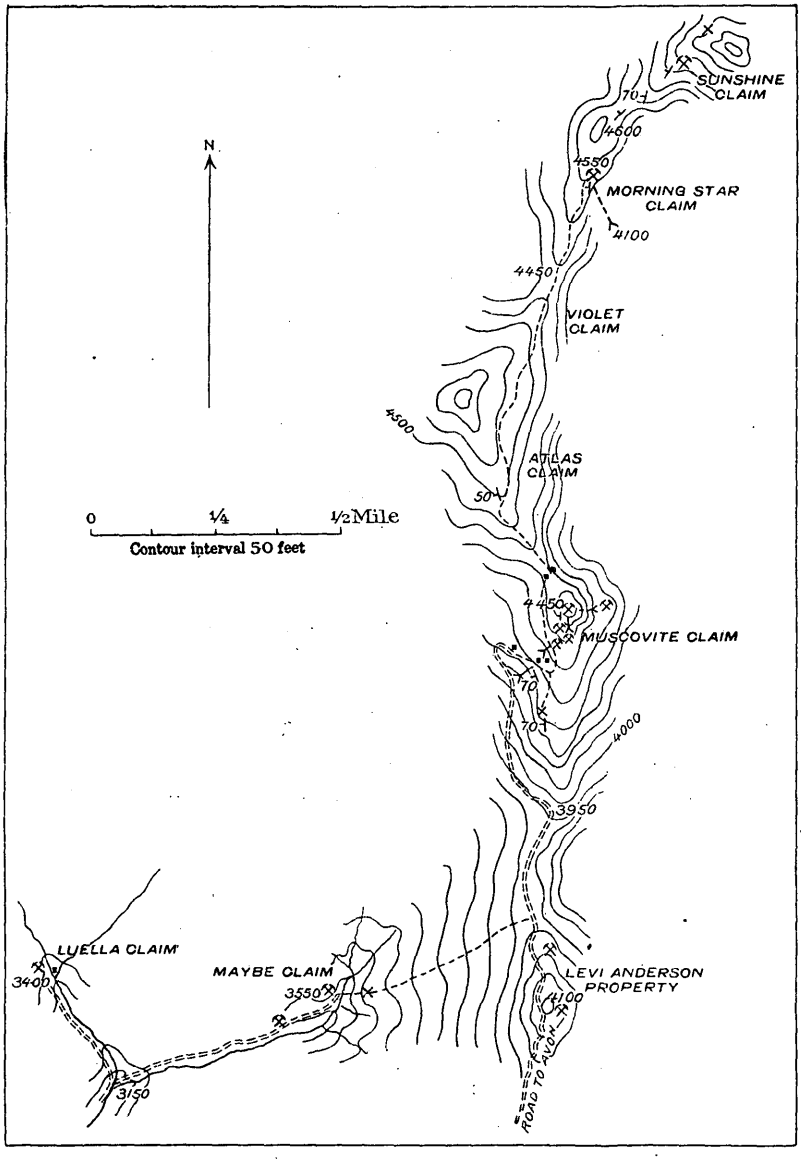


FIGURE 16.—Sketch map showing position of mica deposits in Latah County, Idaho.

The beds have been folded, but in the small area under consideration the larger folds can not easily be distinguished. Small folds whose dimensions can be measured in feet and whose schistosity is turned across the bedding were observed at a few places. In general

the strike and dip are rather regular for a region of tilted metamorphic rocks.

LEVI ANDERSON MINE.

The Levi Anderson mine is in a low, rounded knob on the ridge, at an elevation of nearly 4,100 feet. The main opening is on the east side near the top, and a second opening has been made about 200 yards to the north at a lower level. The main working consists of an open cut about 20 feet wide, 30 feet long, and 15 feet deep, with short tunnels to the north and to the south and an incline from the bottom. The workings have fallen in badly. As exposed in the open cut the pegmatite is about 20 feet wide and approximately conformable with the inclosing rock. The country rock is mica schist and gneiss, the schistosity of which strikes N. 10° W. and dips 60° W. The pegmatite contains much quartz and some black tourmaline and beryl. Only small crystals and sheets of mica were seen around the mine, but mica in rather large sheets was seen in the possession of Mr. Anderson, at Spokane. At the other working a shaft was sunk on a ledge of pegmatite. Only small blocks of mica were left around this opening also. Part of the muscovite was associated and intergrown with biotite.

A prospect was opened for mica on the roadside on the spur of the mountain ridge about half a mile south of the Levi Anderson claim, about 3,800 feet above sea level. Little could be seen of the formation encountered or the mica found.

MUSCOVITE MINE.

The Muscovite mine was first worked in 1888 by Woody & Lamb. After that it was operated intermittently, and the last work was done by the Muscovite Mica Co., of Spokane. The mine then passed into the hands of Alexander Munro, of Moscow, Idaho, and later into those of the Producers' Mica Co., of Chicago. The "vein" in the Muscovite mine cuts through the apex of a sharp knob whose elevation is 4,450 feet. The position of the different workings is shown in figure 17. An open cut with a shaft has been made on the outcrop at the apex and other open cuts with drifts and a 60-foot shaft to the south on the hillside. The principal work was done from two crosscut tunnels with drifts and stopes at the ends. One of these tunnels was 150 feet lower than the apex and on the east side of the hill; the other was on the southwest side of the knob and 200 feet lower than the apex, and in June, 1910, this was the only part of the mine open for examination. Another crosscut tunnel was started still farther down, about 325 feet below the apex; this has been driven about half of the 600 feet necessary to reach the "vein." Other test pits have been made nearly a quarter of a mile south of

the apex, on an outcrop of pegmatite, which may or may not be the same "vein." The tunnel open for examination had been driven

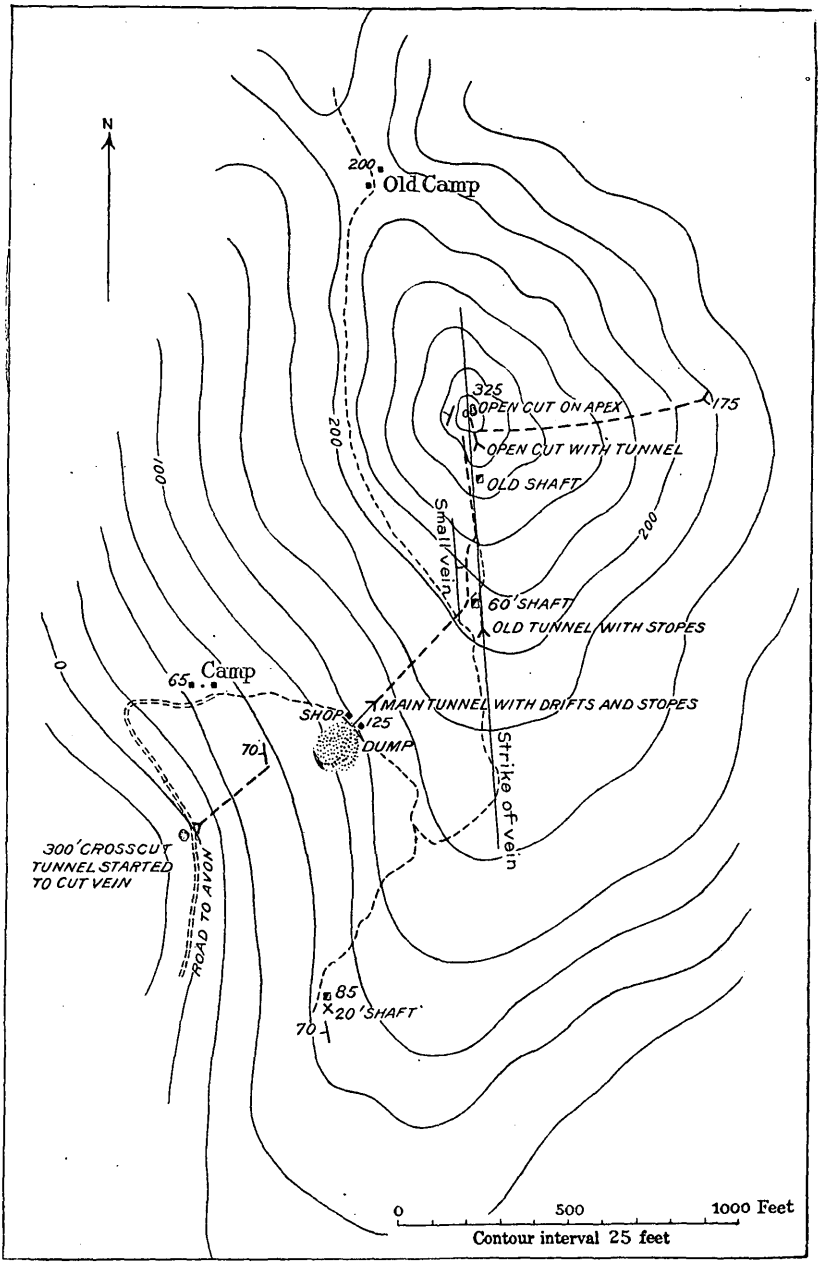


FIGURE 17.—Sketch map showing position of workings on Muscovite mica claim, Latah County, Idaho.

some 200 feet to the "vein." More than 300 feet of drifts, in which much stoping was done, were then carried to the north. At the

junction of the tunnel and the drift at this level a room for a turntable had been made during earlier operations. The timbers of the roof over this turntable and of the stopes in places farther along had given way, so that in order to reach the better part of the mine it was necessary to drive a new tunnel alongside of the main original drift. The 60-foot shaft formerly connected with the drift at the end of the crosscut tunnel. A short crosscut tunnel to the west of the new drift cut a pegmatite "vein," from 12 to 18 inches thick, in which small blocks of good mica and some beryl crystals were found.

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, where the vein includes a horse of gneiss several feet across. There was a large showing of mica "books," some of good size, in the end of the tunnel and at two places in the stopes above. It is said that the best mica in sight had been removed when mining was stopped, though even then the "vein" contained sufficient mica to be termed rich. In the open cut at the apex the pegmatite mass encountered appears to be nearly 40 feet thick. The pegmatite at this point and to the side of the open cut carries considerable quartz. A portion that had not been mined still contains numerous blocks of fair-sized mica on the outcrop.

The country rock is strongly foliated muscovite-biotite gneiss. It strikes N. 10° W. to N. 10° E. and dips about 70° W. The pegmatite is conformable, or nearly so, with the gneiss. The course of the pegmatite is fairly regular, but a few minor deformations were encountered in the workings. Evidently the outcrop at the apex represents a large bulge or swelling of the pegmatite. The increasing thickness of the pegmatite in the end of the drift 200 feet lower than the apex indicates a continued thickness with depth. This drift probably does not lack more than 60 or 70 feet of being under the apex. This chimney or shoot of pegmatite outcropping at the apex is considered to be the richest part of the "vein." In the tunnel on the east, 150 feet lower than the apex, a large vein very rich in mica is reported to have been encountered. A peculiar feature of the "vein" is the small amount of quartz and feldspar it contains at a distance from the apex chimney. In the chimney the quartz and feldspar are plentiful and the pegmatite is more nearly normal in composition.

No records of the production of mica from this mine have been kept, but Mr. Munro estimates that during two periods of operation at least $40,000 worth of mica was taken out each time. The quality of the sheet mica from the Muscovite mine is very good, the color being light rum and sheets clear. The proportion of good sheet mica obtained from an average lot of "books" would probably not equal that obtained from some of the better mines in other parts of

the country, though perhaps only a few mines yield so abundantly from an equal amount of vein matter.

MORNING STAR CLAIM.

The two claims taken up by Alexander Munro, prior to 1910, extending to the north from the Muscovite, are intended to cover the outcrop, if any exists, of the pegmatite between the Muscovite and the Morning Star. The pegmatite in the Morning Star claim outcrops strongly for some distance along the east side of the ridge. The hill slope below is steep, at some places almost cliff-like. The pegmatite is about 20 feet thick and incloses a horse of gneiss, or there are two ledges of pegmatite separated by a sheet of gneiss. The ledge is conformable with the mica schist country rock and strikes north by east with a dip of about 60° W. Both the schist and the pegmatite contain black tourmaline. Only a little mica is exposed in the outcrop of this ledge. About 450 feet lower a crosscut tunnel was started on the east side of the ridge and driven 660 feet under the outcrop. The dip of the pegmatite carries it still farther west, and the tunnel will probably have to be carried about 90 feet farther. The rocks through which the tunnel cuts are muscovite and biotite schist and gneiss, which in places show a slight banding across the foliation. The schistosity strikes east of north and dips 50°–70° W.

SUNSHINE CLAIM.

The Sunshine claim adjoins the Morning Star on the north. The ledge of pegmatite crops out strongly on the hillside and is probably the same ledge as that opened on the Morning Star. An open cut 20 feet long and 10 feet deep has been made in the hillside on a body of pegmatite striking north by east and dipping 50° W. It is conformable with the schistosity of the inclosing gneiss. Very little mica was found in this cut. The pegmatite carries tourmaline and some garnets larger than walnuts. It is said that a better showing for mica was found in a prospect opened about 200 yards to the north, over the hill.

MAYBE MINE AND ADJACENT PROSPECTS.

The Maybe mine, sometimes called the Silver White mine, is in a steep hillside in the bend of a stream. Several tunnels have been run into the hill and a few pits and other openings have been made, but these have caved in so badly that little could be seen. Either there are two or more ledges of pegmatite, or a single ledge is folded and lies somewhat like a blanket on the hillside. In one of the openings the schistosity of the mica schist country rock has a strike

of N. 55° W., about parallel with the contour of the hill at that point. The pegmatite carries considerable tourmaline and some garnets, the largest as big as walnuts. The mica is clear and of a very light color, inclining to rum. The waste mica left around the mine shows that the sheets are of good quality and split well.

On the hillside across the small stream east of the Maybe mine several prospects for mica were worked long ago. The indications for mica here are good. A few hundred yards southwest of the Maybe mine, near the corner of the claim, another body of pegmatite was prospected for mica. A very good deposit of mica was found in the open cut, but a tunnel started 15 feet lower down very quickly lost the main "vein" and followed a stringer for nearly 300 feet.

LUELLA MINE.

The Luella mine was opened by a crosscut tunnel, run southwest, and an open cut on the outcrop above it. Evidently a large deposit of pegmatite was found and much of it was stoped out. Only small blocks of mica, though of good quality, were left around the mine. The blocks of pegmatite on the dump contain black tourmaline and pink garnets, some of which are embedded in crystals of mica. The country rocks are muscovite and biotite schist and gneiss. Blocks of fine-banded tourmaline-quartz rock, associated with the schists, were left on the dump.

CONDITIONS AFFECTING DEVELOPMENT.

The operation of mines in this region is facilitated by an abundant supply of good timber. Part of this timber is included in the claims and part is either on State land or in the Coeur d'Alene National Forest. On the mountains the more abundant trees are tamarack or larch and red fir; in the valleys there are good stands of white pine, red pine, tamarack, red fir, and cedar. The rocks are not hard to drill, and Mr. Munro states that in some of the mines tunnels can be driven at the rate of 3 feet a day without power drills. The shipping point for the mines is Avon, on the Washington, Idaho & Montana Railway.

WASHINGTON COUNTY.

Specimens of mica were received by the United States Geological Survey in January, 1916, from Fred Mullin, of Council, Idaho. They were found by Gilman Rinehart about 12 miles southeast of Council, near Middle Fork of Weiser River. The specimens consisted both of clear mica with smooth, flat cleavage and of A mica. The clear mica would trim into sheets of 2 by 2 and $1\frac{1}{2}$ by 3 inches. It has a dark-green color in thick sheets, splitting down to material suitable for glazing.

MAINE.

GENERAL FEATURES.

Mica mining has never been a large industry in Maine, but some deposits have from time to time made a small output. About 2,000 pounds of sheet mica, valued at $2,000, was produced in Maine in 1880, according to the Tenth Census.[42] In the reports on the Mineral Resources of the United States for 1882, 1883, and 1884, published by the United States Geological Survey, mention is made of mica mining in progress during those years. Mica was sold from the Mount Mica tourmaline mine, and unsuccessful attempts were made to work deposits in Gilead and Albany. The deposits are in Oxford, Androscoggin, and Sagadahoc counties, in the southwestern part of the State. Many of them have been described by E. S. Bastin,[43] whose descriptions are given below and supplemented by brief notes made by the writer during a visit to some of the gem-bearing pegmatites in 1913.

Most of the mica produced in Maine is obtained as a by-product in mining feldspar and gems. A small part of it is suitable for use as sheet mica, but most of it can be used only for grinding because of its segregation into compact masses in such a way that individual crystals have interfered with one another's growth and the presence of A, wedge, and fishbone structures. A figure given by Bastin to show the wedge and fishbone structures found in mica from Topsham is reproduced in Plate V.

ANDROSCOGGIN COUNTY.

Several quarries have been operated by the Maine Feldspar Co. on Mount Apatite, 3½ miles west of Auburn. Orthoclase and microcline with minute intergrowths of perthitic albite are quarried from a large bed or ledge of pegmatite that covers much of the summit of the hill. Variable quantities of muscovite mica are found, as well as other minerals, such as biotite, black tourmaline, occasional colored and gem tourmaline, lepidolite, garnet, and beryl. Mica is fairly plentiful, but none of it is suitable for making sheets, for the A and wedge structures are strongly developed in it. Some bladelike crystals of mica are a foot long. Similar mica is found in the Wade and Pulsifer quarries, on the northwest side of Mount Apatite. It would probably pay to save the mica at the different quarries to sell as scrap for grinding, but much of it is thrown away.

[42] Mining industries: Tenth Census, vol. 15, p. 850, 1886.

[43] Geology of the pegmatites and associated rocks of Maine, including feldspar, quartz, mica, and gem deposits: U. S. Geol. Survey Bull. 445, 1911.

OXFORD COUNTY.

BENNETT PROSPECT.

A small mass of pegmatite on the farm of F. H. Bennett, in the western part of Albany, about 5 miles west of Hunt Corners, has been prospected for mica by W. S. Robinson. The pegmatite is exposed to a thickness of 10 feet and is intrusive in granite gneiss like that farther west. The pegmatite is a coarse association of quartz, muscovite, orthoclase, and black tourmaline. The muscovite occurs in graphic intergrowth with quartz and also in "books," the largest 6 inches across, though most of them measure less than 3 inches. Nearly all of it is wedge mica and shows twinning. The feldspar here is too intimately mixed with black tourmaline to be of any value. Neither the quantity nor the quality of the materials here seem to warrant further development.

PINGREE PROSPECT.

Another mass of pegmatite, on the farm of C. P. Pingree, in the extreme western part of the town of Albany, was worked for mica in 1878–79 and was opened again in 1900 by W. S. Robinson, but no shipments were made except of samples. The ledge has yielded some gem beryl. In the absence of the owner of this property the writer was unable to visit it. Bethel, the nearest station, is about 8 miles distant on the Grand Trunk Railway.

HICKS POND PROSPECT.

A mica prospect was opened in pegmatite in the southern part of the town of Greenwood, about three-quarters of a mile east of Hicks Pond. The pegmatite is composed largely of quartz, muscovite mica, albite of the clevelandite variety, and some potash feldspar. Some of the mica crystals are 14 inches across and a foot thick, but twinning and wedge structure have made most of them useless for sheets. At some places about half the rock is composed of mica. Gem tourmaline has been taken from pockets or cavities in the pegmatite.

HIBBS FELDSPAR AND MICA MINE.

A small feldspar and mica mine was opened in 1906 on the farm of Alton Hibbs, about 1½ miles north of Hebron village, near the Buckfield road. The operators were J. A. Gerry, of Mechanic Falls, and W. Scott Robinson, who abandoned it in 1907. The property was visited by the writer in August, 1906, after considerable stripping and prospecting had been done. The ledge was exposed for 300 to 350 feet along the southwest side of the valley of a small creek.

The width of the outcrop averaged about 30 feet, but increased at one point to at least 50 feet. Only shallow excavations had been made, exposing numerous masses of pure orthoclase-microcline feldspar 2 to 3 feet across, associated with much graphic granite. The spar is mottled buff to blue-gray. Small quantities of albite are found. The principal iron-bearing impurity is black tourmaline, so aggregated that it can be readily separated in the mining. Feldspar of grade suitable for making pottery formed about 60 per cent of the rock mined. Small quantities of biotite in the usual lath-shaped crystals, some as large as 1 foot by 3 feet, were also seen.

Muscovite is found in most parts of the pegmatite mass in "books" 2 to 3 inches across, but it occurs in abundance and in larger plates only at its southwestern border, where, in a zone averaging 3 to 4 feet in width, the mica books average 5 inches across and one imperfect book reaches a diameter of 30 inches.

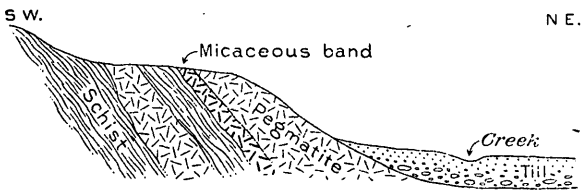


FIGURE 18.—Relations of pegmatite and wall rock at Hibbs feldspar and mica mine, Hebron, Maine.

The muscovite forms on the average at least 10 per cent and in some places 20 per cent of the rock, and fully 60 per cent of it could be trimmed into plates, the remainder being usable only as scrap mica. Wedge structure and ruling are the common defects. Plates as large as 5 by 6 inches could be trimmed from a few of the mica "books."

The exposures are not numerous enough to reveal the full form or extent of the pegmatite mass. On its southwest side it is bounded by quartz-mica schists, which trend from N. 30° W. to N. 50° W., averaging about N. 45° W., and apparently dip about 45° NE. The northeast border of the deposit is wholly obscured by drift. The mica-rich band that follows the southwest margin of the pegmatite mass can be traced for 300 to 350 feet—nearly the whole distance through which the pegmatite mass itself is exposed. The apparent relations of the pegmatite and schist are shown in figure 18.

The exposures seen by the writer indicate that this property is a promising one for both feldspar and mica mining. Further stripping will probably show that the deposit extends northwest and southeast of the present exposures, and as it seems to be steeply inclined there is no reason why it should not persist in good quality to considerable depth. The development work was suspended for reasons wholly aside from the quality of the deposit. The output must be hauled by teams 3 miles to Hebron station, on the Rangeley division of the Maine Central Railroad.

MILLS QUARRY.

The Mills feldspar quarries consist of two pits about a quarter of a mile apart on Hill No. 4, near the line between the towns of Hebron and Paris. The feldspar quarried consisted chiefly of the potash varieties but included some of the soda variety, albite. Small segregations of quartz are scattered through the pegmatite. Bunches of wedge-shaped and A mica crystals occur in parts of the pegmatite. Mica was saved during mining, but practically the whole output was suitable only for grinding.

MOUNT MICA.

Mount Mica is about 1½ miles east of the village of Paris. It has been famous for the gem tourmaline and the specimen minerals it has yielded since it was discovered in 1820, but it has produced also some mica and feldspar. The work started with shallow pits along the outcrop and has been carried progressively deeper toward the southeast. The present depth is from 20 to 30 feet along the southeast face of the quarry.

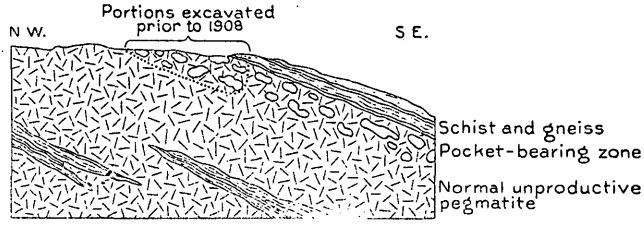


FIGURE 19.—Diagram showing geologic structure at Mount Mica tourmaline mine, Paris, Maine. (After Bastin.)

The country rock is schist, which contains quartz, muscovite, biotite, feldspar, garnet, and probably fibrolite. Strikes measured on the schist ranged from east and west to north by west and dips from 10° to 25° south and east. The pegmatite dips 20°– 30° SE., as shown in figure 19, taken from Bastin's report. The mass of pegmatite is large, but its full thickness is not exposed. About 7 feet of the upper part is worked for gem minerals, and from this layer the mica and feldspar were also obtained. The best gem and specimen minerals were obtained from pockets; the other minerals from the solid pegmatite in which the pockets occur.

The principal constituent minerals of the pegmatite are quartz, orthoclase, microcline, muscovite, biotite, and black tourmaline, with the clevelandite variety of albite, lepidolite, and colored tourmalines in the gem-bearing zone. Graphic intergrowths of feldspar and quartz, which are common in many of the other tourmaline-bearing pegmatites of New England, are comparatively rare at the Mount Mica mine. Quartz occurs through the pegmatite in small irregular masses of a white to slightly smoky color and in groups of color-

less crystals in the pockets. Orthoclase and microcline are the principal feldspars of the pegmatite and have been gathered from the dumps for use in pottery. Muscovite occurs in graphic intergrowths with quartz in bunches of wedge and A-shaped crystals and in flat crystals, a few of which measure more than a foot in diameter. Some of the mica has a clear light rum color and good cleavage and is purchased by mica-manufacturing companies. Much of it has been sold as it came from the mine for about $25 a ton.

YORK PROSPECT.

A prospect was opened on the farm of J. P. York, near the central part of the town of Peru. The principal minerals of the pegmatite are potash feldspar, quartz, muscovite, and biotite. The feldspar crystals are so intermixed with biotite that it would not pay to separate them for use in making pottery. Most of the muscovite crystals are less than 4 inches in diameter, and the best specimens preserved in a neighboring house would not have yielded sheets larger than 2 by 3 inches.

BLACK MOUNTAIN MICA MINE.

A deposit of pegmatite on Black Mountain, in the northern part of the town of Rumford, has been mined for scrap mica by Oliver Gildersleeve, of Gildersleeve, Conn., who has dug two pits about two-thirds of the way up the western slope of the mountain, about three-quarters of a mile from the road between North Rumford and Roxbury Notch. The upper pit is about 200 feet long, 50 feet wide, and 25 feet in greatest depth. The lower pit is about 100 feet wide, 100 feet long, and 35 feet in maximum depth.

The rock at these pits is an exceedingly coarse pegmatite, which has been intruded irregularly into metamorphosed sedimentary beds that trend N. 30°–40° W. and dip 70°–80° NE. These beds are slightly contorted but reveal their sedimentary origin through an alternation of quartzitic and more shaly beds.

The pegmatite here is different in some respects from that at the other deposits in Maine, though in general it approaches the pegmatite of the gem-tourmaline localities. It contains little or no potash feldspar, the dominant feldspar being albite of the bladed variety of clevelandite. Muscovite is the mineral next in abundance, constituting generally 30 to 40 per cent of the whole deposit, though it locally forms three-quarters of the mass of pegmatite. The largest crystal of mica seen by the writer was 1½ feet wide and 3 feet long, but blade-shaped or spearhead-shaped crystals 1 to 2 feet long are very common. Some masses of almost pure mica weigh half a ton. All the mica shows one or more of the defects known as twinning, wedge structure,

and ruling. None of it will yield any plate mica. Several of the mica books observed were 1 foot thick at right angles to the cleavage. Near the walls of the pegmatite mass the mica books tend to orient themselves with their long axes perpendicular to the contact, though only within 6 inches or so of the wall is there any noticeable decrease in the coarseness of the pegmatite. Most of the quartz of this pegmatite is opaque but is pure white. Spodumene is unusually abundant and occurs in long, flat light-gray to white crystals, some of them 2½ feet long and 3 to 4 inches thick. Some of the spodumene is intimately intergrown with quartz.

A remarkable feature of this deposit is the presence in the pegmatite of irregular masses of medium-grained granite, which in some places consists of muscovite, quartz, and plagioclase, and along certain bands or irregular bunches one-third to one-half the rock consists of bright-pink tourmaline, producing a stone of considerable beauty.

The quarry was opened about 1901 by Oliver Gildersleeve and was worked for four seasons. About 250 tons of mica is reported to have been mined in 1905. The quarry was idle throughout 1906, in which year the writer visited it, and so far as is known has not reopened since. Steam drills were employed and sheds built for hand picking the mica, which was packed in 100-pound bags and hauled by team 7 miles to Frye, on the Rangeley division of the Maine Central Railroad. From Frye it was shipped to a grinding mill at Gildersleeve, Conn. About 1,000 tons in all are reported to have been shipped. The quantity of scrap mica still available at this quarry is large, but there is no plate mica, nor is it probable that further excavation will disclose any.

BEECH HILL MICA MINE.

A deposit on Beech Hill, in the town of Waterford, on the farm of George L. Kimball, has been operated for mica on a larger scale probably than any other deposit in the State. The mica is a constituent of a sill-like mass of coarse pegmatite, which dips about 30° E. and which is at least 12 feet thick, though its base is not exposed. The commercial mica is confined to a zone about 5 feet thick in the lowest part of the pegmatite layer now exposed. The muscovite within this 5-foot zone forms 10 to 20 per cent of the pegmatite.

Some of the masses of pure orthoclase feldspar associated with the mica are 5 feet across, but the total quantity present is not sufficient to make it commercially valuable. Intergrowths of quartz and muscovite are common.

The pegmatite contains no biotite and no black tourmaline. The associated rock is a granite gneiss, and both gneiss and pegmatite are intruded by a dike of diabase.

Some of the muscovite books are a foot across, but most of them are less than 5 inches. The larger plates are invariably cut by ruling planes into a number of smaller pieces. Much of the mica is worthless for anything but scrap because of ruling, wedge structure, and twinning. Most of the thumb-trimmed material seen by Bastin was in pieces 2 or 3 by 3 inches across. The mine was not being worked at the time of the writer's visit in September, 1906. Although several tons of mica lay in the trimming sheds the best of the output was reported to have been sold, so that it was impossible to make a fair estimate of the average value of the mica mined, but the material is superior to that from any other mine in Maine.

The property was opened in 1900 and was worked also in 1902 by the Beech Hill Mining Co., which subsequently sold it to New York investors. About a ton of thumb-trimmed mica was marketed at prices ranging from 8 cents to $1 a pound, and about 10 tons of scrap mica was sold. The remainder of the material quarried was still in the mine buildings.

SAGADAHOC COUNTY.

MOUNT ARARAT FELDSPAR QUARRIES.

Two quarries have been opened on Mount Ararat, about a mile north of Topsham village, one on the east slope and the other on the north slope of the hill. There are two pits at the eastern quarry and one at the northern. In the eastern quarry large and small masses of cream-colored to white potash feldspar, gray to smoky quartz, and graphic granite were encountered. Mica is an abundant constituent of the pegmatite exposed in the upper pit. It is pale green to nearly colorless and some of the crystals are as much as 10 inches in diameter. Most of the mica is of the wedge variety and shows twinning and is therefore suitable only for grinding. A small quantity of sheet mica is obtained, some of which would trim into sheets 4 by 5 inches. Most of the sheet mica is specked with thin films of magnetite. A few imperfect crystals of columbite occur in the quartz-feldspar masses.

In the northern quarry there is a very irregular association of quartz, feldspar, muscovite, biotite, garnet, and rarer minerals. Muscovite is not plentiful and none of it is suitable for making sheets.

FISHER'S FELDSPAR QUARRY.

A quarry was operated for feldspar by J. A. Fisher 1¼ miles west-northwest of Cathance station, on the northern valley slope of Cathance River. None of the minerals show a regular arrangement in the pegmatite except the mica, which occurs principally along certain zones, but these zones have no definite trend with

respect to the general outlines of the deposit. Apparently all the mica is of the wedge and A varieties. In places the pegmatite contains more biotite than muscovite mica, especially in the finer-grained parts.

G. D. WILLES'S FELDSPAR QUARRY.

A quarry was operated by G. D. Willes, of Brunswick, for the Trenton Flint & Spar Co., about 2 miles northwest of Cathance station. The pegmatite contains very large masses of pure feldspar, quartz, and graphic granite. A mass of pure white quartz was exposed through a distance of 50 feet and a height of 10 feet at the north end of the quarry. The feldspar is chiefly of the potash variety, and some of the crystals measure 15 feet across. The mica is concentrated along certain belts that traverse the pegmatite in several directions. These belts consist of heterogeneous aggregates of small crystals (solid mica) that grade into similar aggregates of spearhead-shaped crystals, some of which stand nearly perpendicular to the general plane of the mica belt. The largest of these spearhead-shaped crystals are a foot long. In the southern part of the quarry the mica occurs in nearly equidimensional masses, some as much as 5 feet across, composed of the same heterogenous aggregates of small crystals, which also grade into larger aggregates of spearhead-shaped crystals that branch out into the surrounding quartz, feldspar, and graphic granite. Bastin saw no sheet mica.

MARYLAND.

GENERAL FEATURES.

Mica has been prospected or mined at several places between Washington, D. C., and Ellicott City, Md., in Howard and Montgomery counties. Several prospects were examined in 1910 and in 1914. The deposits lie in three groups, one about 6 miles northwest of Laurel, in Howard County; another 4 or 5 miles N. 65°–75° E. of Laurel, in both Howard and Montgomery counties; and the third about 4 miles northeast of Kensington, in Montgomery County. These deposits lie in typical rolling Piedmont country at a distance from the streams and from the steeper valleys in areas along the larger streams where the relief is 50 to 200 feet.

The deposits are associated with highly metamorphosed schists and gneisses, which contain an abundance of mica and in some places considerable garnet. These rocks are strongly folded and crumpled and in places contain bodies of pegmatite, a few of which carry mica worth prospecting for. The schist and gneisses appear to be identical with the rocks of the Carolina gneiss as mapped by A.

Keith[44] and weather down to a highly micaceous soil. These rocks are mapped as Baltimore gneiss by the Maryland Geological Survey.[45]

BALTIMORE COUNTY.

Deposits of pegmatite occur in Baltimore County and have been prospected for mica in a few places. In 1915 specimens of surface-weathered sheet mica were received at the United States Geological Survey from George E. Swem, of Cockeysville. The sheets measured 2½ by 3½ inches but were so badly cracked around the borders that they were unfit for use. The mica was clear and colorless in thin sheets, and if the deposit is mined below the limit of surface weathering it may yield sheets large enough for use in glazing.

Deposits have also been reported by C. Lyon Rogers, jr., near McDonogh; by August H. Mattheiz, of Baltimore, near Hollofield station on the Baltimore & Ohio Railroad; and by other parties near Woodstock.

HOWARD COUNTY.

MARYLAND MICA CO.

Three deposits have been worked on the land of Charles Myer, 1¾ miles N. 5° W. of Scaggsville, or about 6 miles northwest of Laurel. Two of these were opened by old workings and the third was opened by the late William Theis, of Ellicott City, Md., in 1909. Work was done in 1914 by the Maryland Mica Co., the present owners, under the management of J. O. Arrington, of Overlea, Md. One of the prospects is in a steep knoll about 150 yards southeast of the house. It is said that this prospect was opened about 1885 by a shaft 45 feet deep. No work has been done recently and there is now on the summit of the knoll a shallow pit or sink 20 feet across and 3 feet deep. The ground in and around this sink is covered with scrap mica and earth to a depth of a few feet. Some of the mica plates are as much as 6 inches across, and a few are firm and clear enough for punching. The pegmatite may occur in a short, thick body or chimney that crops out at the summit of the knoll, though there are indications that it has an easterly extension down the hill. The mica has a light, clear apple-green color and it splits to the best quality of "white" mica for stove use. The waste and scrap around the prospect could be screened out for grinding.

A little mica has been plowed and dug out of the surface soil about 50 yards northeast of the prospect in the knoll, but no regular work has been done.

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[44] U. S. Geol. Survey Geol. Atlas, Washington folio (No. 70), 1901.

[45] Clark, W. B., Geological map of Maryland, Maryland Geol. Survey, 1907.

The prospect opened by William Theis is about 150 yards east of Myer's house. The work consists of an open cut, 25 feet long and 2 to 10 feet deep, run northward into a hillside along a pegmatite ledge, and a second cut started 50 feet to the south to crosscut the "vein." The pegmatite strikes about north and crops out 30 feet farther up the hill, above the open cut. The dip could not be measured. The country rock is mica gneiss in highly schistose layers. The pegmatite contains considerable quartz, part of which, though smoky, is nearly clear. The feldspar is the flesh-colored potash variety, partly decomposed. The mica occurs in pockets in this deposit, and all that was mined came from one pocket several feet long and about 2 feet thick, which is apparently exhausted. The mica was found in blocks or crystals weighing from 1 to 50 pounds and measuring from an inch to a foot in diameter. This mica is brownish-green and much of it is specked. Most of the crystals have the A structure strongly developed, so that only small perfect sheets can be cut from large blocks. Wedge-shaped blocks of mica occur, especially where the smaller crystals are bunched with quartz. Some of the larger blocks of mica would cut sheets 4 by 6 inches, though there would be a large quantity of waste in trimming.

Work was done by the Maryland Mica Co. around an old shaft in a knoll about 50 yards east of the house. A few surface pits and a trench were made southwest of the shaft, but the main work consisted of a drainage cut 60 feet long, 7 feet wide, and 1 foot to 10 feet deep, run in from the hillside on the east, and a tunnel driven from the inner end of the cut to the old shaft. Here difficulties were encountered because of caving ground, and work was stopped until the old shaft was cleaned out. This shaft was several feet deeper than the tunnel, which was about 25 feet below the surface of the knoll. A few pockets of mica were found in the work in the main pegmatite deposit near the shaft and in a smaller "vein" cut in the tunnel southeast of the shaft. Most of the mica obtained is more or less clay stained and though it would yield a few small-sheet and punch sizes would chiefly be used as scrap. It is green, and most of it is clear, but part is a little specked.

PARLET PROSPECT.

A prospect was opened by a shaft sunk some years ago on the Parlet place, 1½ miles north of Scaggsville. In 1914 the shaft was filled to a level within 15 feet of the surface. This shaft exposed a body of pegmatite about 10 feet thick, which included horses of mica gneiss. The formations have an east and west strike and a high north dip. Both the gneiss and the feldspar of the pegmatite are badly decomposed. Quartz segregations more than a foot thick were exposed in the walls of the shaft. Only a few small clay-stained apple-green crystals were observed around the prospect.

BEN MURPHY MINE.

The Ben Murphy mine is 1 mile S. 55° W. of Scaggsville, in a small ravine entering a branch from the west. It was opened by a cut 60 feet long in a S. 25° W. direction and a shaft in the southwest end of the cut. The cut is 12 feet deep, but the depth of the shaft was not learned. The country rock is strongly folded mica gneiss. The pegmatite is about 15 feet thick and incloses a large horse of mica gneiss. Clear apple-green mica crystals that show smooth flat cleavage were found. A few specimens of translucent to opaque yellowish-green beryl were found in the dump.

MONTGOMERY COUNTY.

EARTH PRODUCTS CO.

The Earth Products Co.'s mines are 4 miles N. 70° W. of Laurel, or about 1½ miles northeast of Burtonsville, on the old Irvington farm. The mineral sought was feldspar, but several mica prospects on the property were tested. These prospects are about 150 yards southwest of the old farmhouse, 100 yards east of the house, and 150 yards northeast of the house. The surface showings at these places were promising, but the results of the tests made were discouraging.

At the prospect 150 yards southwest of the house boulders of white quartz and pegmatite are scattered over a field, and rough plates of mica 2 to 6 inches across were plowed up around them. A belt of soil carrying mica crystals extends from the brow of the hill about 75 yards southwest across the field. A prospect was opened near the brow of the hill, but the mica found was not as good as that plowed up in the field. Mica 2 to 6 inches wide was also found in shallow pits at the other prospects, but deeper shafts failed to find better material. In the prospect about 100 yards northeast of the house a number of opaque greenish beryl crystals were found. Another outcrop of pegmatite about one-third of a mile north of the house, near Patuxent River, contained mica crystals from 3 to 4 inches across. This prospect was mined for feldspar by the Earth Products Co. but failed to yield much mica.

The mica from the various prospects is light, clear apple-green, and where free of A lines splits into smooth flat sheets.

GILMORE OR B. H. WARNER MINE.

A mine was worked from 1882 to 1884 on the southwest side of Northwest Branch, 4 miles N. 55° E. of Kensington. It was then known as the Gilmore mine but is now owned by B. H. Warner, jr., of Washington, D. C. The mine was worked by an open cut 60 feet

long, 15 to 25 feet wide, and 10 to 15 feet deep, driven S. 35° W. into a hillside, with a shaft and some underground work in the northeast end of the cut. The shaft has caved badly, so that the underground work could not be examined. It is reported that a crosscut tunnel was run to the west, turning southwest along a mica streak in the pegmatite.

The exposures are not good, but a study of those seen indicates that the pegmatite is from 10 to 15 feet thick and is inclosed conformably with the mica gneiss country rock. The gneiss strikes about N. 30° E. and dips northwestward. Little mica has been left on the dump, but several tons of badly weathered scrap mica is scattered around the site of the trimming house on a ridge about a quarter of a mile northeast of the mine. Part of this scrap material is clear, light apple-green mica like that found near Scaggsville and Burtonsville and was probably brought to the trimming house from other mines, but the remainder, though nearly clear, is dusted through with fine microscopic specks of magnetite, like that found on the dump, and therefore came from this mine.

MASSACHUSETTS.

Massachusetts has been only a small contributor to the mica production of the United States, having been credited in 1880[46] with an output of 1,000 pounds, valued at $1,250. Twenty-five men are reported to have been engaged in the industry. B. K. Emerson[47] mentions the occurrence of pegmatite deposits (coarse granite) in the towns of Blandford and Chester, Hampden County, and near Knightsville, in the town of Huntington, Hampshire County. A few quarries have been opened for quartz and feldspar, and some of the deposits might yield good mica.

MONTANA.

Deposits of mica have been reported in Montana. One prospect,[48] 8 miles southeast of Dillon, is said to have yielded plates 8¼ by 18¾ inches. Another prospect was reported in the Benton Record,[49] near Barker, in Cascade County. Mica of good quality is said to have been found in a "vein" 4 feet thick.

NEVADA.

Deposits of mica in Nevada are mentioned in the literature, but apparently the only attempt to work any of them was made by

[46] Mining industries: Tenth Census, vol. 15, p. 850, 1886.
[47] U. S. Geol. Survey Geol. Atlas, Holyoke folio (No. 50), 1898.
[48] Eng. and Min. Jour., vol. 47, p. 573, 1889; vol. 48, p. 230, 1889.
[49] Eng. and Min. Jour., vol. 32, p. 272, 1881.

Daniel Bouelli, of Rioville, Nev., in 1893 and 1894. Mr. Bouelli furnished information[50] to the Geological Survey from which the following notes have been abstracted. In 1893 and 1894, 500 pounds of sheet mica was shipped from Nevada to Hamburg, Germany, and 1,300 pounds to Syracuse, N. Y. This mica had been trimmed of excess waste and was expected to yield sheets from 2 by 3 inches to 8 by 10 inches, a good proportion of which were 3 by 5 inches. The deposits are in the Virgin Range, Lincoln County, about 15 miles east by north of Rioville. Rioville is at the mouth of Virgin River, on Colorado River. One of the claims, the Pioneer, is about 5,000 feet above sea level, near springs, and is accessible to wagons. A belt of mica-bearing rocks crops out along the Virgin Range in a north by east direction, extending northward into Arizona.

A deposit of mica has been reported in the Ruby Mountain Range, of Elko County, where sheets ranging from 2 inches to 2 feet in diameter are said to have been found.

NEW HAMPSHIRE.

GENERAL FEATURES.

Mica has been mined intermittently in New Hampshire since the early part of the nineteenth century, and for many years prior to 1860 the mines of that State furnished practically all the mica used in the United States. Supplies were afterward obtained from mines in other States and from foreign countries, and the mines in New Hampshire were worked less regularly. The increased demand for mica has led to the opening of several new deposits and the reopening some old ones. Some of the old dumps have been worked over for the smaller sizes of sheet mica and for scrap mica that had been thrown away.

Mica deposits have been mined in Grafton, Cheshire, Sullivan, Merrimack, Strafford, and Coos counties. The best deposits lie in a broken belt that extends from Keene through the middle of Cheshire County northward into Sullivan County and the northwestern part of Merrimack County and north by east to about the center of Grafton County. The principal mining districts in this belt are in the towns of Rumney, Groton, Alexandria, Orange, and Grafton, in Grafton County; Danbury and Wilmot, in Merrimack County; Springfield and Acworth, in Sullivan County; and Alstead, Gilsum, and Sullivan, in Cheshire County. There are also a few mines in Wentworth, Dorchester, and Canaan, in Grafton County, and a mine has been worked on the town line between Newport and Clare-

[50] Parker, E. W., Mica; U. S. Geol. Survey Mineral Resources, 1893, pp. 753–754, 1894.

mont, in Sullivan County. The shipping points have been Rumney, West Rumney (now Swainsboro railway station), Bristol, Canaan, Grafton Center (now Cardigan railway station), Grafton, Danbury, and Keene.

The mica deposits lie in broken mountain country at elevations ranging from less than 1,000 to more than 3,000 feet above sea level. Swampy areas, ponds, and lakes, such as are common in glaciated regions, occur in unexpected places among the hills; much of the country is thickly covered with second-growth timber and brush; and the roads away from the main line of travel are bad or indifferent, so that some of the mines are not easily accessible. Many of the farms in the mica region have been abandoned, and the roads have therefore been neglected and are bad, and a heavy growth of brush now mantles large areas. This desertion of the farms also makes it difficult for the miners to find boarding places or for the companies to purchase food and forage for the camps. The location of many of the mica mines and prospects in New Hampshire is shown on Plate XII.

The rocks of the mica region of New Hampshire are complex and consist of a series of metamorphic schists and gneisses with intruded granite and pegmatite. The mica deposits are not confined to rock of any one definite type. Hitchcock [51] states that most of the valuable deposits of mica are found in an area of fibrolite-mica schist, a subdivision of the "Montalban group" as mapped in his Geologic atlas of New Hampshire. Many of the largest mines are in areas of this rock, but some valuable mines are in areas of rock mapped under different names.

For practical purposes the rock with which the mica-bearing pegmatites are associated may be called mica gneiss. This rock, which is evidently of great age, includes highly metamorphosed schists and gneisses of various types, such as biotite and muscovite schist and gneiss containing layers rich in quartz or black tourmaline, garnet, etc. In places the gneiss is porphyritic.

CHESHIRE COUNTY.

LAKIN PROSPECT.

A prospect for mica has been opened on the land of George A. Lakin, 1½ miles N. 25° E. of East Alstead, by E. Howard. When examined in October, 1914, the work consisted of an open cut, which was 5 feet deep on the lower side and 15 feet deep on the upper side. The country rock is granite, which is cut at different angles by streaks of pegmatite. The surface is covered with a sort of blanket deposit

[51] Hitchcock, C. H., Geology of New Hampshire, vol. 3, pt. 5, pp. 89–91, 1878.

of pegmatite. The pegmatite contains segregations of smoky-gray quartz and in places grades into the granite. Mica is rather plentiful, but a large proportion of it would be classed as scrap. Crystals of mica as much as 10 inches across have been found. The clear grades of mica have a light rum color. Common beryl crystals 1 inch to 2½ inches in diameter and small crystals of opaque bluish-green apatite are among the associated minerals.

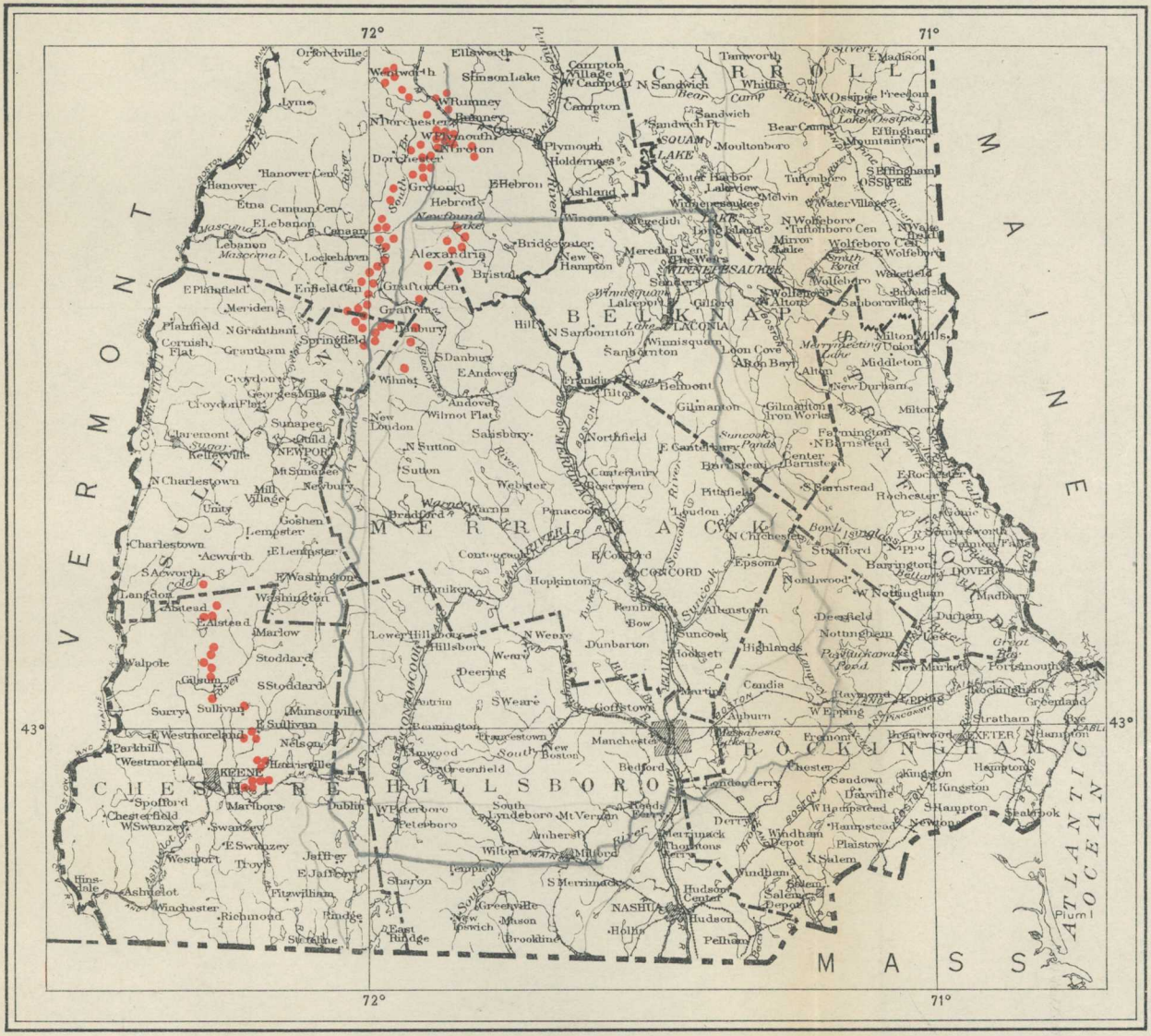
PARSON MINE.

The Parson mine, worked by the Fitzgibbon Mica Co., is 1¼ miles N. 5° E. of East Alstead, on the west side of the public road. The workings consist of several open cuts and pits within a distance of about 175 yards in a line extending N. 30° E. The largest of these pits is 50 feet wide and 200 feet long and from 10 to 40 feet deep. They were worked as open quarries, from which the waste and ore were removed. The last work, which was extensive, was done in 1906 or 1907. The open cut at the northeast end of the workings, near the road, was cleaned out for examination in 1914. It is about 20 feet deep. The pegmatite exposed in this cut is more than 30 feet thick at the west end but pinches down at the east end near the surface. During 1915 it was operated by Leon Phillips for the American Mica Co., of Newton Lower Falls, Mass.

The country rock is mica gneiss containing layers of highly foliated muscovite-biotite schist. The pegmatite is probably at least 100 feet thick but incloses streaks of schist as well as large segregations or veins of quartz. The mica nearest the quartz is richest. One mass of quartz exposed in the northeast cut is more than 15 feet thick. Much black tourmaline, some in close association with the mica, was observed. The mica has a clear light rum color, and small pieces seen on the dumps possessed good cleavage. At the north end of the mine the pegmatite forks, part of it extending along the west side of the road and part pitching under the surface and evidently connecting underground with the vein of the Granite State Mica Co.'s mine.

GRANITE STATE MICA CO.'S MINE.

The mine of the Granite State Mica Co. has been in operation for several years. At the examination made in October, 1914, there was an open cut about 250 feet long extending northeastward. This cut ranges in depth from 15 to 90 feet, and is deepest in a stope near the southwest end. Near the middle it is about 60 feet deep. The deeper workings were filled with water at the time of examination, and mica was being mined chiefly at the northeast end of the cut. A derrick hoist and an incline track have both been used to hoist ore and waste from the workings, but most of the hoisting in



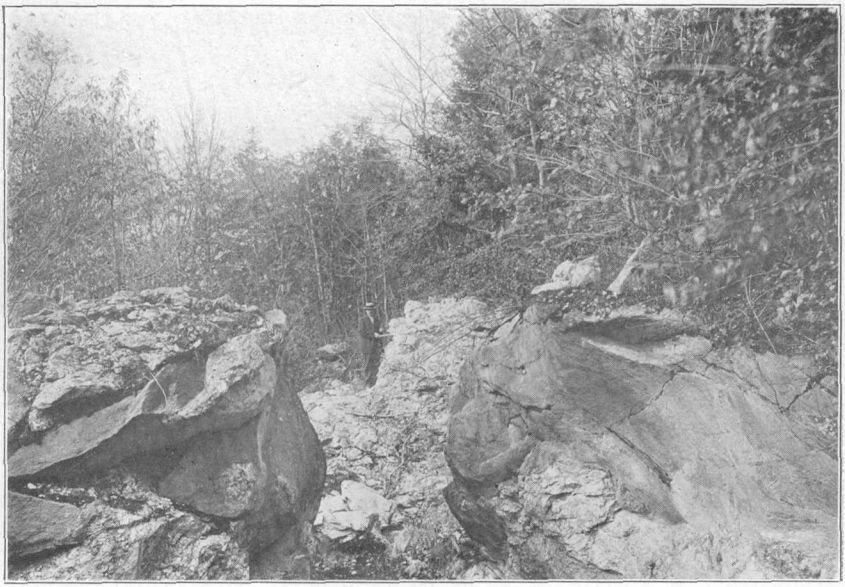
MAP OF SOUTHERN NEW HAMPSHIRE SHOWING LOCATION OF MICA MINES AND PROSPECTS

Scale 1/1000000

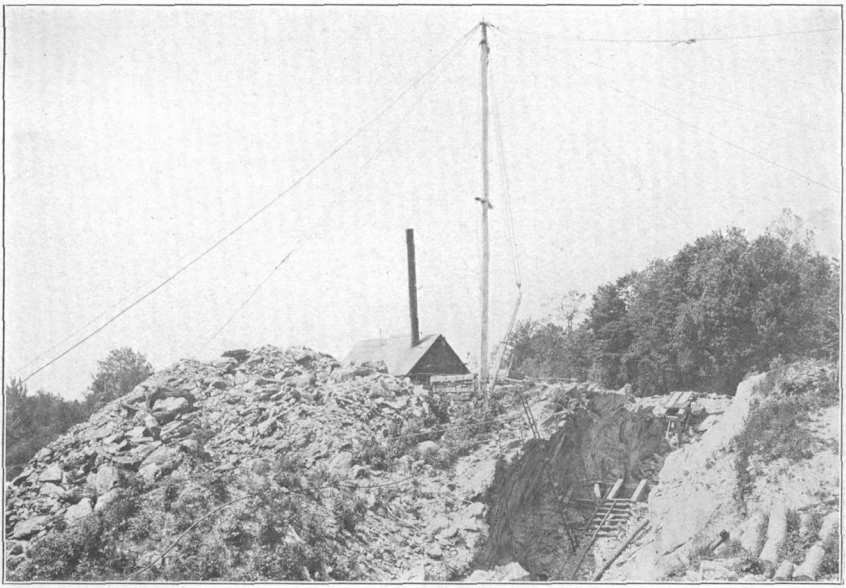
10 0 10 20 30 Miles

10 0 10 20 30 40 Kilometers

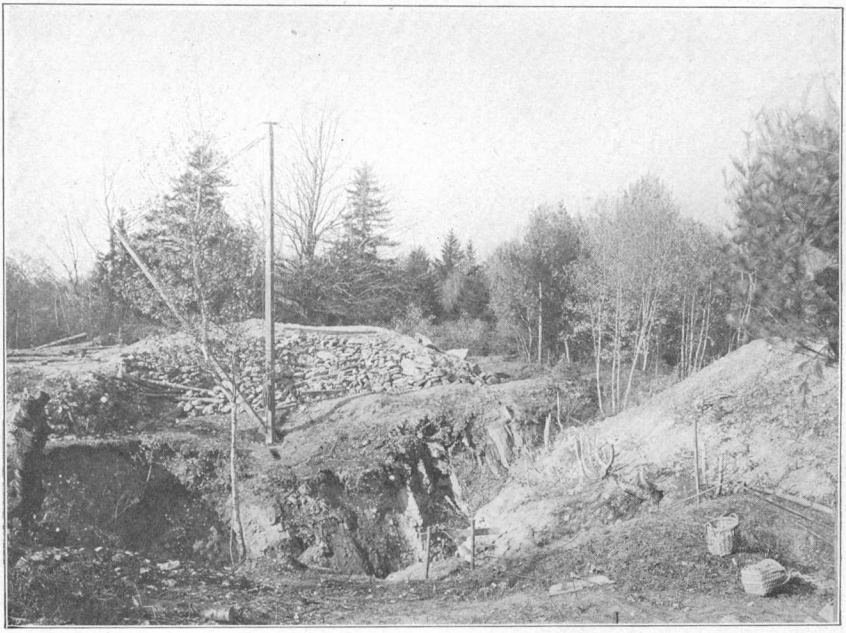
ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY



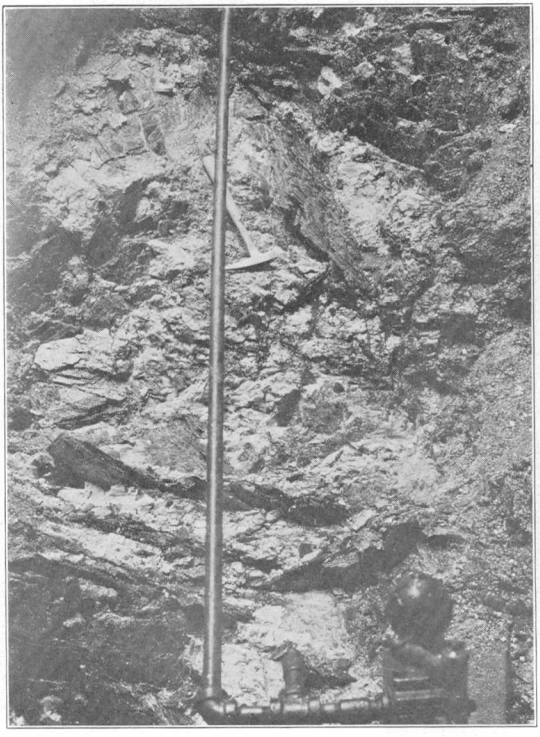
A. VIEW NORTHEASTWARD ACROSS THE QUARRY OF THE FRANKLIN PLAYTER MICA-BERYL MINE, SULLIVAN COUNTY, N. H., SHOWING THE PINCHING OF PEGMATITE BETWEEN MICA GNEISS WALLS.



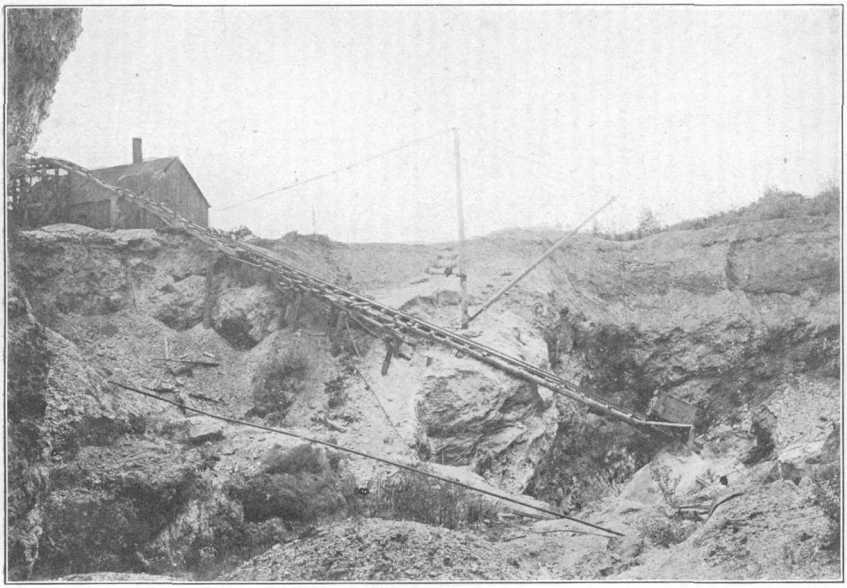
B. VIEW SOUTHWESTWARD OVER THE OPEN CUT OF THE GRANITE STATE MICA CO.'S MINE, CHESHIRE COUNTY, N. H.



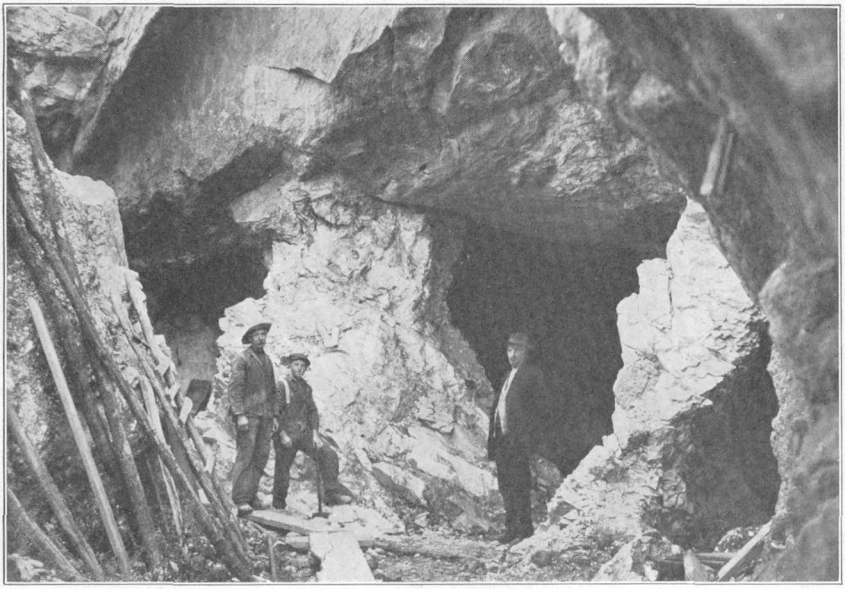
A. VIEW N. 15° W. ACROSS THE MAIN OPEN CUT OF THE RHODA MICA MINE, CHESHIRE COUNTY, N. H.



B. MICA CRYSTALS IN A FACE OF PEGMATITE IN THE DEEP STOPE UNDER OPEN CUT SHOWN IN *A*.



A. VIEW SOUTHWESTWARD ACROSS OPEN CUT OF THE FRENCH MICA MINE, CHESHIRE COUNTY, N. H.

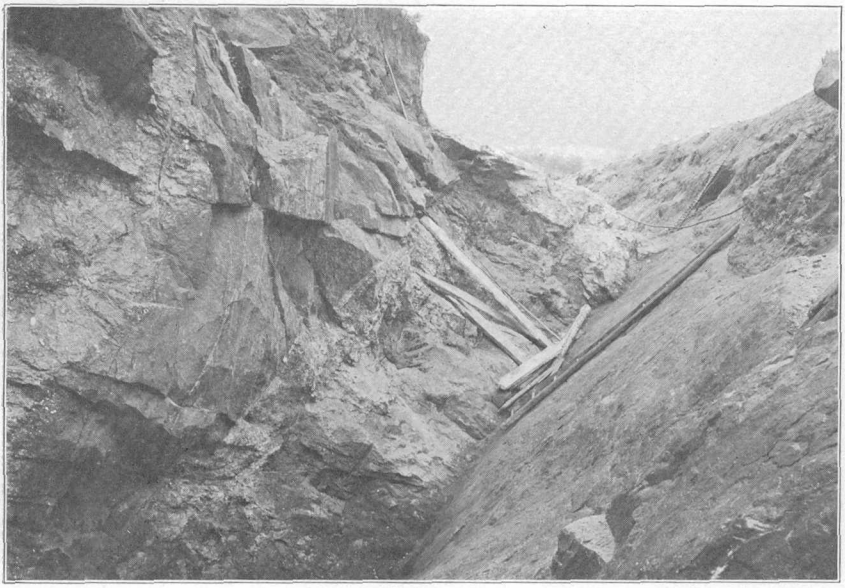


B. VIEW NORTH OF EAST IN THE OPEN CUT OF THE KILTON MICA MINE, GRAFTON COUNTY, N. H.

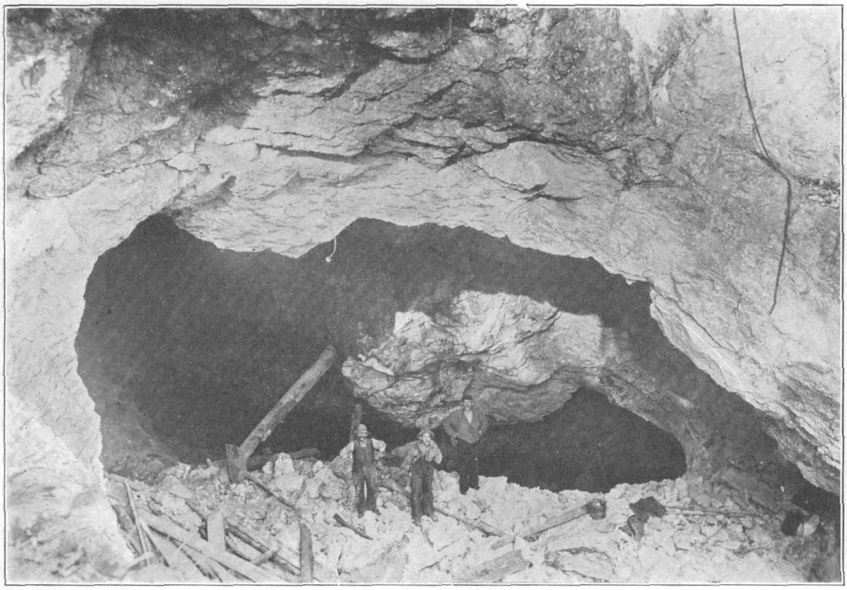
A. VIEW FROM MIDDLE OF NORTH SIDE OF OPEN CUT OF KEENE MICA PRODUCTS CO.'S MICA MINE, CHESHIRE COUNTY, N. H.

Horse of mica gneiss inclosed in pegmatite near center.

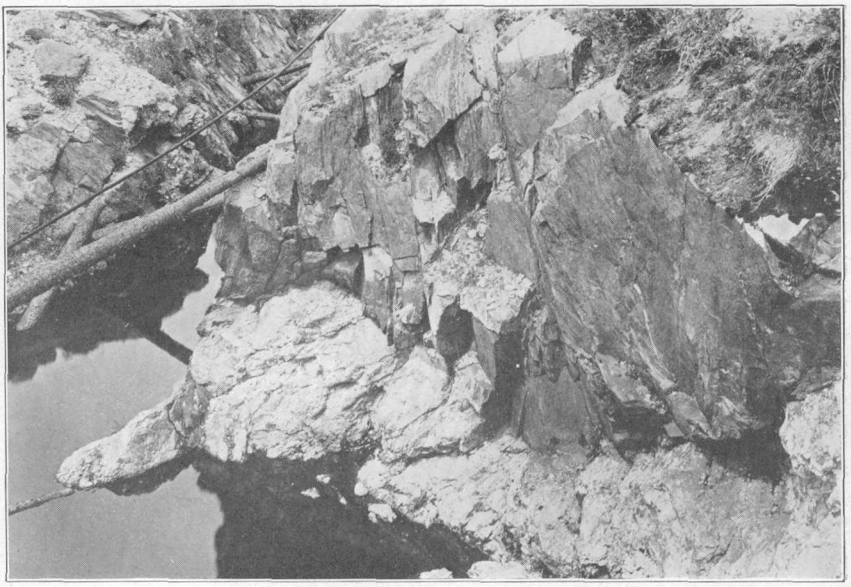
B. ENRICHMENT OF MICA IN PEGMATITE ALONG THE WEST SIDE OF THE HORSE OF MICA GNEISS SHOWN IN *A*.



A. FORK IN THE PEGMATITE AT GENERAL ELECTRIC CO.'S MICA MINE NEAR WEST RUMNEY, N. H.



B. VIEW NORTHEASTWARD DOWN INTO THE STOPES OF THE PALERMO MICA MINE, NEAR NORTH GROTON, N. H.



A. CONTACT BETWEEN PEGMATITE AND OVERLYING GNEISS AT SANBORN MICA MINE, GRAFTON COUNTY, N. H.

B. VIEW SOUTHWESTWARD ACROSS THE OPEN CUT OF THE BELDEN OR STANDARD MICA MINE, GRAFTON COUNTY, N. H.

recent years has been done with the derrick, the track having been abandoned. Conditions in the southwest half of the cut in June, 1913, are shown in Plate XIII, *B*. The deepest part of the cut is below the place where the incline track has been removed. Because of the overhanging southeast wall it has been necessary to hoist a quantity of country rock from the workings.

The pegmatite cuts the mica gneiss country rock about conformably with its average attitude—that is, it trends northeast and has a high southeast dip. It is from 2 to 8 feet thick through much of the open cut and nearly 20 feet thick in the middle, though here it is thickest near the surface, pinching somewhat downward. The main pegmatite forks in places, offshoots branching to the northwest between the middle and southwest end and at the northeast end of the workings. Much of the pegmatite is medium to fine grained, but some has a coarse texture and contains large segregations of quartz. In most of the workings mica has been most plentiful near the hanging wall, but a small quantity is scattered through the pegmatite or occurs along the footwall. Crystals of mica more than 2 feet across are reported. The muscovite has a clear light rum color and is of good quality. A little biotite is associated with it. Black tourmaline is plentiful in places. At the northeast end of the cut a 4-foot "vein" branching out from the main deposit carries much mica near the surface and little tourmaline, though the same vein several feet below carries much black tourmaline and little mica.

DAVIS MINE.

The Davis mine is 2½ miles N. 15° W. of Gilsum, on the southwest side of the road leading to East Alstead. This is one of the older mines of New Hampshire and, according to information furnished by Silvester Mitchell, of Gilsum, to James Davis, who last operated it, the mine was opened about 1810 by Simon Bowers. It was worked intermittently by three generations of the Bowers family and then by Silvester Mitchell. Prior to 1894, when Mr. Davis began operations, most of the mining consisted of open quarrying. The mine now belongs to the American Mica Co., of Newton Lower Falls, Mass. The Davis Mica Co. was well equipped with buildings, aerial tram, track, hoists, power drills, etc., and carried on extensive underground work. The workings are chiefly along the side of a low hill above swampy ground. From the shop an open cut extends southward about 100 yards and then northeastward about 100 yards to the road. (See fig. 20.) All the workings were filled with water to the level of the swampy ground west of the mine when the mine was examined in 1913 and 1914. The underground workings, as reported by Mr. Davis, consist of a shaft 93 feet deep and a drift 200

feet long to the south opening into large stopes above. This drift and the stopes above lie east of the open cut.

The country rock is mica gneiss containing prominent layers of biotite schist carrying black tourmaline. The rocks have a variable north to northeast strike and a high east to southeast dip. The pegmatite is conformable with the inclosing gneiss through part of its course but bulges out in places, cutting across the schistosity of the gneiss. Horses of gneiss are inclosed in different parts of the pegmatite, which in places forks or branches. In the southern part of the mine there appears to be one large body of pegmatite, which, with the inclosed horses of gneiss, is from 50 to nearly 100 feet thick, but to the northeast it has branched out into at least three smaller beds, which have been prospected by open cuts.

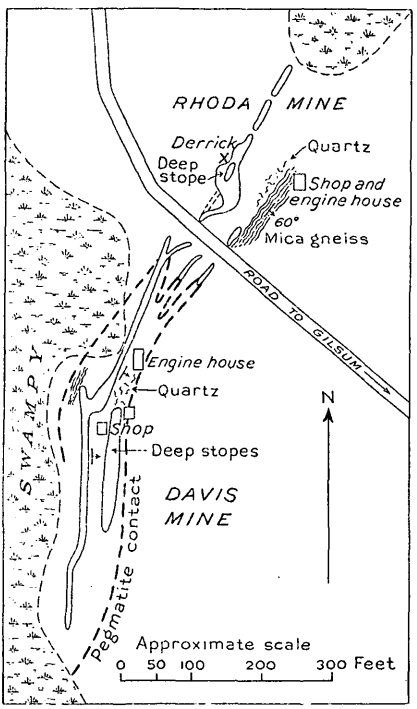


FIGURE 20.—Plan of the Davis and Rhoda mines, 2¾ miles north-northwest of Gilsum, Cheshire County, N. H., showing part of geology.

The pegmatite varies greatly in texture and composition. In the southern part of the workings it contains plentiful biotite, much of which is intergrown with muscovite. In part of the rock exposed in the open cut to the south crushed biotite crystals from a quarter of an inch to an inch thick and several inches wide are so abundant as to make the pegmatite very dark gray. Mr. Davis states that biotite was so plentiful and so closely intermixed with the white mica in places in the stopes as to cause trouble in mining and separating them. The muscovite mica is of good quality and has a clear light-rum color. A little beryl, greenish apatite, and black tourmaline were observed around the dumps. Quartz occurs in large, massive segregations, one of which is exposed south of the engine house.

RHODA MINE.

The Rhoda mine, called the Tripp No. 2 in a former report,[52] is a continuation of the Davis mine across the road to the northeast and has been worked by a series of open cuts along the outcrop. (See

[52] Sterrett, D. B., Some deposits of mica in the United States: U. S. Geol. Survey Bull. 580, p. 93, 1915.

fig. 20.) The open cuts continue as stopes to varying depths where the pegmatite was richest in mica. The southern part of the workings had been cleaned out and was in operation at the last visit (October, 1914). This part consists of an open cut of irregular shape about 25 feet across and 30 feet deep, with a stope 6 feet wide carried 20 feet deeper. The mine is equipped with an engine, derrick hoist, pump, compressor, and air drills. Plate XIV, *A*, is a view looking N. 15° W. across the open cut and deep stope.

The body of pegmatite is large, probably nearly 75 feet thick. Most of the work has been done along the northwest or footwall contact, where a rich streak of mica was found. This streak ranges in thickness from 2 to more than 4 feet and has a somewhat sinuous northeastward trend and an irregular southeasterly dip. The stope opened at the time of visit was very rich in mica. Many large crystals measuring from 1 foot to 2 feet across were exposed. Most of these were only 2 to 3 inches thick. Some of the crystals were arranged with cleavage perpendicular to the wall of the pegmatite; others were turned at different angles. A number of these mica crystals in the working face of the deep stope are shown in Plate XIV, *B*. The mica has a clear rum color and is of good quality. On the southeast side of the workings a large mass of quartz is inclosed in the pegmatite in contact with the mica gneiss country rock.

TRIPP MINE NO. 1.

The Tripp mica mine No. 1 is about a quarter of a mile north by west of the Island mine, or 2¼ miles N. 20° W. of Gilsum. It has not been operated for several years, and when it was visited it was filled with water and badly overgrown with brush. The workings consist of an open cut run northward more than 125 feet long and 20 to 30 feet wide. The waste and ore were removed by an inclined track at the north end of the cut. Some of the pegmatite was coarse grained and contained large quartz segregations and crystals of potash feldspar more than a foot thick. At the north end of the open cut a tree had been recently uprooted, exposing a deposit of mica several feet across in the pegmatite. Some of the crystals of mica were 12 inches in diameter, and a few were seen that would cut into sheets measuring 4 by 6 inches. The mica has a clear rum color and is of fairly good quality.

ISLAND MINE.

The Island mica mine, 2 miles N. 20° W. of Gilsum, was worked long ago by James Davis. It is now owned by Watson Bros., of Boston, Mass., but has not been operated for several years. The workings consisted of three open cuts and a short tunnel. Two of

the open cuts were at the east foot of a small knoll that stands about 25 feet above the surrounding swampy ground. These open cuts were 20 and 25 feet deep but are now filled with water. The third cut was made back into the knoll at a level a few feet above that of the lower cuts but still 18 or 20 feet lower than the summit of the knoll. (See fig. 21.)

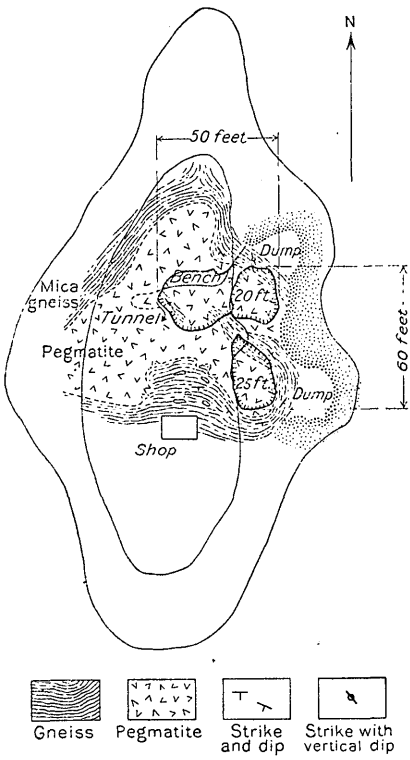


FIGURE 21.—Plan of Island mica mine, 2 miles N. 20° W. of Gilsum, Cheshire County, N. H., showing geology.

The country rock is biotite gneiss, which contains much black tourmaline near the pegmatite. The gneiss has a highly varied strike and dip adjoining the pegmatite, as shown by symbols in figure 21. It has been much folded and crinkled in places by the intrusion of the pegmatite. The pegmatite body is very irregular in shape but has a general westerly trend across the knoll. It incloses streaks of mica gneiss, and small stringers and bodies of it are intruded into the surrounding gneiss. North of the shop, where the rock has been stripped bare by glacial action, a number of small curved lenses or bulblike masses of pegmatite are exposed in the crinkled gneiss. Along the contact of the gneiss and the main body of pegmatite these small masses appear to have been forced out into the gneiss, which has curved around them. A tongue or streak of mica gneiss included in the pegmatite extends between the two lower cuts and may have connected with a body of gneiss exposed in the bottom of the upper open cut.

The pegmatite contains large segregations of smoky, gray, white, and pale rose-colored quartz, some graphic granite, pockets or bunches of mica (both muscovite and biotite), black tourmaline, green apatite, a few red garnets, and numerous beryl crystals. The mica seen was mostly "bunchy," but of course the best had been removed in the last mining. It has a clear rum color and is of good quality. Mr. Davis reports a good yield of mica, with some large crystals, during his work at the mine. A few crystals of biotite are intergrown with the muscovite. The crystals of beryl, some of which are as much as

a foot in diameter, are blue, blue-green, yellow-green, and rich and pale golden yellow. Good gem beryl has been found, but most of the beryl is translucent or opaque. Small golden beryl gems of exceptional beauty have been cut from clear portions of large crystals.

FRENCH MINE.

The French mine of the American Insulator & Mica Co. is 1⅔ miles N. 25° W. of Gilsum, in the town of Alstead. It is an old mine, opened more than 50 years ago and worked successively by the discoverer, a man named Mitchell, by a Mr. Bowers, and for a long time by W. A. & C. H. French. The workings consist of a large open cut 60 yards long, 30 to 40 yards wide, and 20 to 60 feet deep, with smaller openings at the north end and a shaft or pit 20 feet deeper than the bottom of the cut, or 80 feet from the surface. Two steam drills are used in mining, and derrick hoists and an inclined track are used to remove waste and mica from the pit. A view looking S. 30° W. across the open cut is shown in Plate XV, *A*. The derrick hoists rock from the bottom of the cut into the car at the foot of the incline track.

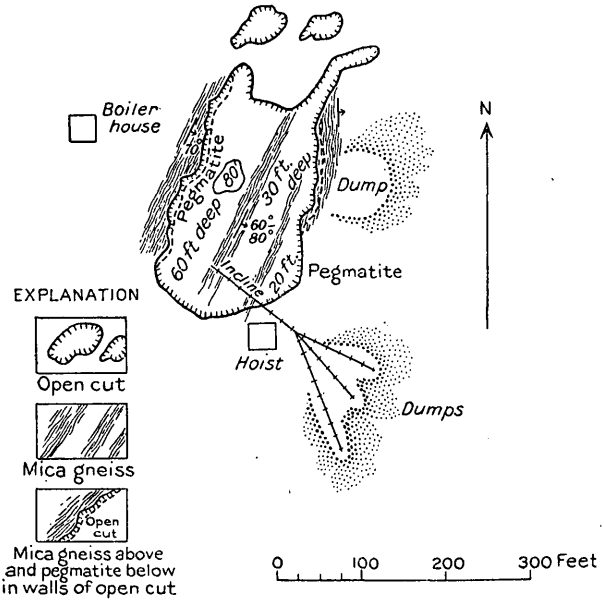


FIGURE 22.—Plan of French mica mine of American Insulator & Mica Co., 1⅔ miles northwest of Gilsum, Cheshire County, N. H., showing geology.

The country rock is mica gneiss with highly schistose layers. The gneiss strikes north to N. 30° E. and dips 60°–80° SE. The pegmatite occurs in a large irregular mass cutting the gneiss. Streaks or horses of gneiss and schist are inclosed in the pegmatite, retaining about the same strike and dip as the country rock. Two prominent horses of schist, which extend nearly across the pit, were left standing above the level of the adjoining floor. The relations between the pegmatite and gneiss walls and horses are shown in figure 22. The area of the pegmatite is larger below ground than at the surface, so that the walls of the cut show pegmatite below with mica schist

or gneiss above. Both the gneiss and pegmatite are somewhat altered by weathering, but in places the pegmatite is fresh and hard. The feldspar of the pegmatite is mostly the potash variety, and has perthitic texture. Quartz does not occur in large segregations, and only a few small masses were observed. Black tourmaline is abundant in places and, near the bottom at the south end of the open cut, crystals 8 inches or less in diameter are associated with the mica. The mica is scattered irregularly through the pegmatite, there being some richer places, chiefly along the mica schist inclusions or walls. Mica crystals of various sizes, some 18 inches or more in diameter, were abundant in the working face at the south end of the cut, below and south of the end of the incline. The mica has a good cleavage with very elastic sheets. Some of it is slightly smoked or dusted with minute particles between the laminae.

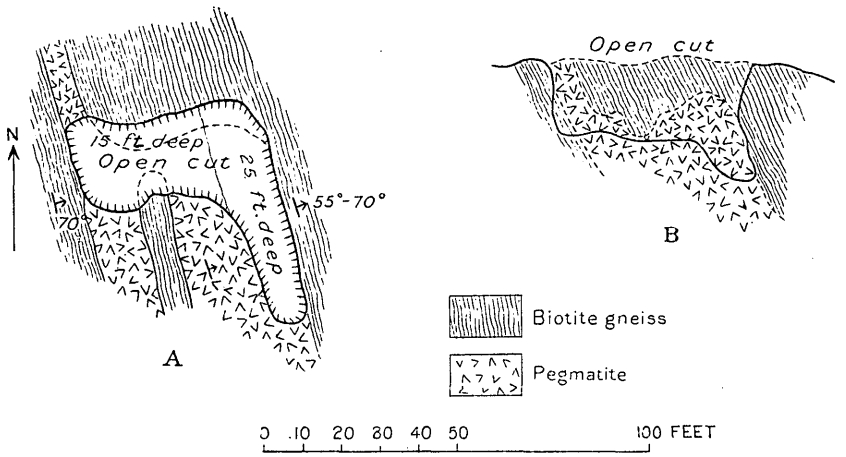


FIGURE 23.—Plan (A) and cross section (B) of Keene Mica Products Co.'s mine, 1 mile northwest of Gilsum, Cheshire County, N. H., showing geology.

KEENE MICA PRODUCTS CO.'S MINE.

The mine of the Keene Mica Products Co. is 1 mile N. 40° W. of Gilsum. It has been worked by an irregular-shaped open cut 65 feet long and 15 to 25 feet wide, shown in figure 23. This cut is about 25 feet deep along the east side, where there is a slight overhanging wall, and 15 feet deep on the west side at the north end. The country rock is biotite gneiss carrying considerable tourmaline near the pegmatite. The gneiss strikes N. 15° W. and has a high but variable dip to the east. The pegmatite mass is large and irregular in shape. In part it is conformable with the foliation of the inclosing gneiss and in part it cuts the foliation. The relation between the gneiss and pegmatite exposed in the north end of the cut is shown in the cross section in figure 23. From the south side of the northern part of the open cut a trough-shaped horse of

tourmaline-biotite gneiss, 12 to 15 feet thick, with pegmatite on each side of and below it, extends southward for more than 70 feet. Apparently this horse did not connect with the deeper roll of the gneiss on the north end of the cut shown in the cross section. The pitch of the pegmatite and gneiss contact along this side of the cut is about 15° N. This would mean that the surface relation restored would give the approximate contacts shown by the dotted lines in the plan, and such were the original conditions as reported by the miners. Plate XVI, *A*, is a view from the middle of the north side of the open cut looking south. The sequence from west to east is plainly shown—that is, the biotite gneiss wall on the west, pegmatite, the horse of gneiss shown in figure 23, more pegmatite opened by a cut 25 feet deep, and the gneiss wall on the east in the open cut.

The pegmatite is of diverse texture, some parts showing a very coarse crystallization with feldspar crystals 2 to 3 feet across and large quartz segregations. A little graphic granite was observed. The mica is richest near the hanging wall of the pegmatite, in streaks 3 to 7 feet thick. A thickness of 6 to 7 feet has been removed in mining, and in places the work has been extended to other parts of the pegmatite where pockets of mica were found. A mica streak, part of which has been worked, occurs along the west side of the horse of biotite gneiss. The face left on the pegmatite at this point shows a quantity of smaller sheet mica which will pay to remove. Plate XVI, *B*, shows this local enrichment of mica near the biotite gneiss. The mica obtained from this mine has a clear light rum color and is of good quality. A little biotite is associated with the muscovite.

The mine is equipped with a Sullivan gasoline-engine compressor, with two hand drills and one large drill. The mica is hauled to the company's plant at Keene, where numerous mica products are manufactured for the glazing and electric trades.

JEHIAL WHITE MINE.

The Jehial White mine is 1 mile south of Gilsum on the east side of the State road leading to Keene. The mine was opened about 8 years ago by James Davis and has been worked intermittently since. At the time of examination (October, 1914) Mr. White was operating under contract with the Keene Mica Products Co. The workings consist of an irregular-shaped open cut about 90 feet long, 15 to 30 feet wide, and 5 to 25 feet deep made in a S. 25° W. direction into a hillside. Much of the lower end of the cut has been filled with waste from the upper end of the workings. The shape of the open cut is shown in figure 24. The equipment consists of a shop, gasoline engine, air compressor, drills, and a derrick hoist.

The country rock is highly foliated biotite gneiss, which strikes about north and dips from 30° to 60° E. The pegmatite cuts the gneiss very irregularly, parallel with its bedding at one place and across it at another. Strikes from north to northeast and dips from 20° to 60° east and southeast were measured on the pegmatite. The thickness of the pegmatite is difficult to determine, as it forks in some places and includes horses of gneiss in others. In the exposures available for examination it ranges from 1 foot to 8 feet in thickness, these measurements not including large horses of gneiss. The texture is moderately coarse. Quartz occurs in segregations from 3 to 12 inches thick. The feldspar is chiefly a plagioclase. Black tourmaline is rather plentiful. A little biotite and some beryl were observed. The beryl is opaque to partly translucent gray, yellow, and aquamarine green. The mica has a fine clear rum color and good cleavage. Most of the crystals found during 1914 were less than 10 inches in diameter, but Mr. Davis is reported to have obtained some larger sheets in working the lower part of the quarry.

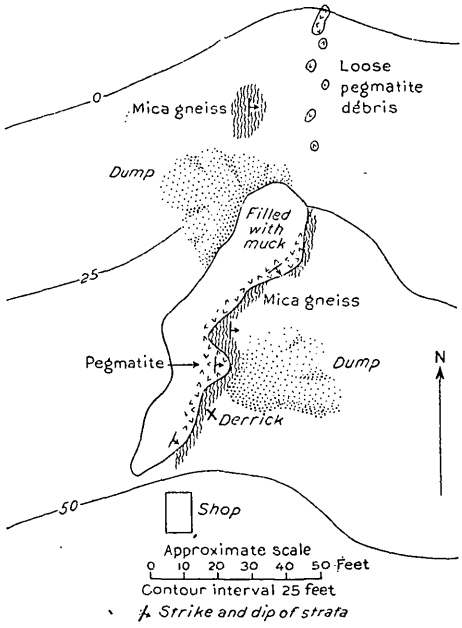


FIGURE 24.—Plan of Jehial White mica mine, 1 mile south of Gilsum, N. H., showing part of geology.

NIMS MINE.

A mica deposit on the land of E. S. Nims, half a mile north of Sullivan, was operated a few years ago by a mica company of Keene. Two open cuts were made, one 30 by 35 feet across and 14 feet deep and a smaller one a few feet to the north. A gasoline engine and air compressor with two air drills were used in quarrying. The country rock is porphyritic biotite gneiss, which strikes north and has a variable easterly dip. The pegmatite cuts across the gneiss with a strike of N. 65° E. and a dip of 20° SE. along the southeast contact. The northwest contact is not exposed. A horse of mica gneiss is inclosed in the pegmatite a few feet northeast of the workings.

The texture of the pegmatite is very coarse, some of the crystals of potash feldspar measuring 4 feet across, all clean feldspar. Gray and smoky quartz occurs in irregular masses. The mica was scattered irregularly through the pegmatite, but in one place a streak or

pocket of light-green wedge, A, and fishbone mica was encountered. About 5 tons of mica is reported to have been taken out, some of which would yield good sheets. Among the associated minerals in the pegmatite, observed chiefly on the dump, were triphylite, beryl, black tourmaline, and pyrite. The triphylite occurs in grayish masses several inches across, with blue streaks, due to alteration products, along the cleavage faces. The beryl crystals are opaque, are yellowish or greenish gray, and some of them measure as much as 12 inches in diameter. Several hundred pounds could easily be gathered from the dumps.

PRICE PROSPECTS.

Several prospects 1¼ miles west of East Sullivan were opened in 1912 and 1913 by James W. Price. The principal one is along the edge of swampy ground, where a large mass of pegmatite crops out to a height of 15 to 18 feet above the ground. This mass strikes about north and is over 40 feet across. The working is on the west side of the mass and consists of an open cut 35 feet long and 4 feet deep. Water causes much trouble in the work. The east wall of the pegmatite is mica gneiss. The texture of the pegmatite is very coarse in places, the quartz segregations being several feet across and the crystals of potash feldspar 1 to 2 feet thick. The mica is richest along the west side of the pegmatite in a streak about 4 feet thick. It has a clear light-rum color and excellent cleavage. Six tons of run-of-mine mica is reported to have been removed from the cut, some of which would yield perfect sheets several inches across. Small crystals of beryl were observed in and adjoining some of the masses of quartz in the pegmatite.

About 250 yards to the south another open cut, 20 feet long, 12 feet wide, and 8 feet deep, had been made in a pegmatite outcrop. The pegmatite trends northward. Crystals of potash feldspar more than a foot thick were encountered in the pegmatite. The mica has a clear light rum color and is of good quality. About 2 tons of mica is reported to have been removed, including one good crystal weighing 60 pounds.

About 200 yards farther south much mica has been found in a deposit of loose material consisting of fragments of pegmatite, feldspar, quartz, and earth. The mica is of good quality, and some fair-sized plates are reported to have been found. This deposit probably represents a bank of glacial drift consisting of material scooped out of a pegmatite mass not far distant, though it may be pegmatite decomposed in place, or waste from older workings that have been covered over or filled.

BROOKS PROSPECT.

A mica prospect was opened in the spring of 1913 on the land of Charles Brooks, 1¾ miles west of East Sullivan. The prospect lies in gently sloping ground and consists of an open cut 45 feet long, 8 to 10 feet wide, and 4 to 10 feet deep, of the shape shown in figure 25. The country rock is grayish muscovite-biotite gneiss striking north and dipping east. The pegmatite has a northeast strike in part of the open cut, but forks, one branch going north and the other (not developed) east. The contact of the pegmatite and gneiss on the southeast side of the cut dips 70° NW. More pegmatite crops out about 30 feet northeast of the open cut. Much of the pegmatite is only medium grained, but in places the texture is coarse. It is composed of a rather even mixture of potash feldspar, quartz, and mica, including a little biotite, with variable quantities of black tourmaline. The mica has been found in crystals measuring as much as 10 inches across. Some of the crystals show wedge, **A**, or hair-lined structure, and others split smoothly. The color is light rum. Sheets 3 by 4 inches could be cut from some of the rough crystals seen. More than 3 tons of rough run of mine mica is reported to have been taken from the open cut.

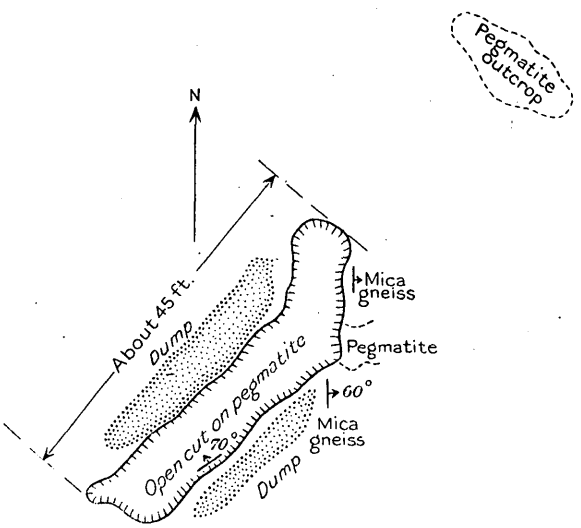


FIGURE 25.—Plan of Brooks mica prospect, near East Sullivan, Cheshire County, N. H.

GRAFTON COUNTY.

GENERAL ELECTRIC CO.'S MINE.

A mine has been operated since 1911 by the General Electric Co., of Schenectady, N. Y., about half a mile west of West Rumney (Swainsboro station on the Boston & Maine Railroad). The deposit is in the south side of a small hill and about 75 feet above a stream. The position of the workings and the surrounding geologic features are shown in figure 26, A. The trimming plant is at the foot of the hill.

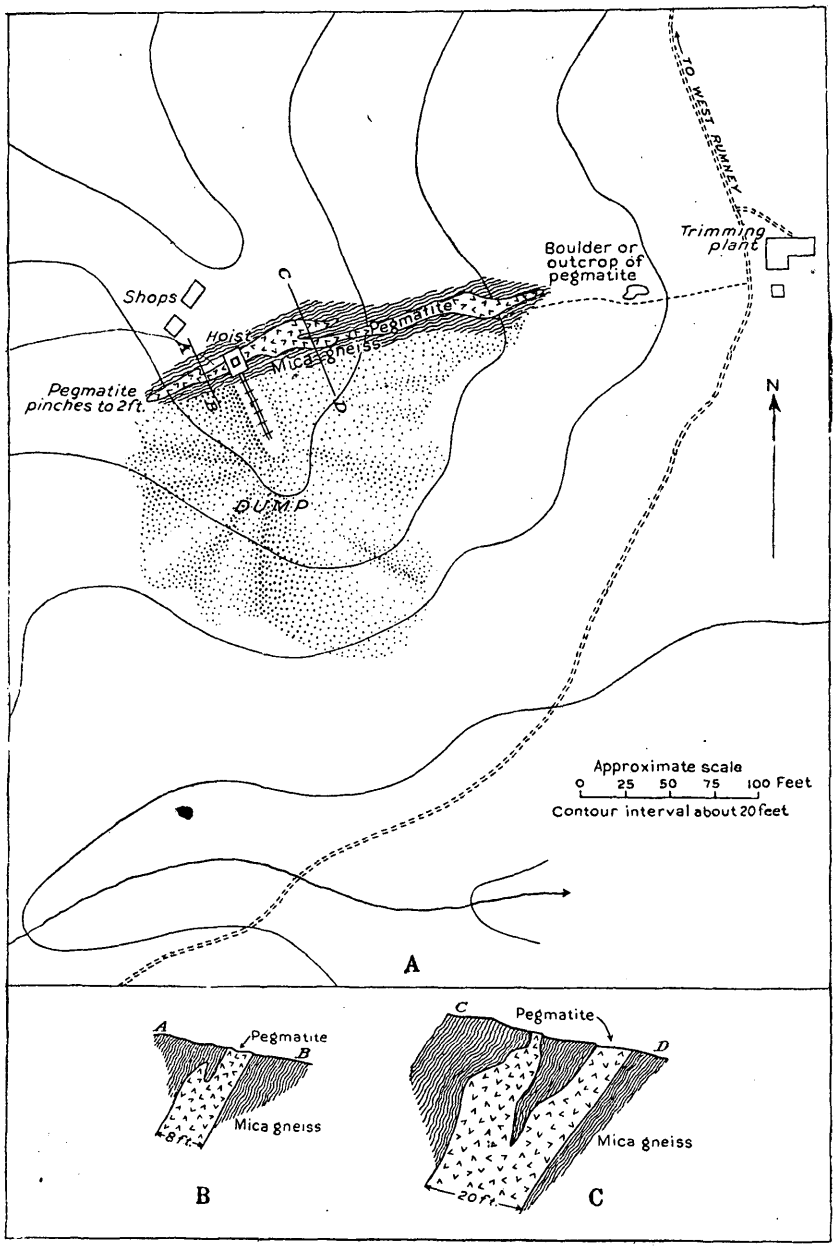


FIGURE 26.—Plan of General Electric Co.'s mica mine, near Swainsboro, Grafton County, N. H. A, Position of workings and geologic features; B, cross section of vein at *A–B*; C, cross section of vein at *C–D*.

In October, 1914, the work consisted of open stopes and open cuts through a distance of about 200 feet in an irregular east by north direction. The open cut ranged in width from 6 to 20 feet, conforming to the width of the "vein." The stopes were carried to a depth of more than 100 feet but had been filled up to the 60-foot level, for the vein was poor in the bottom. The stopes exposed ranged in width from 4 to 12 feet, increasing in width upward at some places into the open cut. The deepest work was done at the highest point of the outcrop and was carried about 65 feet along the vein. The open cut extended about 50 feet west by south from the west end of the deep stope and nearly 100 feet east by north from the east end down the hillside toward the trimming plant.

The country rock near the pegmatite is quartz-biotite-muscovite gneiss. A few yards to the northwest the gneiss contains also fibrolite. The gneiss has been strongly folded near the mine and has a somewhat variable strike, approximating N. 65° E., and a dip of 60° NW. Much of the pegmatite is nearly conformable with the inclosing gneiss, especially where it occurs in the sheetlike mass, but in places it is forked, so that part of it cuts the schistosity of the gneiss. The pegmatite pinches down to a thickness of about 2 feet at the west end of the open cut and swells to about 20 feet at the fork shown at *C–D* in figure 26. The average thickness is about 8 feet. Details of two forks in the pegmatite occurring at *A–B* and *C–D* of figure 26, A, are shown in figure 26, B and C. The fork of the pegmatite near *C–D* in the open cut is also shown in Plate XVII, *A*. The horses of gneiss included between the forks of the pegmatite widen to the east, which shows that the forks pitch to the east. Even where the pegmatite does not fork it has local variations in stripe and dip due to warping of the sheet.

The pegmatite has a varied texture, some of it being very coarse-grained and some finer, resembling coarse granite. In places along the contacts where the texture is not coarse there is a partial banding of streaks rich in mica with mixed quartz and feldspar. In the main working a "vein" along the hanging wall was richest in mica, 1 foot to 3 feet thick, but bunches or pockets of good mica were also found scattered through the mass of the pegmatite. The "vein" was richer in the large stope, from the surface down to nearly 100 feet deep, than in the other parts exposed by stripping and open-cut work to the east. The mica has a clear light rum color, and much of it is in clean crystals with good, flat cleavage. Some of the crystals are 2 feet or more in diameter, and the best of them make fine stove mica. Fragments of beryl crystals 2 to 10 inches in diameter were seen on the dump. These crystals had well-defined hexagonal

shapes but were opaque and were of dull grayish-green to yellowish colors.

The General Electric Co. has equipped a trimming plant near the mine for preparing the mica in the forms desired for use at the main works in Schnectady, N. Y., and by the glazing trade. Machine trimmers were used first but were abandoned later, as they did not leave the rough-trimmed mica in favorable condition for splitting and other treatment in the course of manufacture. Power punches are used for making disks and washers. A gasoline engine and dynamo supply the power to the motors operating the mill machinery and the electric-power drills used at the mine.

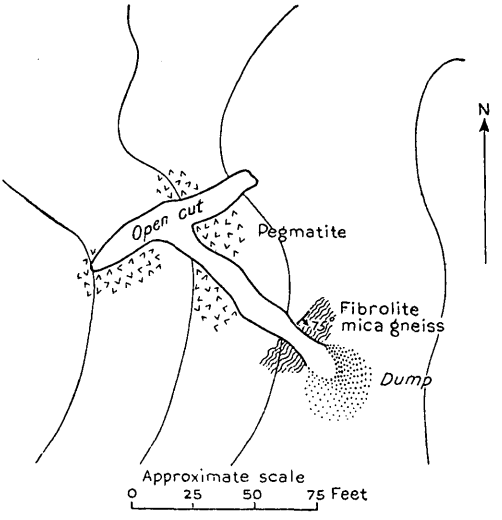


FIGURE 27.—Plan of Wheat mica mine, West Rumney, Grafton County, N. H., showing geology.

WHEAT MINE.

A mine was worked some years ago on the land of Lon Wheat, about 1½ miles northeast of West Rumney on the northeast side near the summit of the divide northwest of Rattlesnake Mountain. Open-cut work 150 feet long, 5 to 10 feet deep, and several feet wide was done as shown in figure 27. The entrance to the open cut was made through fibrolite mica gneiss which strikes N. 20° E. with a high southeast dip. The workings were overgrown by vegetation and the rocks in the sides of the open cut were exposed at but few places. Pegmatite is exposed on several sides (see fig. 27) and the open cut was probably made in one large body of pegmatite.

Little mica was seen in place, but some left in the shop near the mine is light greenish and clear. The shop had been equipped with shears and wooden templets or patterns for trimming the mica.

BELDEN MINE NEAR WEST RUMNEY.

Several prospects were opened by the Belden Mica Co., about half a mile north of West Rumney on a small glaciated plateau that stands about 150 feet above Bakers River, in the valley of which West Rumney is situated. The country rock is fibrolite-mica gneiss, which has a general north to northeast strike and a high east to to southeast dip. A number of masses of pegmatite crop out near

the prospects, a few of which have been opened. Most of these masses have a general northeast strike.

The main working consists of an open cut 15 feet wide and 20 feet deep in the southwest face of a small, steep hill and a 15-foot tunnel driven northeast from the inner end of the cut. The mica gneiss wall rock at this prospect contains crystals of black tourmaline. The pegmatite is large and is irregular in shape, cutting across the bedding of the gneiss through most of its course. The pegmatite is very coarse grained, the segregations of feldspar and quartz being 2 to 3 feet thick. Little mica was left in the dumps or seen around the workings.

HERBERT PROSPECTS.

Several mica prospects have been located on the land of Henry Herbert, about three-quarters of a mile northeast of West Rumney, on Rattlesnake Mountain. W. D. Stinson, who has an interest in these prospects, has done a little work on them. The most promising of these prospects consists of a ledge of pegmatite more than 20 feet thick, which outcrops in a northeasterly direction around the mountain side and from which large blocks have broken off and slid down. One block 20 feet thick, which lies about 30 feet below the ledge, contains a large proportion of mica between massive quartz and finer-grained pegmatite. The quartz segregation is 2 to 3 feet thick and lies between the mica and a mass of coarse orthoclase or microcline feldspar crystals and graphic granite. Some of the crystals of mica are as large as 10 inches in diameter and 7 inches thick. They are bunched together in an exposure several feet long and 2 feet wide. Some biotite in thin sheets nearly 12 inches across is included in the mass of muscovite.

The part of the ledge from which this block of pegmatite has been detached is covered with soil, but if the mica continues into it prospecting would probably locate the deposit easily. Exposures in the main ledge do not show deposits so rich in mica, possibly because the lower part of the ledge, which is largely concealed by soil, is the mica-bearing part. Mica crystals are seen in some of the other masses of pegmatite that crop out on the hillside.

The country rock near the prospects is fibrolite-mica gneiss, which strikes north by east and has a high easterly dip. A little hornblende gneiss is interbedded with the fibrolite gneiss.

WHICHER & PILLSBURY PROSPECT.

A prospect has been opened by a few blasts on land owned by Whicher & Pillsbury, 2¾ miles S. 20° W. of the village of Wentworth, in the town of Wentworth. The prospect is on the steep slope of the

southeast end of a hill or small mountain that rises about 1,050 feet above sea level. An outcrop of pegmatite which cuts biotite granite gneiss extends N. 80° W. about 150 yards along the hillside. The mass of pegmatite has an average width of about 8 feet through most of its exposure but pinches to a mere seam toward the west. The pegmatite is moderately coarse grained, the crystals of orthoclase feldspar and the segregations of quartz measuring 6 to 10 inches across. Crystals of mica are plentiful in the outcrop, but most of them are less than 4 inches across. A few crystals that measured 8 to 10 inches and one over a foot across were seen.

McGINNIS AND WHICHER & PILLSBURY PROSPECT.

Another prospect nearly half a mile southeast of the Whicher & Pillsbury prospect or 3 miles S. 18° W. of Wentworth crosses the boundary line between the land of Elias McGinnis and that of Whicher & Pillsbury. The prospect is in a small knoll close to a brook, about 400 feet lower than the Whicher & Pillsbury prospect. A little open-cut work has been done in places along an exposure of pegmatite about 100 feet long and 8 feet thick. The pegmatite cuts biotite granite gneiss with a strike of N. 60° E. and a vertical dip. The pegmatite contains quartz segregations or lenses of quartz 1 foot to 15 feet long and as thick as 2½ feet, chiefly in its middle part and parallel with its walls. The feldspar is largely of the potash variety. Other minerals observed were a little black tourmaline, red garnet, biotite, and a number of crystals of beryl ranging in thickness from half an inch to 5 inches. Most of these crystals are opaque and aquamarine green, and a few contain translucent and small transparent portions. The pegmatite contains abundant crystals of mica, the largest 12 inches in diameter. The mica is clear light rum-colored and has good cleavage. The cleavage of the crystals near the walls of the pegmatite is nearly perpendicular to the walls.

SAUNDERS HILL PROSPECTS.

Several mica prospects have been found on the lands of Elias McGinnis and David Dow, on Saunders Hill, about 2 miles S. 60° W. of Wentworth. The country rock on this hill or mountain is biotite granite gneiss. Outcrops of pegmatite are numerous, and those at a few places contain enough mica to form promising prospects. Only a little blasting has been done in the outcrops and this not always at the best places.

At one place on the McGinnis property a thickness of about 4 feet of pegmatite from the hanging wall is exposed in a small bank for about 15 feet. Numerous crystals of mica, some as much as 10 inches across, are visible in the face of the rock. On the Dow place several

prospects have been blasted into a large blanket ledge of pegmatite with indifferent results. In one of these prospects crystals of beryl were found associated with small crystals of mica. In other outcrops of pegmatite on Saunders Hill crystals of mica ranging from a few inches to 10 inches across were seen.

VALENCIA MINE.

The Valencia mine is 2¼ miles N. 75° E. of North Groton, in the west side of a small mountain ridge called Fletcher Hill, about 1,400 feet above sea level. It is one of the older mines, having been discovered about 1880 by Capt. William Simpson and William Rice, of Bristol, N. H. Operations were carried on steadily for 10 or 12 years, until a big cave-in of the workings occurred. The mine was operated on an extensive scale, and fortunately the large force of miners was out of the mine at dinner when the slide took place. The accident caused the loss of the power drills and other mining machinery and the closing of the mine.

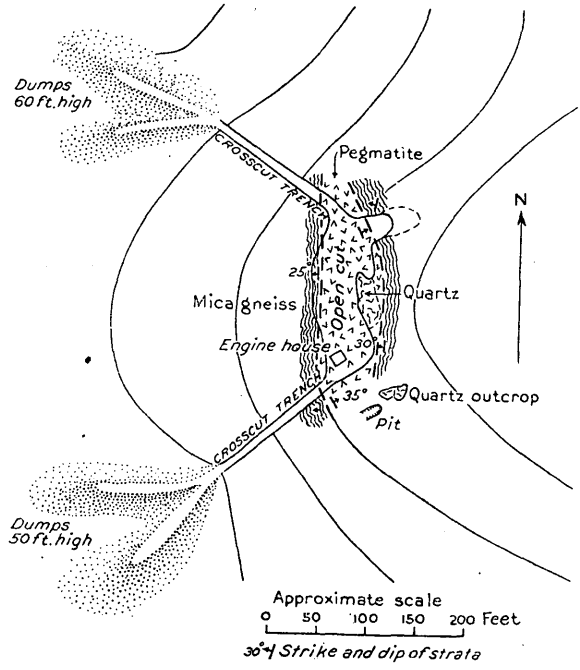


FIGURE 28.—Plan of the Valencia mica mine, 2¼ miles N. 75° E. of North Groton, N. H., showing geology.

The work consisted of an open cut run northward, more than 150 feet long, 30 to 50 feet wide, and 10 to 40 feet deep, and of stopes run from the east side of the cut to a depth in places of 50 feet. Two long crosscut trenches, one at the north end and the other at the south end of the open cut, were run out to the hillside, where the waste rock was dumped. The dump piles are 50 to 60 feet high on their lower sides. Much waste rock was piled on the west side of the open cut and in the middle part, so that the full depth of the cut is not exposed. When examined the stopes were filled with water to the level of the lower end of the open cut. The shape of the workings and the relations between the gneiss and pegmatite are shown in figure 28.

Parts of the pegmatite are very coarse grained, the quartz occurring in irregular masses or segregations more than 10 feet across and the feldspar in crystals as large as 2 by 7 feet and some 6 feet square. The point projecting into the open cut from the middle of the east side is composed largely of massive quartz. The feldspar is chiefly of the potash variety—orthoclase or microcline. Among other minerals observed in the dumps were apatite and beryl. The beryl was fragmental and consisted of parts of crystals ranging from 1 inch to 6 inches in diameter, some with a translucent aquamarine color. George F. Kunz[53] states that 100 aquamarine gems weighing from 1 carat to 4 carats were cut from beryl found at the Valencia mine in 1885. The mica has a fine clear rum color and good cleavage, and many large crystals are reported to have been found.

FLETCHER MINE.

The Fletcher mine is about 2½ miles east of North Groton, in a gap on the summit of Fletcher Hill ridge, about a mile southeast of the Valencia mine. The deposit was discovered after the Valencia deposit and was purchased by the General Electric Co. It was not in operation at the time of examination (October, 1914) but was ready to be worked when needed.

Three sets of openings have been made, one on the north side of a narrow glacial valley that cuts across the summit of Fletcher ridge and two on the south side. These workings are about 75 yards apart in a line that runs N. 15° E. to S. 15° W., and may be called for convenience the north, middle, and south workings. The glacial valley is a canal-like channel running S. 80° E., cut into the gneiss across the summit of the ridge. It is about 30 feet wide, has nearly vertical rock walls 10 to 20 feet high and steep slopes above, and holds a straight course for more than 200 feet across the bedding of the gneiss, crossing at an acute angle the general direction of the glacial striae of the region. It was probably formed by the plucking of great blocks of gneiss that lay between parallel joint planes by glacial ice. The position of the workings and the glacial valley are shown in figure 29.

The country rock is porphyritic mica gneiss containing fibrolite crystals in places. It has a general strike of about N. 15° E. and an approximately vertical dip, but it exhibits many small crumplings.

At the north working an open cut about 125 feet long, 10 to 20 feet wide, and 5 to 18 feet deep extends N. 10° E. from the side of the valley. A 40-foot shaft was sunk in the east side of the open cut on the vein. The cut has not been opened through the full thickness of the pegmatite, which cuts across the gneiss with about a parallel

[53] Precious stones: U. S. Geol. Survey Mineral Resources, 1885, p. 439, 1886.

strike but with a dip of 50° E. At the north end of the cut the "vein" of pegmatite forks around a tongue or horse of gneiss. This "vein," though rich in mica in most of the exposures, contains still richer streaks or patches, one of which lies along the west side of the cut near the north end and another on the east side between the 40-foot shaft and the split in the vein at the north end. The crystallization of the pegmatite is fairly coarse, plagioclase feldspar occurring in

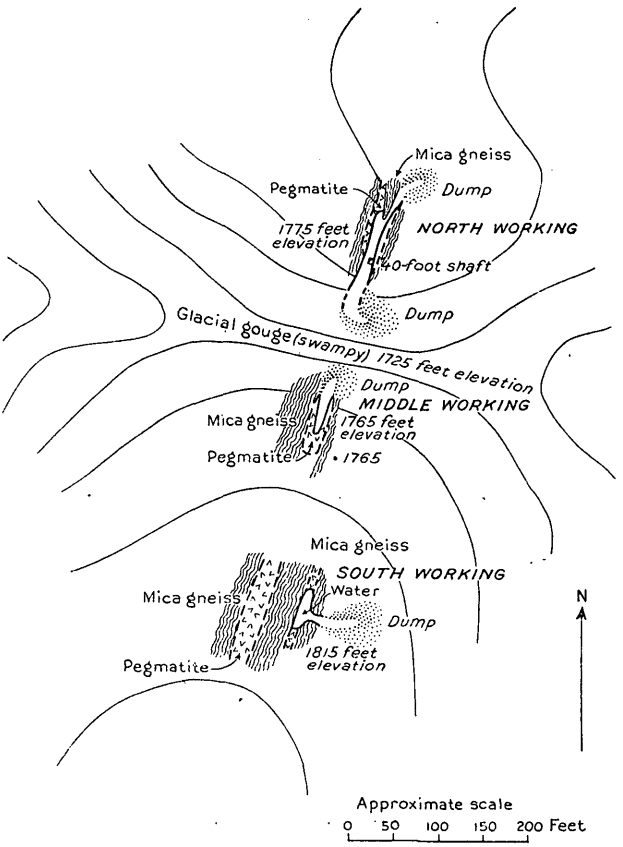


FIGURE 29.—Plan of Fletcher mica mine, 2½ miles east of North Groton, N. H., showing geology.

crystals more than a foot across. A few crystals of beryl were observed in the pegmatite.

The middle working consists of an open cut 50 feet long, 15 feet wide, and 5 to 20 feet deep, and a 15-foot tunnel driven from the south end of the cut. The pegmatite is 15 feet thick and lies nearly in line with the vein of the north workings. It cuts the gneiss in about the same way as in the north working—that is, with almost parallel strike and a dip of 50° E. A horse, or possibly the wall rock folded into the vein, is exposed in the bottom on the west side of the

cut. The mica is scattered through the whole of the pegmatite, but a streak richer in crystals lies along the east wall of the vein.

The south working consists of an open cut 65 feet long and 40 feet deep. It is on a different "vein" from that exploited by the other two workings, possibly on a fork from the main body of pegmatite, which crops out 35 feet to the west. The strike of the pegmatite in this working is about the same as in the others, but the dip was not exposed. The pegmatite to the west shows crystals of mica in its outcrop.

The mica from the Fletcher mine is clear, is of light rum color and has good cleavage. The mine can probably be made to yield a large output.

EASTMAN PROSPECTS.

Three mica prospects have been opened on the land of E. A. Eastman, about 2 miles north of North Groton. One of these is in a bank on the south side of a brook a few hundred yards northeast of the house, another is in the side of a mountain about a quarter of a mile to the north and 450 feet higher, and the third is a few hundred yards north of this and 200 feet higher, on the summit of a knob. Only small pits have been made at the two lower prospects, and there is an old shaft more than 50 feet deep on the summit of the knob.

The country rock around these prospects is mica gneiss, which in places contains fibrolite. The gneiss is strongly crinkled and has an approximately northeast strike and a vertical dip.

In the prospect on the brook a face 12 feet high had been opened in a deposit of pegmatite. Part of the pegmatite is rather fine grained and part is rather coarse grained, containing crystals of orthoclase feldspar more than 2 feet thick and irregular masses of quartz of about the same size. Most of the crystals of mica exposed were small, but one was 10 inches across though it was ruled into smaller pieces. The mica has a fine clear rum color. Among other minerals of the pegmatite were biotite, black tourmaline, lithiophyllite, and arsenopyrite or löllingite. A mass of lithiophyllite 8 inches across containing numerous patches of arsenopyrite was exposed in the pegmatite.

In the prospect on the mountain side a large body of pegmatite has been opened without exposing the wall rock. The crystallization is very coarse, some of the orthoclase crystals measuring as much as 3 feet across. Except for surface staining, the mica is of good quality and has a clear rum color. The largest crystals seen were 8 inches in diameter.

Several ledges of pegmatite are exposed on the summit of the knob. The crystallization is in places fairly coarse, the rock containing large crystals of orthoclase and segregations of quartz. The ex-

posures of mica are not unusual, for similar outcrops occur elsewhere in the region, but they may be worth prospecting.

UNION MINE.

The mine of the old Union Mica Co. is about 1 mile N. 10° E. of North Groton, on the eastern side of Bailey Hill. It ceased operations about 1888, and since then it has been idle and has become overgrown with brush and saplings. The workings consist of an open cut in the edge of a bench on the hillside about 150 feet long, 10 to 18 feet wide, and 5 to 35 feet deep, with a shaft, drift, and stopes in the bottom. The open cut is filled with rubbish and water to a depth of 20 feet. The shaft was 50 feet deep. Rock at first was carried from the open cut in a car to the lower dump, but later it was hoisted from the open cut up an incline track and carried northward to a higher and larger dump. The shape of the workings is shown in figure 30.

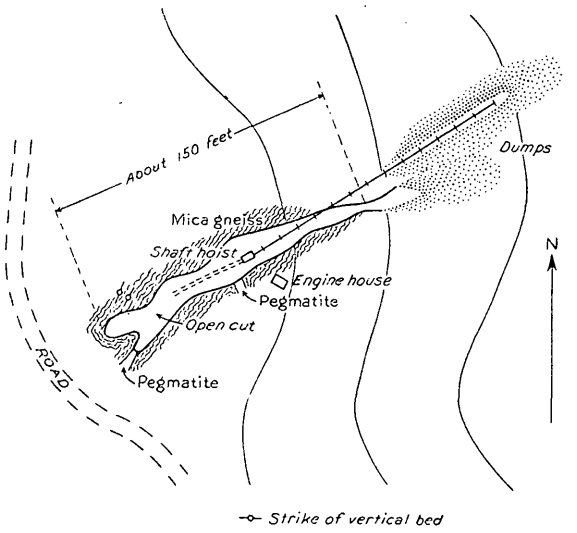


FIGURE 30.—Plan of Union mica mine, 1 mile N. 10° E. of North Groton, N. H., showing part of geology.

The country rock is mica gneiss, which in some places contains fibrolite. It has a general northeast strike and an approximately vertical dip, and shows local contortions and crumplings, especially around the pegmatite. The pegmatite, which cuts the gneiss irregularly, strikes N. 60° E. and has a vertical dip. It varies considerably in thickness, pinching and swelling from 10 to 18 feet. The pegmatite pinches out abruptly at the southwest end of the cut, where the gneiss is folded around it. In the fork at the south end the pegmatite is 5 feet thick at the surface and 3 feet thick at a depth of 15 feet. Little of the pegmatite is exposed, but a study of the dumps shows that white quartz was encountered in large masses. Only a small proportion of pure orthoclase was removed in mining, most of the feldspar being plagioclase. The mica is of good quality, has a fine clear rum color, and is reported to have been plentiful in the "vein" and to have carried many large crystals.

About 300 yards southwest of the Union mine a series of prospects were opened on a large pegmatite outcrop extending about 100 yards to the Holden property, near the summit of the hill. Some of the outcrops of mica are fairly promising.

HOLDEN MINE.

A prospect was opened in 1914 on the property of Mrs. C. A. Holden, 1 mile N. 35° E. of North Groton. In October, 1914, two prospect pits about 70 feet apart from east to west had been dug on a hillside. Around the west pit the surface had been stripped of soil over an area about 35 feet square, the stripping exposing pegmatite composed of coarse crystals of feldspar, massive quartz, and crystals of muscovite and biotite mica, some intergrown, with parallel cleavage. The muscovite has a fine clear rum color. Other prospects have been located on the same property.

STINSON AND CRAIG PROSPECTS.

An outcrop of pegmatite on the land of W. D. Stinson, 1½ miles northwest of North Groton, contains numerous crystals of mica. This ledge crops out for 250 yards N. 20° E., extending from the public road up a low hill and along a glaciated ridge. Through most of the outcrop the pegmatite ranges in thickness from 4 to 25 feet, pinching and swelling approximately in conformity with the schistosity of the inclosing fibrolite mica gneiss.

The pegmatite contains irregular segregations of quartz, some of them 2 feet thick, and large crystals of orthoclase feldspar. It includes also horses of gneiss. A few rough crystals of beryl were seen. The mica occurs in bunches of crystals, chiefly near the segregations of quartz. Some of these crystals measure 4 inches in diameter.

Two prospects have been located on the land of George Craig, a quarter of a mile west by south of the Stinson prospect. At one of these prospects an open cut 50 feet long, 5 to 10 feet deep, and 10 to 20 feet wide has been made in a southwesterly direction up a hill slope. The pegmatite is, in places, 40 feet thick and contains numerous segregations of white quartz and some orthoclase crystals as much as 2 feet across. Small crystals of mica are plentiful, and some bunched or solid mica was observed.

CHARLES DAVIS MINE.

The Charles Davis mine, two-thirds of a mile west of North Groton, was worked by the Belden Mica Co. The workings consist of an open cut 100 feet long, 12 to 18 feet wide, and 15 feet deep, driven southwestward into a hillside, and a shaft at the southwest end of the cut. The country rock is fibrolite-mica gneiss, which strikes

N. 45° E. and dips vertically. The pegmatite is conformable with the gneiss. It is the full width of the open cut except near the southwest end, where it pinches to 4 feet and passes under a cover of soil. The pegmatite is rather even in texture and contains segregations of quartz about a foot thick and crystals of feldspar several inches across. The mica, which was richest near the walls, occurs throughout the mass and is of good quality but was not obtained in sizes and quantity sufficient to pay the rather high cost of mining. Specimens of blue lazulite without crystal form were found in fragments of pegmatite on the dump. This is an unusual occurence, for the ordinary matrix of this mineral is quartzite, kyanitic schist, or some other metamorphic rock.

MICA PRODUCTS CO.'S MINE.

Two deposits of mica a mile west of North Groton were opened in 1913 by the Mica Products Co., of Philadelphia. At one of these an open cut was being made southwestward into a steep hillside for a height of about 45 feet. The cut was carried back into the hill by benches and the waste rock was rolled to the bottom and carried off in mine cars to the dump. The country rock is mica gneiss, in places carrying fibrolite. It is cut by pegmatite striking N. 48° E. and dipping about 80° NW. The pegmatite ranges in thickness from 8 to 16 feet and averages more than 12 feet. The mica is richest near the middle of the vein, but some is scattered through other parts of it. Much of the mica is rather small but of fine stove quality. It is of a beautiful clear rum color in sheets one-tenth of an inch thick. One crystal was found that weighed 24½ pounds and would cut into sheets more than 6 inches square.

The other deposit lies a couple of hundred yards north and was being prospected by small cuts in an outcrop of hard pegmatite about 50 feet wide. The pegmatite is inclosed in mica gneiss or schist and has a strike of N. 45° E. and a vertical dip. The mica obtained here has been exposed to the weather and is not so sound as that from the other working. It might improve with increase in depth, if the quantity is sufficient to pay for development. Crystals of pale-green beryl were found, parts of which were clear enough for use as gems.

PALERMO MINE.

The Palermo mine (formerly called the Hartford) is about 1½ miles southwest of North Groton in one of the ridges on the northeast side of Bald Head Mountain. This mine is one of several large producers of mica that have been worked extensively in New Hampshire. It had long been idle until it was purchased by the General Electric Co. which started reworking the dumps and made an examination of part of the underground workings. To make this

examination the mine was unwatered to a depth of nearly 150 feet below the highest workings, or 60 feet below the bottom of the open cut. The trouble with water was not great, for a 5-horsepower gasoline engine removed about 60 feet of water. In two weeks after pumping was stopped the water had risen only 10 feet and this was the condition of the mine at the time of the writer's visit, in October, 1914.

A description of this mine has already been published[54] from notes obtained during a previous examination, when the mine was

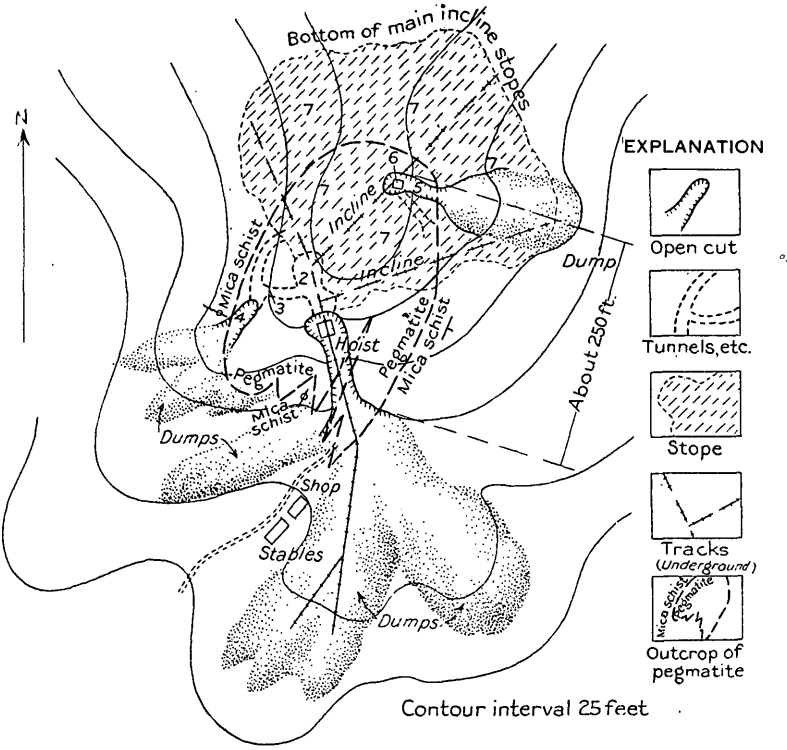


FIGURE 31.—Plan of Palermo mica mine, 1½ miles southwest of North Groton, N. H., showing geology. See text for explanation of numbers.

idle and filled with water, and from information furnished by Mr. L. R. Brown, of Canaan, superintendent of the mine for nearly 20 years during the previous operations. A few changes have been made in the description and diagram used in the previous report as a result of better information obtained during the last examination.

The mine is in a knob that projects southward from the end of a small ridge. The workings consist of an open cut (1, fig. 31) 100

[54] Sterrett, D. B., Some deposits of mica in the United States: U. S. Geol. Survey Bull. 580, p. 72, 1915.

feet long, 40 feet deep at the end, and 20 to 30 feet wide, driven N. 10° W. into the knob. The bottom of the cut is about 90 feet lower than the summit of the knob. At the end of the cut there is a large tunnel or room (2), 50 feet long, with deep inclined stopes (7) extending from it to the northeast and east and a drift with stopes extending upward to the north; an upraise (3) connects with workings from the outcrop about 50 feet higher and to the west, where an open cut (4) 30 feet long has been made with drifts and stopes carried underground from it. Another open cut (5) 40 feet long and 35 feet deep had been made northeast of the main lower open cut and about 40 feet higher. From this open cut (5) an inclined shaft (6) was sunk that connected with the main stopes (7) of the mine at a depth of 4 feet below the bottom of the main open cut (1).

Incline tracks were run eastward and northeastward into the stopes and another track was run northward into the drift. A view from the entrance to the large room (2) looking northeastward down into the stopes (7) is shown in Plate XVII, *B* (p. 108). At the time of examination the greater part of the vein was stoped out from above the drift to the east to a depth said to be more than 300 feet, on an incline of about 35°. The mine had been stripped of all but a few pillars and was dangerous. One room stoped out was at least 60 feet long, 30 feet wide, and 35 feet high, and was without support or pillar. Hauling and hoisting were done by an engine in the inner end of the main open cut. All drill work was done by hand, mostly with single-hand drills. At one time 85 miners were employed and 25 or 30 girls were kept busy sorting and trimming mica.

At the time of examination deeper mining had not been undertaken by the General Electric Co., but a stope that was extended back to the southeast end of the large room (2) located a promising pocket of mica, and work was probably continued there. Other operations were confined mainly to the dumps, which cover more than 2 acres of ground, to depths ranging from a few feet to 30 feet or more. Part of them have already been worked over, but a number of the older dumps are still untouched.

The country rock is fibrolite-mica gneiss and lumpy or porphyritic biotite gneiss, in which the lumps are composed almost entirely of bunches of muscovite mica. The strike and dip of the gneiss measured near the mine vary widely, owing to distortion during intrusion of the pegmatite. The pegmatite cuts across the country rock in a large, irregular-shaped mass, whose approximate outcrop is shown in figure 31. This outcrop indicates an oval or pipe-shaped deposit, but the workings below ground show that it has a greater elongation north and south on an east dip. The rock is so resistant that its outcrop forms a small knob on the end of the ridge. The texture of the

pegmatite is varied and is in places extremely coarse. Feldspar occurs in crystals and masses several feet across, and some of the irregular segregations of quartz are large. In places the "vein" carries much small mica mixed with feldspar and quartz. Large crystals of mica are reported to have been found in pockets through the vein, one crystal measuring 4 feet 2 inches long and 28 inches wide and another fine crystal with sharp prismatic outline and fairly smooth faces measuring 2 feet square and 2 feet thick. The mica has a beautiful clear rum color and good cleavage. The dumps from early mining will yield some small plate mica of good quality and a large quantity of mica of punch size.

Among interesting specimens found on the dumps were beryl and zinnwaldite mica. The beryl was mostly opaque and some crystals were 3 inches across. They were bluish to yellowish green, with translucent and small transparent portions here and there. One crystal of rough mica less than an inch across found on the dump was determined to be zinnwaldite by W. T. Schaller, of the United States Geological Survey. The sheets of this mica show a clear brown core and a greenish-blue exterior about the color of some indicolite tourmaline. These colors are arranged parallel to planes of crystallization, and the blue contains thin zonal growths of the brown. Mica with the two colors gives the reactions of zinnwaldite.

INDIA MICA CO.'S MINE.

The India Mica Co.'s mine is in the southeast corner of the town of Dorchester, near Bryant Pond, about 5¾ miles N. 40° E. of Canaan. The mine was closed in 1906 after several years of active operation. It had a good equipment, including camp, engines, and machinery. Two principal openings were made—an open cut 70 feet long and 20 feet deep north of the engine house and a cut 50 feet long opening into a stope 50 feet deep south of the engine house. Pillars were left in this stope and five tiers of floors were built with stulls and lagging. An inclined track extended from the engine house down into the stope for the removal of mica and waste rock.

The country rock is quartz-biotite schist, which strikes N. 20°–35° E. and has a steep west to vertical dip. The schist near the pegmatite contains much black tourmaline in small crystals. The pegmatite is approximately conformable with the inclosing schist. In the north working the formations have been kinked or folded. The pegmatite is in the main from 6 to 10 feet thick, and the entire thickness was removed in mining at the southwest end of the mine. At the surface the pegmatite bulges to 12 feet in thickness but is poor in mica. At 50 feet below the surface the vein, it is reported, pinches down to 12 inches in thickness. The texture of the pegmatite

appears to be rather even. The feldspar is mostly oligoclase and was not found in very coarse crystals. The mica has a clear light-rum color, and part of it is of good quality. It occurs in crystals, some of which weigh 50 pounds. In the folded part of the pegmatite many of the mica crystals are twisted and of poor quality.

Two hundred yards north by west of the mine a prospect was opened on an outcrop of pegmatite 15 feet thick. Mica, most of it small, was found associated with large segregations of quartz. The pegmatite contains also black tourmaline.

During the earlier days of mining by the India Mica Co. the mica as it came from the mine was hauled to Canaan and there graded for

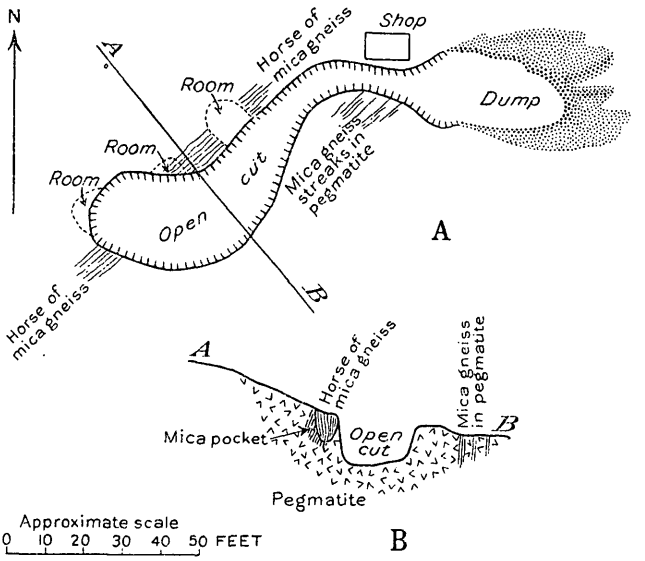


FIGURE 32.—Plan (A) and cross section (B) of Keyes mica mine, 4¾ miles northeast of Canaan, Grafton County, N. H., showing part of geology.

shipment. Later a plant was set up in Canaan and the mica was rough trimmed for the market.

KEYES MINE.

The Keyes mica mine is 4¾ miles N. 50° E. of Canaan, in the town of Orange, on the east side of the north end of Tugg Mountain. The principal working was an open cut of about the shape shown in the rough plan in figure 32, and 5 to 18 feet deep. Most of the open cut was in pegmatite, but streaks or horses of the biotite mica gneiss country rock were encountered at the places shown. The full thickness of the pegmatite was not exposed but is probably at least 50 feet with the mica gneiss inclusions. One large horse of gneiss is 10 feet thick but does not extend far into the pegmatite, as shown in the cross section (fig. 32). The inclusions all strike northeast, which is probably also the trend of the pegmatite. The texture of

the pegmatite is coarse in places, the feldspar crystals measuring a foot or two across. The mica is somewhat pocketed and appears to be richest near the contact with the mica gneiss. At the bottom and on the west side of the large horse of mica gneiss good mica has been left in the pegmatite. The mica has a clear light-rum color and some of it is of good quality. The pegmatite carries beryl, pieces of which were seen on the dump, and one crystal 8 inches across had been left in the rock. A few rough quartz crystals were removed during mining, but most of the quartz is massive.

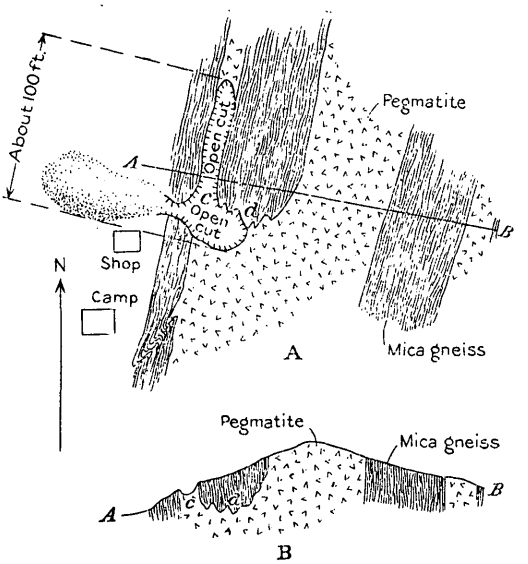


FIGURE 33.—Plan (A) and cross section (B) of Sanborn mica mine, 3¼ miles N. 70° E. of Canaan, Grafton County, N. H., showing geology.

SANBORN MINE.

The Sanborn mica mine is on Tugg Mountain, about 3¼ miles N. 70° E. of Canaan. It has not been operated for three years. The developments consist of an open cut of the shape shown in figure 33, A. This cut is about 100 feet long, with an enlargement at the south end, and is 10 to 20 feet deep. The country rock is a highly foliated mica gneiss containing quartzose and micaceous layers and both biotite and muscovite. The gneiss strikes N. 10°–20° E. and has a high dip to the east. Several masses of pegmatite, whose surfaces have been rounded by glacial erosion, crop out on the summit of the hill. These masses are in part conformable with the inclosing gneiss but in places cut across its bedding. The mica has been obtained from a small body of pegmatite about 10 feet thick, which has branched out from a large mass of pegmatite into the surrounding gneiss and from around the end of the body of mica gneiss that is included between the fork and the main mass of the pegmatite. The inclosed body of gneiss is about 60 feet thick, and at the south end the contact has a pitch to the north of about 35°. Details of this contact between *c* and *d* of figure 33 are shown in Plate XVIII, *A* (p. 109). The horse of mica gneiss overlies the pegmatite unconformably, as seen on the right. The pegmatite is the lighter-colored rock rising above the water. The cross section in figure 33, B, shows the relations between the pegmatite and gneiss. The pegmatite has an un-

even texture and in places contains segregations of quartz. More mica is exposed in the outcrop south of the open cut near the contact of the pegmatite at a place where the mica gneiss has been crumpled by folding. The mica seen around the mine was of fair quality, some having a clear rum color and some a slightly greenish cast.

BELDEN OR STANDARD MINE.

The Belden or Standard mine is on the south end of Tugg Mountain, 3 miles N. 75° E. of Canaan. It has been operated by several persons and companies and worked by the Standard Mica Co. on an extensive scale. The last work was done by C. W. Bryant, of Lebanon, in June, 1913. At that time the mine consisted of an irregular-shaped open cut or quarry about 250 feet long in a northerly direction, about 200 feet wide, and from 10 to 45 feet deep. Another smaller open cut had been made to the south of the main quarry. The position of the openings, mine buildings, tracks, dumps, etc., is shown in figure 34. The quarry was worked to different levels in benches. At the south end of the main quarry two short tunnels were made. A view looking southwestward across the open cut is shown in Plate XVIII, *B* (p. 109).

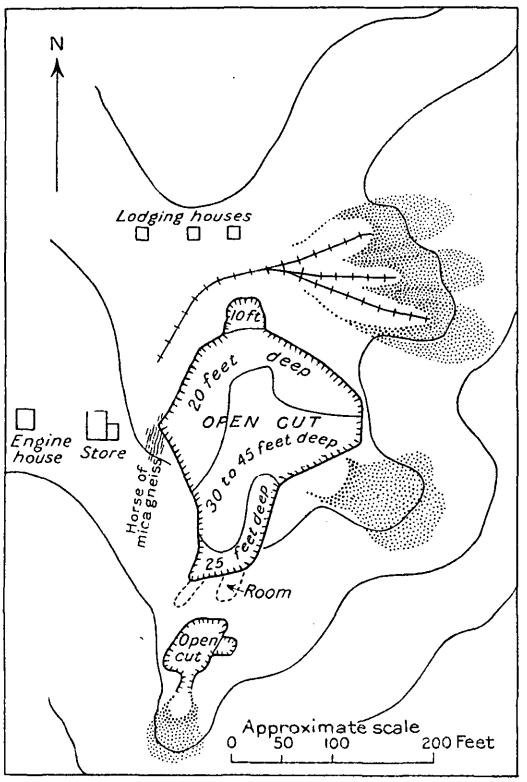


FIGURE 34.—Plan of Belden or Standard mica mine, 3 miles N. 75° E. of Canaan, Grafton County, N. H.

The country rock is mica gneiss composed of quartzose layers and layers rich in biotite and muscovite. The pegmatite is a very large mass whose relation to the country rock is not exposed. The impression gained by examination of the workings is that of a thick bed with a northerly strike and a dip of 20°–30° E., but it is possible that the dip is more nearly vertical. The open cut is wholly in pegmatite except for a small horse of mica gneiss on the west side. This gneiss has been strongly metamorphosed and contains black tour-

maline. It appears to merge into the pegmatite. The pegmatite varies in texture and in places is very coarse. Feldspar crystals 1 foot to 3 feet thick were seen, and quartz occurs in irregular segregations and veins, in one place 7 feet thick. Beryl crystals are rather common, and the mica and beryl are most plentiful around the quartz masses. In general the mica is rather pockety, but a few crystals occur scattered through the pegmatite, and to insure the recovery of all this mica the whole of the pegmatite was mined by the Standard Mica Co. This proved to be an extravagant method. The later work by Mr. Bryant was directed only toward those parts of the pegmatite found to be richest in mica.

The pegmatite is composed of two kinds of feldspar, microcline and albite. In places the microcline has formed a rough graphic intergrowth with quartz. Some of the albite occurs in rough crystals almost of the clevelandite type. Black tourmaline, bluish-green apatite, and opaque garnets are scattered through the pegmatite. The largest crystals of beryl are 10 inches in diameter and 12 inches long. Probably several tons of rough opaque crystals could be gathered up around the mine. Most of the mica is small, less than 4 by 6 inches, but sheets 8 by 10 inches are reported to have been cut from the largest crystals. The mica is of fair quality, showing shades of both rum and green colors.

Other mica prospects have been tested on the same property, one 150 yards southwest, another about 300 yards southwest, and another 250 yards north-northwest of the main mine. At the first of these the pegmatite is at least 40 feet across and carries a quantity of small mica. Along the west contact of the pegmatite the gneissic wall rock merges into the pegmatite as if by a fusion contact. At the second place an open cut 50 feet long was made on a vein of pegmatite 2½ to 6 feet thick, and another cut 45 feet long on another vein 1 foot to 4 feet thick, lying 60 feet to the west. These veins of pegmatite are in part conformable with the inclosing gneiss, but one of them has a branch or fork cutting across the foliation.

HOYT HILL MINE.

The Hoyt Hill mine is 3 miles S. 75° E. of Canaan, near the summit on the west side of Hoyt Hill. The working consists of an open cut or shaft 20 feet across and reported to be about 50 feet deep, inclined to the north. It was filled with water at the time of examination, and only surface conditions could be studied. The country rock is mica gneiss composed of biotite and muscovite schists containing quartzose layers. Some of the layers contain black tourmaline. The schist layers of the gneiss are in places strongly folded and crumpled and inclose lenses and streaks of quartz, pegmatite,

and granite. The strike is N. 30°–40° E. and the dip is rather variable. The pegmatite cuts through the gneiss in the form of a stock or pipe. On the northeast side the pegmatite forks out into the gneiss. On the east side the gneiss has been crumpled by the intrusion of the pegmatite. Among the minerals observed on the dump were pinkish plagioclase feldspar, black tourmaline, and green apatite. The mica has a clear rum color, and crystals of good size are said to have been obtained.

PROSPECT NEAR ORANGE.

A mica deposit was worked on the road from Orange to Alexandria, about 3½ miles east of Canaan and half a mile southeast of Orange. Two open cuts and a short tunnel were dug. The cut near the road is reported to have been 30 feet deep but is now filled up. The one to the north is about 15 feet deep but is filled with water. The country rock is mica gneiss containing streaks of fine biotite schist. It strikes N. 10° E. and stands vertical. The pegmatite is irregular in shape and was not found in the northern open cut in line with the strike shown by the work near the road. Black tourmaline is plentiful in the pegmatite and occurs in crystals 4 inches in diameter. Very little mica had been left around the mine.

SUMMMIT MICA MINING CO.

A mica prospect was opened about 25 years ago by the Summit Mica Mining Co. near the north edge of the town of Grafton, on the east side of the railroad, about 3 miles north of Grafton Center. No work had been done for many years prior to the time of examination, in October, 1914, and little could be seen then. An open cut 35 feet long, 10 to 18 feet wide, and 10 feet deep to water had been made in a large pegmatite ledge that crops out for 150 feet east and west across swampy ground. This outcrop is 40 to 100 feet wide and stands 10 feet above the surrounding swamp. Most of the feldspar is albite. Small crystals of clear, light rum-colored mica were seen in the walls of the cut.

GRAFTON MICA WORKS.

The mine of the Grafton Mica Works is about 2 miles north by west of Grafton Center on the east side of the same mass of hills to which Isinglass Mountain belongs, at an elevation of about 1,150 feet above sea level. The workings consist of several open cuts and a tunnel in a spur projecting northeast from the mountain side. One cut is about 30 feet square and from 5 to 10 feet deep and another is 40 feet long, 8 feet wide, and 30 feet deep in the inner end.

The other openings are smaller. The openings on the ridge are about 60 feet higher than those in the tunnel below. The country rock is biotite gneiss and carries abundant fibrolite in some beds and black tourmaline near the pegmatite. In the tunnel the gneiss strikes N. 30° E. and dips 65° SE. The mass of pegmatite is large, possibly 200 feet across the outcrop. Its relation to the gneiss is not well exposed, but the southeast contact strikes about N. 30° E. and dips steeply. The texture of the pegmatite ranges from medium to very coarse grain. Masses of solid mica from 2 to 4 feet thick were seen in three places. Quartz occurs in segregations several feet across. The mica is reported to have been found in bunches or pockets several feet across, but none of these was left exposed in the working faces. Among the associated minerals black tourmaline and a few small crystals of beryl were observed.

RUGGLES NEW HILL MINE.

The Ruggles New Hill mine is 1¾ miles N. 20° W. of Grafton Center, in the north end of a small ridge on one of the summits of Isinglass Mountain, at an elevation of about 1,375 feet above sea level. The mine was in operation when the atlas was prepared for Hitchcock's "Geology of New Hampshire," published in 1878, but was closed soon after that time, and but little work has been done since. The earlier work was all open quarrying, but a little tunneling was done later. The principal work consists of an open cut 40 feet square, now filled to within 10 feet of the surface with rubbish. The last work in this cut consisted of a heavy blast which broke off great blocks of country rock from above that fell into the cut and concealed the working face. Three other large open cuts were made on the hillside about 150 feet southeast of the main cut, but the relations between the "vein" and the wall rock were not well exposed in these cuts either. The country rock consists, in part at least, of granite, which forms a cap rock over the pegmatite at the main quarry. The mine is reported to have yielded mica of fine quality and good sizes in the earlier workings, but later did not produce mica so good. The mica has a light rum color and good cleavage.

RUGGLES MINE.

The Ruggles mine is in the south end of Isinglass Mountain, about 1⅓ miles northwest of Grafton Center, at elevations ranging from 1,300 to 1,450 feet above sea level. The workings cover a large area on a steep mountain side. They start from a break at the base of a steep slope and extend up nearly to the summit of the mountain, about 150 feet higher. The early workings consisted entirely of open quarries in the steep slope. These quarries were large, but some of

the lower ones are now covered by the dumps from those above. The later workings consist of large tunnels and stopes driven back into the mountain. Two sets of these have been made, one near the bottom of the steep slope and the other more than 100 feet higher and slightly east of the lower one. The dumps from the upper tunnels cover much of the old quarry workings, and these and the thick growth of vegetation over much of the hill make a careful study of the old part of the mine impossible. The dumps from the workings are extensive and contain a large quantity of mica that is now merchantable. The relative positions of the workings in the hillside are shown in figure 35.

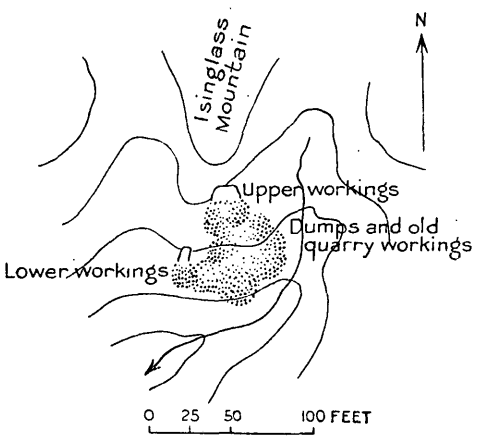


FIGURE 35.—Sketch showing relative position of upper, lower, and old workings and dumps of Ruggles mica mine, on the south end of Isinglass Mountain, Grafton County, N. H.

The upper workings consist of three partly connected open cuts from which tunnels are driven back into the mountain. The open cut on the west is 15 or 20 feet lower than the others. Two large, irregular tunnels open into each other at intervals and form spacious rooms with down stopes on the west side. These tunnels are about 150 feet long and might be considered one large tunnel with pillars left near the middle. Rooms 40 feet across and 20 feet high without support were made at two places, and into these rooms great blocks of rock have fallen from the roof. Views of the upper workings are shown in figure 36.

The lower workings consist of an open cut about 100 feet long, 50 feet wide, and 25 feet deep in the inner end, with a tunnel and stopes driven about 160 feet farther. The workings have been cut back in a general northerly direction, as shown in figure 37. The inner end of the raised stope is more than 30 feet higher than the mouth of the tunnel. The main tunnel is really a large stope containing rooms 25 feet high.

The country rock is mica gneiss in which biotite schist is prominent. Its banding is due chiefly to other layers, especially layers rich in quartz. Crystals of fibrolite were observed in the gneiss on other parts of Isinglass Mountain. Near the pegmatite the gneiss is more or less contorted and contains much black tourmaline. The country rock strikes N. 10°–20° E. and has a prevailing high easterly dip with local variations ranging from 60° E. to 70° W. around

the pegmatite intrusions. The mass of pegmatite at the Ruggles mine is large and is presumably all part of the same intrusion. In the upper workings the pegmatite occurs as a large dome-shaped mass cutting across the gneiss, as shown in figure 36. On the sides the dip of the contact is steep and approximately conformable with the schistosity of the inclosing rock. The contact of the dome-shaped mass of pegmatite is irregular and pitches 20° S. in the workings on the surface. Back in the tunnel the pitch is lower, approaching the horizontal. Horses of tourmaline-biotite schist are inclosed in the pegmatite. Large segregations of quartz occur both in the open cut and in the tunnels. Large bodies of pegmatite rich in mica were evidently found where the stopes and rooms are large, and in some places good mica was left in sight in the pillars and walls. At least part of the feldspar in the mine is albite, and if there are other varieties they were not observed.

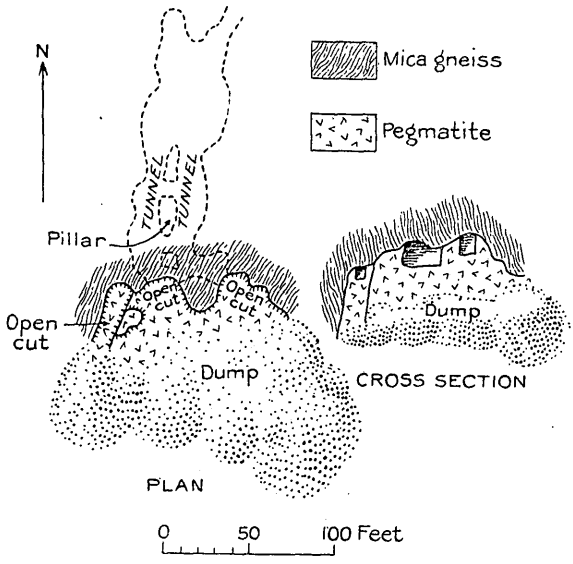


FIGURE 36.—Plan and cross section of upper workings of the Ruggles mica mine, Grafton County, N. H., showing geology.

In the lower workings the pegmatite has a high dip to the west on the west wall, but elbows off abruptly to the east, cutting the bedding of the gneiss over the open cut, as shown in figure 37. A small body of fine-grained biotite granite cuts the pegmatite and gneiss on the east side of the cut, and from this point eastward the contract of the pegmatite is concealed. The contact of the gneiss and pegmatite over the workings pitches southward, or rises as it is followed back into the mountain. A horse of tourmaline gneiss is inclosed in the pegmatite at the place where the raised stope leaves the tunnel. Large masses of quartz occur in parts of the pegmatite, and one exposed in the bottom of the open cut (fig. 37) is about 20 feet thick. A body of solid mica about 35 feet long, with a maximum width of 6 feet, lies on the west side of the quartz. This body of mica is composed of many crystals that measure from half an inch to 2 inches in diameter, grown together at all angles. In the tunnel and stope a

number of crystals of mica have been left exposed in the rock. Some of these crystals measure from 1 foot to 2 feet across but have been partly ruled into small sheets.

In some of the old quarry workings east and northeast of the lower workings and below the upper workings exposures of pegmatite show large quartz segregations and masses of feldspar with or without mica. At one place an empty cavity or pocket 2 feet in diameter was exposed in a face of pegmatite. The bottom of this pocket was lined with clusters of well-formed crystals of muscovite, the largest 2 inches in diameter. Contacts of pegmatite and gneiss were observed at two places in the old workings.

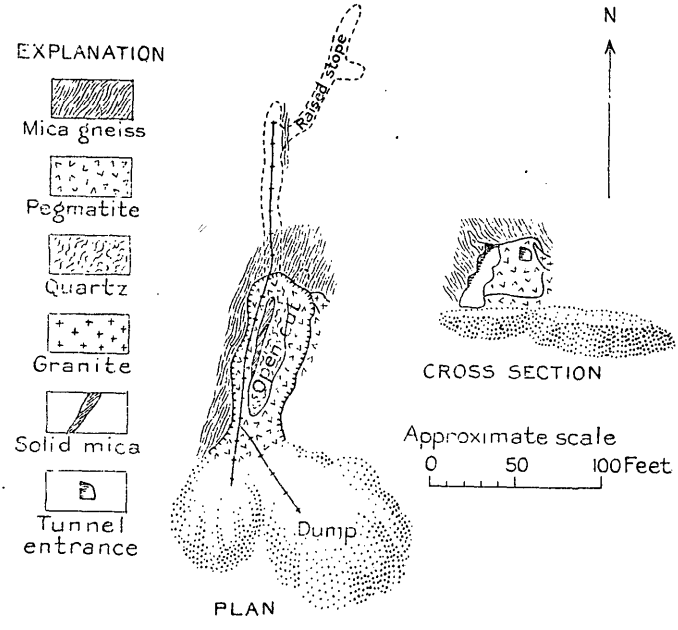


FIGURE 37.—Plan and cross section of lower workings of the Ruggles mica mine, Grafton County, N. H., showing geology.

The relation between the pegmatite in the upper, lower, and old quarry workings is not plainly visible, but the main mass of the pegmatite doubtless crops out in the area of old quarries and dumps, and the lower and upper workings are probably along the hanging wall of the deposit. The hanging-wall contact has a series of vertical stretches with nearly flat offsets to the east, so that it crops out northeastward around the mountain side and over the top of the mountain northeast of the upper workings. The contacts observed in the old quarries may be those of inclusions or horses of gneiss in the pegmatite.

The dumps covering the old workings are large, one of them forming a steep talus slope about 100 feet high. These dumps contain some

valuable mica that was once thrown away as waste, not only a large quantity of scrap mica suitable for grinding, but sheet mica ranging from punch size up to sheets that will cut 3 by 4 inches. Since 1912 a part of the dumps have been worked over each year by a crew of several men. Unless a large force of men is employed it will take many years to work the dumps over thoroughly. The mica in these dumps is of good quality, not having deteriorated much by its long exposure to the atmosphere. The mica from the Ruggles mine has a clear rum color and good cleavage. Some is quite flat and the remainder has slightly bent or curved cleavage faces.

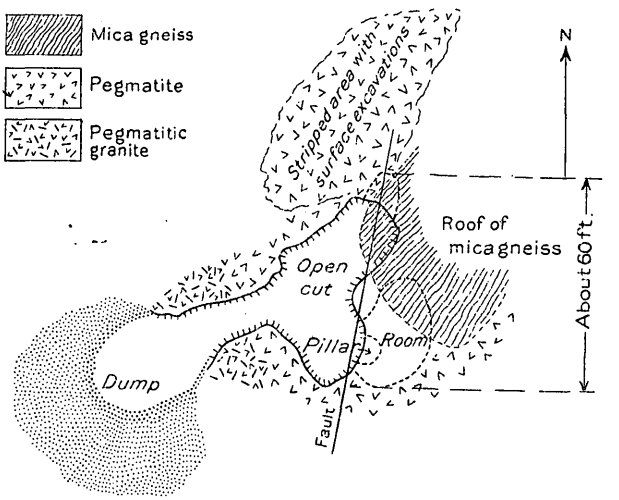


FIGURE 38.—Plan of Kilton mica mine, near Grafton Center, Grafton County, N. H., showing geology.

KILTON MINE.

The M. M. Kilton mine is 1 mile N. 50° W. of Grafton Center (Cardigan railway station). It has been in operation in a small way for a number of years, and at the time of examination the prospects for opening a good deposit of mica were bright. The mine is in a steep hillside at the south end of Isinglass Mountain, about a third of a mile south of the south end of the Ruggles mine. The workings consist of an irregular open cut about 25 feet deep with rooms from its sides and a stripped area with surface excavations on the hill above. The relations are shown in the rough sketch in figure 38.

The country rock is mica gneiss composed of beds of schist containing variable quantities of biotite, muscovite, and quartz as principal constituents, with accessory minerals. The gneiss strikes north by east and has a nearly vertical dip. The pegmatite body is large and varied from coarse-grained rock in the deeper workings to fine pegmatite granite carrying black tourmaline southwest of the mine. The excavations have developed a mass or roof of mica gneiss covering a part of the pegmatite on the east side of the mine. The lower contact between the pegmatite and the gneiss is approximately horizontal, with small rolls, but it is not conformable with the foliation of the gneiss. A small normal fault trending N. 10°

E. and dipping 80° W., with a 3-foot downthrow to the west, cuts through the workings, as shown in figure 36. A view looking east by north in the open cut is given in Plate XV, *B* (p. 108). The light-colored rock in the pillars is pegmatite and the darker rock overlying it is mica gneiss. The fault plane indicated in figure 36 is seen in the roof above the two men on the left. The mica occurs in streaks and pockets, and in the room at the north end of the open cut a large pocket or bunch of crystals was being removed at the time of examination. These crystals were 2 feet or less in diameter but were rather thin, some measuring only 2 or 3 inches. The quality of the sheet mica is good. Among the associated minerals of the pegmatite are black tourmaline (in crystals, some 4 inches in diameter), massive yellow beryl, and garnet.

EUREKA MINE OF M. M. KILTON.

A deposit of feldspar was opened under lease by the Eureka Mining & Milling Co. on the land of M. M. Kilton, at the north end of Ford Hill, 1¼ miles west of Grafton Center. Some mica was found in the quarrying for feldspar but was reserved by Mr. Kilton. The deposit is on a steep north slope, about 1,450 feet above sea level. An open cut about 40 feet long, 25 feet wide, and 35 feet deep in the deepest part had been made in the hillside at the time of examination, in October, 1914. The rock is removed in a mine car and the feldspar emptied into wagons held in readiness or dumped on storage piles.

The country rock is mica gneiss, which in some beds carries fibrolite. It has a variable strike, ranging from east by north to northeast, and a dip of about 35° SE., but it has been locally distorted by the intrusion of the pegmatite. The pegmatite, which is approximately conformable with the bedding of the inclosing gneiss, swells from a thickness of about 15 feet at each end of the open cut to more than 20 feet near the middle. The feldspar occurs in large, fairly pure masses and contains only a small quantity of intermixed or graphically intergrown quartz. A little mica is scattered through the pegmatite, but most of it occurs as crystals in a streak 2 feet thick that lies about parallel with and 3 or 4 feet from the hanging wall. The largest of these crystals are 2 feet across, but they have been badly crushed and ruled into smaller pieces. The mica has a clear light rum color but is not of very good quality.

A promising exposure of feldspar has been opened in another cut about 75 feet northeast of the main working. The pegmatite exposed here contains a larger proportion of quartz than that in the larger cut but is of marketable grade.

ALGER MINE.

The Alger mine is 1 mile S. 80° W. of Grafton Center near the summit of Alger Hill, at an elevation of about 1,500 feet above sea level. It is an old mine, worked first about 1875 by J. E. Martin and J. B. Page and later by the Grafton Mica Co. No work had been done for nearly 30 years prior to the examination in October, 1914, and the mine was then thickly covered with brush. The workings consist of an open cut about 120 feet long, 30 to 45 feet wide, and 5 to 30 feet deep, with a room and stope on the north side and two small cuts on the south and southwest. (See fig. 39.)

The country rock is rather fine to medium grained biotite granite, which in places shows a gneissic structure. The gneissic phases strike N. 10° W. and have a nearly vertical to steep east dip. The pegmatite occurs as a bulging mass in the granite, starting with an outcrop about 20 feet thick at the northeast end of the cut and increasing in thickness southwestward to nearly twice the width of the open cut. The general relations between the pegmatite and granite are shown in figure 39. The pegmatite is coarse grained and contains masses of quartz several feet thick and orthoclase crystals 6 feet across. Among the associated minerals are black tourmaline and beryl. The quartz ranges from opaque white to smoky and some is translucent. A few fragments of beryl crystals were seen on the dump, and the mine is reported to have yielded the largest beryl crystals in the world. F. W. Clarke[55] states that one crystal weighed more than 2 tons. Large crystals of mica were evidently found, for a remnant of one crystal that measured 2 feet in diameter remained in the wall. Several tons of scrap mica had been left around the mine, a little of which was suitable for cutting into small sheets or punching. The mica has a clear light rum color and a good cleavage.

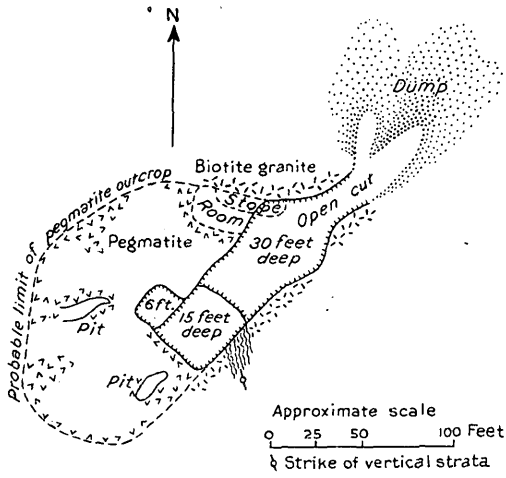


FIGURE 39.—Plan of Alger mica mine, near Grafton Center, N. H., showing geology.

[55] Mica: U. S. Geol. Survey Mineral Resources, 1883–84, p. 907, 1885.

GAGE MINE.

An old mine owned by Fred Gage, on the northeast side of Prescott Hill, 2½ miles S. 85° W. of Grafton, was last worked 20 years ago, and the workings were covered with vegetation when examined in October, 1914. An open cut 50 feet long, 18 feet wide, and 15 feet deep was made in a northeasterly direction along the hillside and a crosscut trench extending southeastward from it. The country rock is biotite granite gneiss. The mass of pegmatite is large and only its southeast wall is exposed. This strikes N. 35° E. and dips 50° NW. Much massive quartz is piled on the dump. The feldspar is the potash variety, and it is reported that a quantity was shipped for use in making pottery. A little biotite was seen. The mica is light greenish, and part of it is heavily ruled. Crystals as wide as 12 inches, left in the rock, were cut by ruling lines into small pieces. In one place a mass of solid mica, composed chiefly of mica crystals from one-eighth to 1 inch across, is exposed in the walls of the cut. The large mica seemed richest near the footwall.

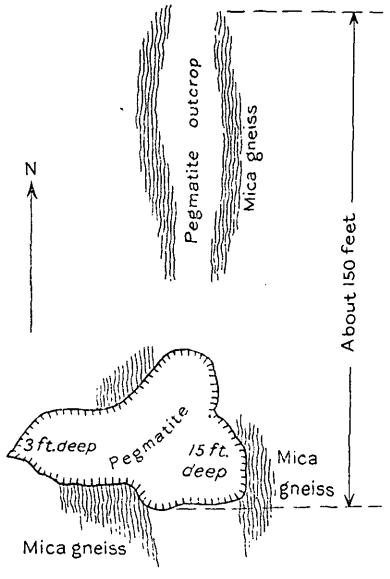


FIGURE 40.—Plan of De Mott mica mine, on Prescott Hill, Grafton County, N. H., showing geology.

DE MOTT MINE.

The De Mott mine is 2½ miles east by south of Grafton, near the crossroads on Prescott Hill. It has been worked by an irregular-shaped open cut 30 feet across and 3 to 15 feet deep. The country rock is highly foliated mica gneiss which has a north by west strike and a variable easterly dip. At the place where the work has been done the pegmatite cuts across the foliation of the gneiss, but north of the mine the pegmatite ledge is more nearly conformable with the inclosing gneiss, as seen in the prominent exposure extending up the hill. The relations between the country rock and pegmatite and the shape of the open cut are shown in figure 40. The whole open cut is in pegmatite. Quartz occurs in the pegmatite in irregular masses or segregations several feet thick, and feldspar occurs in rough crystals 1 foot to 3 feet across. The mica is pockety or occurs in bunches near the quartz. Crystals of beryl, the largest a foot thick, are plentiful, and a ton or more of them has been laid out near the dump. Only scrap mica was left around the mine.

HAILE OR BUCKLEY MINE.

The Haile or Buckley mine is on the south side of Prescott Hill 3 miles S. 65° W. of Grafton, at an elevation of about 1,900 feet above sea level. It was last worked by the American Mica Mining Co. but had been idle for several years preceding the examination in October, 1914. The mine was worked by an irregular-shaped open cut about 120 feet long, 60 feet wide in the widest part, and 10 to 20 feet deep, with a little open stoping from the end and side of the cut. A 75-foot tunnel was driven from the hillside about 25 feet lower than the open cut, but it failed to locate good mica. Two buildings in good repair remain standing near the mine.

The country rock is mica gneiss, which in some places carries fibrolite. The pegmatite is very large, and its contact with the mica gneiss wall rock is not exposed in the workings. A horse of gneiss is inclosed in the pegmatite at the mouth of the tunnel. The pegmatite forms a prominent rounded ridge that extends several hundred feet southwestward from the mine. A small diabase dike about 12 inches wide cuts across the pegmatite in an easterly direction with a dip of 55° S. It is exposed both in the open cut and the tunnel.

The texture of the pegmatite is coarse. Quartz occurs in irregular segregations from 2 to 3 feet thick and orthoclase-feldspar in crystals 2 feet across. A little biotite-mica occurs with the muscovite. Fragments of beryl crystals were seen on the dump, and one piece had a good clear aquamarine color but was somewhat flawed. The mica is clear rum color. Only small sizes were found around the mine, but pieces of ruled crystals from 8 to 10 inches across were seen in the face of the workings.

UNITED MICA CO.'S MINE.

The mine of the United Mica Co. is on the southwest side of Prescott Hill, 2½ miles S. 50° W. of Grafton Center (Cardigan railway station). The company has a trimming house and plant with good equipment at Grafton Center. The mine has been worked by open cuts and tunnels from which stopes have been driven northeastward into the hillside. The main open cut is divided into upper and lower parts, the upper part being 15 to 20 feet higher than the lower. A large stope has been carried from it 200 feet to the northeast, a few pillars having been left for the support of the roof. An inclined track extends from the open cut into the stope to a depth of about 30 feet in a distance of 100 feet, and the track is then run on a level 100 feet farther, to the end of the stope. From the head of the incline the track leads to the dump, a distance of about 150 feet. Another small cut was made above the main open cut to the north, and still another with a tunnel and stope to the southwest. The vein

has been opened to a depth of about 60 feet from the outcrop in the highest cut, on an incline of about 45° SE. There are local variations in the incline where the vein rolled.

The mass of pegmatite is variable in shape, pinching from a large, irregular body 15 feet or more thick in the open cut to a vein 1 foot thick in the bottom of the incline below the track. The vein strikes about northeast and dips 45° SE. The pegmatite has branches or offshoots extending into the quartz-biotite gneiss country rock and includes horses of the gneiss. In the lower part of the mine at the end of the stope the gneiss appears to roll, cutting the pegmatite off in a bulging mass. On the surface the pegmatite pinches out northeast of the workings. Further development would be required to learn whether the vein is thicker below the incline. The indications are that the body pitches southwestward down the hill, and if so a part of it has been removed by erosion.

Quartz is plentiful in the pegmatite in large masses or segregations. One lens-shaped body 6 feet in greatest thickness and 30 feet long was encountered in the stopes. The feldspar is chiefly plagioclase, and much of it has been stained a dull green. The mica was scattered through the vein but was richest near the quartz beds or lenses. In places the crystals were reported to be very plentiful. A little biotite mica is scattered through the pegmatite.

The mica has a clear rum color and is of good quality. Much of it was sold in the rough or after rough trimming until the company erected its own manufacturing plant at Grafton Center, where washers, forms for electric apparatus, and ground mica were produced. To cover mining costs, machinery being supplied by the company, the factory allowed the mine $60 a ton for run of mine mica.

A quarter of a mile northeast of the mine a large outcrop of pegmatite has been worked for feldspar. Boiler equipment, steam drills, etc., were installed for mining on a large scale. In places this pegmatite has large segregations of the constituent minerals, the feldspar crystals measuring 2 to 4 feet across, and irregular masses of quartz several feet thick. Parts of the pegmatite contain black tourmaline, biotite-mica, and a little muscovite, as well as intergrowths of graphic granite, consisting of feldspar and quartz.

WILD MEADOWS MINE.

The Wild Meadows mine is 2½ miles N. 75° E. of Grafton. It is not now in operation but has been worked by an open cut nearly 175 feet long and in places 20 feet deep, driven southwestward into a hillside, with a shaft and two pits to the southwest. The country rock is a rather coarse porphyritic biotite gneiss interbedded with mica schist, striking N. 20°–40° E. and having a vertical dip. The pegmatite ranges from 8 to 12 feet in thickness and has a slightly

sinuous course, approximately conformable with the inclosing gneiss. All the pegmatite was not removed by mining, masses of it being left in the sides of the open cut where it was folded or bulged out into the country rock. The texture of the pegmatite ranges from medium to coarse grained, some of the feldspar crystals being a foot thick. Both potash feldspar and albite, or soda feldspar, are present. The mica left exposed in the walls of the cut was in small bunches of crystals. The mine yielded a clear light-colored mica with a fine cleavage. Crystals of black tourmaline, beryl, and red garnets are scattered through the pegmatite.

MUD MINE.

The Mud mine is 2 miles S. 80° W. of Alexandria, in a steep hillside. It is now owned by the General Electric Co. but has not been operated for several years. It has been opened by a cut 150 feet long, 35 feet in greatest depth, and 30 feet wide, and by a tunnel driven 300 feet farther into the hill. Another open cut was made in the hillside at a higher level, and a shaft 70 feet deep sunk from it to the tunnel. The underground workings had caved badly and could not be examined, but some stoping is reported to have been done. Down stopes 10 to 15 feet deep are reported to have been made in the floor of the tunnel, where good mica was found. The country rock is coarse porphyritic biotite gneiss. The pegmatite strikes about N. 35° E. and has a vertical dip. A prospect crosscut trench shows that it is at least 50 feet thick near the end of the open cut. The pegmatite contains both plagioclase and potash feldspar, and the mica apparently occurs in a streak, 4 to 6 feet thick, along the northwest wall. Some of the mica is specked.

NEW HAVEN MICA CO.

The mine of the New Haven Mica Co. is on the summit of a mountain 2¾ miles N. 70° W. of Alexandria, at an elevation of about 2,000 feet above sea level. The mine has been idle for several years but was in good condition for examination at the time of visit in October, 1914, though a graded road that had been built to the property was in bad repair.

The workings consist of an open cut 75 feet long, 12 feet wide, and 5 to 18 feet deep, driven S. 65° W. into the hillside, and a shaft 10 feet deep, about 70 feet west of the end of the open cut. The rock has been stripped bare of moss and soil for about 100 yards west of the open cut along the summit of the mountain. The country rock is coarse granitic porphyritic biotite gneiss, containing phenocrysts of feldspar that attain a size of 1 by 2 inches. The mass of

pegmatite is 25 to 35 feet thick. It strikes about N. 75° E. and dips 35° N. The rock is of very coarse texture and contains segregations of quartz as large as 10 feet thick and 30 feet long, orthoclase crystals as much as 3 feet thick, and masses of nearly pure feldspar and graphic granite more than 10 feet thick. The mica occurs through the pegmatite in pockets or streaks ranging in size from 2 feet by 8 feet to 6 feet by 20 feet. In places the pegmatite carries little mica, but some of the pockets are rich. Some crystals of mica exposed in the outcrop measure as much as 10 inches across and 4 inches thick; others are less than 1 inch thick; and a few contain intergrowths of biotite. Irregular-shaped masses of white to gray and smoke-colored quartz and several opaque to translucent yellow, yellowish, and bluish-green crystals of beryl a quarter of an inch to 2 inches thick were observed.

MONARCH MINE.

The Monarch mine is 3 miles N. 40° W. of Alexandria, on Fowlers River. Two deposits were opened here but are not now worked—one in low ground on the north side of the river and the other on the hillside about 200 yards to the south, across the river. The northern deposit was opened by a shaft inclined about 30° from the horizontal to a reported depth of 200 feet, with drifts and stopes on the vein to the northeast. Tracks and mine cars conveyed the waste to the dump, which spreads over a considerable area in a flat field northwest of the mine. The country rock is porphyritic biotite gneiss, with phases that resemble metamorphosed porphyritic granite. Plagioclase is the principal feldspar of the pegmatite. Biotite and a little red garnet were also seen.

The other deposit was worked by a pit or shaft 25 feet across and reported to be 20 feet deep on the lower side. The bank on the upper side is 18 feet higher than the water which fills the pit. The country rock is the same as at the northern workings. The pegmatite was not exposed at the time of examination. A few red garnets and pyrite crystals were seen on the dump. The small mica left around has a clear light rum color.

PATTEN MINE.

The old Patten mine, 4 miles N. 52° W. of Alexandria, had been idle for a number of years prior to the time it was examined in October, 1914. The land is now owned by George Phelps, but the mineral right is held by another party. Two open cuts were run S. 60° W. up the side of a hill, one cut at a level 20 feet higher than the other. A derrick was used in quarrying. The pegmatite outcrop is probably more than 100 feet wide, and no exposures of wall rock were seen.

Segregations of quartz as large as 2 feet wide and 15 feet long and large crystals of orthoclase graphically intergrown with quartz occur in the pegmatite. The mica occurs in bunches and streaks of crystals from 1 foot to 6 feet across. The largest crystals seen were several inches wide and 5 inches thick. Much of the mica is ruled or has A structure, but some would cut into good sheets. In some specimens biotite is intergrown with the muscovite. About 2 tons of mica suitable for cutting into small sheet or punch and for grinding as scrap were left at the mine.

RICH MINE.

The mine known as the J. Rich mine is 4 miles N. 38° W. of Alexandria. It has not been operated for a number of years, and at the time it was examined, in October, 1914, one of the openings was filled with waste from a higher opening and both were somewhat overgrown with brush. The deposit is in the side of a hollow and was opened by two small open cuts, one about 10 feet higher than the other, driven N. 20° W. into the hillside. The country rock is granitic biotite gneiss. It strikes N. 10° E. and dips eastward. The mass of pegmatite is large and is exposed for about 75 feet uphill from the workings. The rock is medium to coarse grained and contains segregations of quartz a foot or two across, crystals of orthoclase as much as 8 inches thick, and crystals of mica several inches in diameter. Some of the mica has a clear light rum color and good cleavage. The muscovite is accompanied by biotite, and a few small pinkish-red garnets were observed. Not much mica was exposed in the workings and little could be learned of the richness of the deposit.

SULLIVAN COUNTY.

REYNOLDS BERYL AND MICA MINE.

A mine was opened on Springfield Mountain (Melvin Hill of Hitchcock's Atlas of New Hampshire), 2¼ miles S. 25° W. of Grafton, N. H., by F. H. C. Reynolds, of Boston. Two openings, about 150 feet apart, were made at the east side of the hill, about 400 feet above the valley. The main working is a quarry with a working face more than 80 feet long and 5 to 15 feet high running N. 60° W. along the hillside. The country rock is a quartz-biotite gneiss, which strikes north, has a nearly vertical dip, and shows some folding. The pegmatite cuts across the foliation of the gneiss with a strike west by north and a dip of about 20° N. The contact with the gneiss is not regular but rolling, and a few smaller beds of pegmatite extend out into the gneiss parallel with its foliation. The bottom of the pegmatite is not exposed in the workings. The rela-

tion between the gneiss and the pegmatite in the east half of this quarry is shown in figure 41.

The pegmatite is composed of potash, feldspar, quartz, mica, and other minerals. The feldspar occurs in large, pure crystal masses or is graphically intergrown with quartz. The quartz, which is mixed through the pegmatite in grains and massive irregular segregations, is either white or smoky, and some of it is translucent. The deposit was worked for gem beryl only, but enough mica of a light rum color and good quality was found to help defray the cost of mining if it had been saved. Much biotite mica was observed on the dumps, and in many specimens biotite was intergrown with muscovite. Among other minerals in the pegmatite are black tourmaline, red garnet, green apatite, and beryl. Beryl was evidently rather plentiful, for many fragments of broken crystals of it were seen on the dumps. Some of the crystals measured several inches across, and most of them were opaque or only translucent. Mr. Reynolds reports that in some of the crystals clear gem beryl was found, the golden variety of which was especially finely colored. The colors observed in the fragments of beryl on the dumps were light yellow to rich golden yellow, yellowish green, and light to dark aquamarine-green and greenish blue.

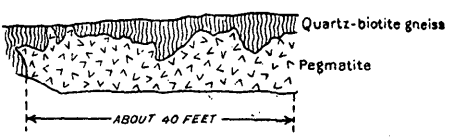


FIGURE 41.—Cross section of east half of quarry of Reynolds beryl mine, 2¼ miles S. 25° W. of Grafton, N. H., showing relation of pegmatite to gneiss.

The other opening of the Reynolds beryl mine is south of the main working. A pit was made in the pegmatite, cutting biotite granite and quartz-biotite gneiss. The pit and dump were overgrown with brush and little could be seen.

PROSPECT OF COLUMBIAN GEM MINING CO.

A prospect was opened for gem beryl and mica by the Columbian Gem Mining Co. on one of the summits of the northern part of Springfield Mountain (called Melvin Hill in Hitchcock's Atlas of New Hampshire), 2½ miles S. 40° W. of Grafton. More than 200 feet of open-cut and trench work has been done, a shaft has been sunk, and considerable stripping of vein outcrop has been made on the summit of the mountain at an elevation of 1,750 feet above sea level. The open cuts are 10 to 25 feet wide and 5 to 15 feet deep. The shaft is filled with water. No work had been done for a few years at the time of examination (October, 1914), but four buildings, in good repair, a quantity of punch and scrap mica, and a few rough crystals of beryl had been left at the mine. The position of the workings and stripped area are shown in figure 42.

The country rock is quartz-mica gneiss, which contains both biotite and muscovite. The gneiss is strongly banded and has been much folded and crumpled, so that definite strikes and dips could not be measured. It has been cut in several directions by pegmatite and associated granite. Some of the pegmatite shows steep to nearly vertical walls; the remainder apparently lies nearly flat or has a low dip, in relations which indicate that nearly vertical dikes acted as channels for forming the flatter beds. The associated granite, which merges into the pegmatite, is chiefly fine-grained biotite granite. The pegmatite ranges from a granite-like rock to masses containing crystals of orthoclase 1 foot thick, segregations of quartz 3 feet across, and crystals of mica 8 to 10 inches in diameter. The arrangement and the position of the minerals in the pegmatite are very irregular.

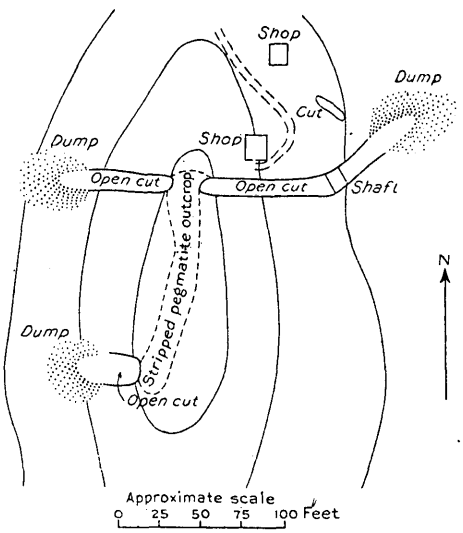


FIGURE 42.—Plan of prospect of Columbia Gem Mining Co., on Springfield Mountain, Sullivan County, N. H.

The quartz of the pegmatite is white, gray, or smoky, and mostly opaque, but some is translucent and nearly clear. The muscovite has a clear rum color and part of it has good cleavage. Biotite is plentiful and some is intergrown with the muscovite. Black tourmaline occurs in crystals measuring 2½ inches across. Crystals of opaque, dull-red garnet half an inch to 2 inches in diameter are scattered through the pegmatite, and a few small pink garnets were seen in one specimen on the dump. A few yellowish green to pale aquamarine-green and mostly opaque crystals of beryl were seen in the rock. Little could be learned of the quality of the gem material mined, but probably neither the mica nor the beryl was found satisfactory in grade or quantity.

PLAYTER MICA AND BERYL MINE.

A deposit was operated for mica and gem beryl several years ago in the town of Springfield by Franklin Playter, of Boston. It is on one of the higher summits of Springfield Mountain (Melvin Hill of Hitchcock's Atlas), 3 miles S. 40° W. of Grafton, at an elevation of 2,100 feet above sea level. The workings consist of four open cuts along a small ridge. Three of the cuts are in a line extending about 150 feet N. 55° E. on the northwest side of the ridge, and the fourth

is about 100 feet southeast, on the opposite side of the small ridge. Two of the open cuts are about 25 feet across and are connected by a passage 6 feet wide. The openings range in depth from 8 to 25 feet.

The country rock is muscovite-biotite gneiss, which has a general northeast strike and a vertical to high southeast dip. The pegmatite cuts the gneiss irregularly, but its greatest length corresponds approximately with the schistosity of the gneiss. The deposit pinches and swells and thus cuts the schistosity of the inclosing rock in one place and is conformable with it in another. In the two connected open cuts the body of pegmatite is more than 20 feet wide but pinches down to 6 feet at the surface in the passage between the two cuts and widens to 10 feet at a depth of about 10 feet below the surface. At some places where the pegmatite pinches down in this passage it cuts across the bedding of the gneiss; and at others the gneiss bends around its bulging shape. Plate XIII, *A* (p. 108), shows the pinch of mica gneiss between the two connected open cuts. The bulging pegmatite underlies the gneiss on both sides of the passage between the cuts.

The texture of the "vein" rock is variable but is chiefly rather coarse. The quartz occurs generally in large segregations of coarse smoky to gray grains, but in places it occurs in translucent to nearly clear masses several inches across. The rock contains two varieties of feldspar, gray orthoclase or microcline in crystals as much as 2 feet across, and masses of albite 3 to 4 inches across. Crystals of black tourmaline are plentiful, and some are of good crystal form Biotite occurs in large quantity, and some is intergrown with the muscovite. The muscovite is of good quality, splits well, and has a clear rum color. Some crystals seen around the workings would yield perfect plates measuring 2½ by 3 inches and 2 by 4 inches. Beryl occurs rather plentifully, and most of it is opaque, but some is clear and has fairly good color. The quantity and quality of beryl obtained from the mine can not be determined, but the dumps and the pegmatite contained well-formed opaque to translucent pale yellowish-green and bluish-green crystals as much as 2 inches thick, and a few crystals with transparent parts showing the same colors that would cut into small gems. The material seems to indicate that larger clear beryl may still be found.

JOE HILL MINE.

The Joe Hill mine is 1½ miles N. 55° E. of Springfield, near the roadside. It was worked about 30 years ago by a man named Randall, but since that time it has been idle, and when examined in October, 1914, was badly overgrown. It was opened by a tunnel 40 feet

long driven N. 70° E. into a steep hillside. The country rock is fibrolite-mica gneiss, which strikes N. 5° E. and dips 60° E. The pegmatite cuts the gneiss with a strike of N. 70° E. and a southerly dip. The pegmatite is medium to coarse in texture, and contains feldspar crystals as large as 1 foot thick and quartz segregations 1 foot to 2 feet thick. The mica seen in the rock was in small crystals, but was of good quality and had a clear light rum color. Sheets of waste mica that had been thrown on the dump measured more than 6 inches across.

MURPHY PROSPECTS.

Two prospects for mica and beryl were opened in 1914 by Charles Murphy, of Wilmot, on the old Underhill place, about 1¾ miles east by north of Springfield. The deposits are in the hilly country south of Springfield Mountain, at elevations of 1,800 and 1,900 feet, respectively, above sea level. They are about a quarter of a mile north of the Globe mine. The upper one is in a ridge sloping south. The work consists of an open cut about 20 feet square and 12 feet deep in a large outcrop of pegmatite. Much of the rock exposed in the working is graphic granite of both coarse and fine grain. In places there are small segregations of quartz and orthoclase crystals 1 foot or less in thickness. About 4 tons of small mica crystals was taken from this opening. This mica is of good quality and clear light rum color, but most of it is only large enough for punching into disks and washers. Among the associated minerals are biotite, black tourmaline, triphyllite in masses as much as 8 inches thick, opaque crystals of red garnet 2 inches in maximum diameter, crystals of beryl, a little löllingite or arsenopyrite, and apatite. The crystals of beryl range in diameter from one-sixteenth of an inch to 1½ inches. They are simple hexagonal crystals and occur singly, in parallel growths, and in radial groups. Most of them are opaque or translucent and pale-greenish aquamarine in color.

The lower prospect is nearly a quarter of a mile south of the upper one, in a gap. A small glacial gouge cuts through the gap in a southeasterly direction, and the prospect consists of two openings, one on each side of this gouge and about 150 feet apart. A few openings have been made on the east side of the gouge in a face of pegmatite several feet high. The footwall contact of this pegmatite strikes N. 20° W. and dips 45° NE. and the rock crops out for about 100 yards in this direction. The country rock is biotite gneiss, in which fibrolite was seen between this prospect and the upper one a quarter of a mile north. The pegmatite exposed in this ledge contains coarse crystals of orthoclase, some graphic granite, segregations of smoky quartz, hydrated biotite in large thin crystals, and crystals of muscovite mica as much as 8 inches in diameter. Crystals of beryl are said to have been found.

On the west side of the gouge pegmatite has been exposed by stripping over an area about 30 feet square. It contains coarse crystals of orthoclase, large segregations of quartz, graphic granite, and good sound crystals of mica as large as 8 inches across and 2 inches thick. The mica has a clear light rum color. A little biotite and a few opaque red garnets were observed.

Another prospect had been opened about 200 yards north of the upper prospect in a prominent mass of pegmatite striking N. 25° E. This pegmatite contained much graphic granite, large crystals of orthoclase, some plagioclase feldspar, segregations of quartz about a foot thick, black tourmaline, greenish apatite, biotite, and small crystals of clear rum-colored muscovite mica. The results of the prospecting had not been very satisfactory.

GLOBE MINE.

The Globe mine is 1¾ miles N. 80° E. of Springfield, on a rather flat-topped hill about 1,875 feet above sea level. The mine was opened more than 40 years ago but had been idle for many years before it was examined, in October, 1914. The principal work done consists of an irregular open cut more than 100 feet long, 20 to 50 feet wide, and 10 to 25 feet deep. The quarry is in a mass of pegmatite more than 150 feet wide. The work progressed from southeast to northwest, part of the waste and muck being carried back and thrown on the older work. Large masses of quartz were encountered in the workings, and one of these masses was left along the northwest face of the quarry. The mica is reported to have occurred in large deposits or pockets at different places in the pegmatite. Some of the mica that was thrown on the dumps could now be used. The mine yielded good, clear rum-colored mica. Black tourmaline is abundant, and it is reported that the first prospecting done here was for coal, for which the tourmaline was mistaken.

Rock was removed to the dumps by a car on a track and the same track led around to shops about 100 yards south of the mine. About 4 tons of mica suitable for cutting into small sheets and punching had been left in the shop.

Some other prospects were opened on the same property about 200 yards north of the main quarry, but these prospects are thickly overgrown with vegetation and little could be seen at them.

STRAFFORD COUNTY.

FOSS MINE.

A mica deposit was worked during 1913 on the farm of H. R. Foss, about a mile northwest of Center Strafford, Strafford County, N. H., by James Davis, under contract with the Keene Mica Products Co.

The mine is on the southeast side of a benchlike projection or platform on the southeast slope of the Blue Hills Range, at an elevation of about 700 feet above sea level. The working consisted of an irregular-shaped open cut about 100 feet long, 10 to 30 feet wide, and 10 to 40 feet deep to water, and from 30 to 40 feet of water was reported to be in the bottom at two places. The open cut extended N. 25° W. into the hillside, reaching nearly to the top of the bench land. In the lower end of the open cut a pillar of barren rock was left. The workings are shown in figure 43. Two dumps were made, and one of them was rather large. Power drills were used and the rock was removed by a derrick and a mine car. The mica was shipped in the rough to Keene, the nearest railroad shipping point being Center Barnstead, about 9 miles to the northwest.

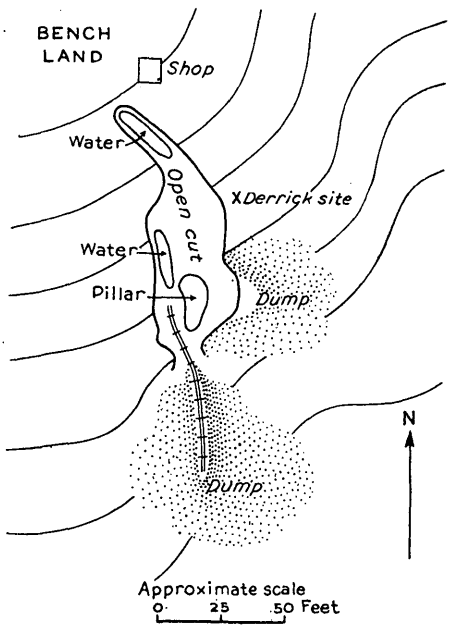


FIGURE 43.—Plan of Foss mica mine, Strafford County, N. H.

The country rock exposed in the Blue Hills Range is chiefly coarse mica schist and gneiss, highly crumpled in places and inclosing beds of pegmatite. Because of drift material on the hillside good outcrops are lacking around the mine. The workings expose granite, which grades into pegmatite at some places and is cut sharply by pegmatite at others. The granite and the associated pegmatite have been exposed for a thickness of about 40 feet from northeast to southwest but extend N. 25° W. for the full length of the workings. A slight banding of the granite in a northeasterly direction was noted, but the pegmatite cuts across this band.

Two pegmatite "veins" were opened, one striking N. 45° W. and dipping 70° NE. and the other striking N. 20° W. and dipping 70° NE. Their position is indicated by the deep stopes filled with water shown in figure 43. These "veins" pinched down small where development was stopped and apparently did not connect, but they consisted of streaks or shoots of pegmatite as much as 10 feet thick, which in places were rich in crystals of mica. Where work was stopped the mica-bearing veins were less than 18 inches thick. At one place a mass of solid mica 5 feet thick, composed of scales half an inch to 2 inches in diameter with little intermixed feldspar and quartz, was left in the side of the opening. The mica "veins" were

reported to have been very rich where worked out and to have yielded some large crystals.

The quartz of the pegmatite occurs both in scattered grains and in irregular-shaped masses, the largest 3 feet thick. It has a gray to smoky color and is opaque. The feldspar occurs in large crystal masses and in graphic intergrowths with quartz. Among the associated minerals were black tourmaline, which is abundant both in the granite and in some of the graphic granite; dark red and opaque garnets; beryl crystals as much as 6 inches in diameter, some of which had small, clear, pale aquamarine-colored parts; much opaque greenish apatite; and numerous grains or particles of arsenopyrite or llölingite.

The mica crystals vary in quality, some having the A structure strongly developed but yielding good flat sheets between the A lines. The mica has a greenish-brown cast and some is a little specked. A specimen obtained from one of the large crystals seen in the office of the Keene Mica Products Co. measured 16 by 26 inches. It would have yielded perfect sheets 8 by 16 inches and smaller perfect plates.

NEW JERSEY.

An attempt was made to mine mica near Bloomingdale,[56] Passaic County, N. J., in the Blue Ridge Mountains.

NEW MEXICO.

GENERAL FEATURES.

Mica deposits occur in Rio Arriba County west and southwest of Petaca and in the Glorieta Mountains, in San Miguel County, N. Mex. Other prospects are said to occur in the belt of crystalline rocks that extend northward from San Miguel County into Taos County. The mines of both regions were opened in the early days of mica mining, and the output was reported for the years 1882, 1883, and 1884.[57] The deposits of Rio Arriba County have been the most actively developed.

MORA COUNTY.

Mica deposits are reported to have been prospected in Mora County [58] near the town of Mora, about 30 miles north of Las Vegas. Several deposits are claimed to have been found, two of which were thought to be rich enough to develop. The mica-bearing pegmatites

[56] Colles, G. W., Mica and the mica industry, p. 45, Franklin Institute, Philadelphia, Pa., 1906.

[57] U. S. Geol. Survey Mineral Resources, 1882–1884.

[58] The Mora mica deposits of New Mexico: Min. and Eng. World, May 4, 1912.

occur in lenses in mica schist. Some of the deposits yield a black to brown specked mica and others yield clear mica. Most of the prospects also contain quantities of A, wedge, and tangle-sheet mica, but these varieties can be separated from the sheet material.

RIO ARRIBA COUNTY.

The mica deposits described below are only a few of a large number in Rio Arriba County, N. Mex. Many of these deposits were mentioned in a report by Holmes,[59] who briefly described some of them. Notes for the accompanying descriptions were obtained during a very brief visit in June, 1911, at a time when none of the deposits were being worked. Through the kindness of Mr. Moritz Leichtle, of Petaca, N. Mex., the few examinations made were possible.

Rio Arriba County lies west of the central part of northern New Mexico. The eastern part of the county, in which the mica region is situated, is composed of broken mountain country that merges into partly dissected table-land. The mountains are a continuation of the San Juan Mountains of Colorado. The mica deposits lie at elevations ranging from 6,500 to more than 8,000 feet, chiefly in the mountain country. The region is drained by the tributaries of Caliente River, some of which are dry during part of the year. The region is a semi-desert at the lower elevations but is better watered and is forested with pine in the higher parts. The mica deposits outcrop in two or more groups on a northerly line and are from 8 to 15 miles west of the Denver & Rio Grande Western narrow-gage tracks between Santa Fe, N. Mex., and Alamosa, Colo. The railroad stations that would serve as shipping points for the mica deposits are Servilleta and Barranca. Petaca, a small settlement, chiefly of Mexicans, near the larger group of deposits, is about 9 miles by road southwest of Servilleta.

The mica mines examined were the Cribben or Cribbenville mine, about 2 miles southwest of Petaca; the American, about three-fourths of a mile S. 75° W. of Petaca; the Globe, about 5 miles south-southwest of Petaca and 12 miles west by north of Barranca; and the Antonio Joseph, 2 miles north of Ojo Caliente and 14 miles southwest of Barranca. All the mines but that near Ojo Caliente are within the area of the Jemez National Forest. The elevations at several points in the mica region, determined by barometer, are: Petaca, 7,500 feet above sea level; camp at Cribbenville mine, 7,800 feet, highest working, 8,000 feet; American mine, 7,750 feet; Globe mine, 7,650 feet; Joseph mine, 6,900 feet; Ojo Caliente, 6,500 feet.

[59] Holmes, J. A., Mica deposits in the United States: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 6, continued, pp. 706–707, 1899.

The mica deposits of New Mexico yield some sheet mica of fairly good quality and merchantable size. A large proportion of the output is scrap mica, suitable only for punching into disks or cutting into small sheets and grinding. At some of the mines the principal value lies in this scrap mica. With several of the better mines in active operation, New Mexico would occupy a prominent place among the mica-producing States. By establishing cutting or trimming plants and grinding mills, either in the mica region or at convenient points on the railroad, the mining industry would be stimulated, and advantage could be taken of the low-priced labor offered in that region. Much of the trimming and splitting of mica could probably be done by Mexican girls and women.

The description of the Cribbenville mine by Holmes is quoted below:

> At the Cribben mine, the best known of them all, a considerable amount of work was done between 1884 and 1889, and on a smaller scale since that time. Openings were made on the property at several different locations—(1) the I Excell tunnel, 300 feet long; (2) San Carlos tunnel, 40 feet long, where there are also stopes and drifts under the crest of the hill; (3) an open cut 100 feet long and a tunnel 40 feet long, near the San Carlos; (4) El Capitan tunnel, shaft, and open cut, some 1,000 or 1,200 feet northwest of Nos. 2 and 3; (5) Columbia tunnel, 40 feet long, with an open cut of 40 feet, in a dike 50 feet thick, located some 200 or 300 yards east of the San Carlos; (6) the Rafugea tunnel, 20 feet long, and open cut, 30 feet long, located some 200 feet east of the last. The larger part of the work at the Cribben mine was done and most of the mica was obtained from the San Carlos and El Capitan openings, and it is in these also that there is the greatest promise of successful future operations. The mica from these openings is all of fairly good quality, generally free from specks, though in places badly ruled.

The several workings described by Holmes are not now readily recognized, as many of them have fallen in badly. The I Excell tunnel is blocked by a cave-in. The San Carlos workings are still open, in part at least, and mica can be obtained by continuing the stopes. The El Capitan workings are nearly all closed. Mr. Leichtle stated that the rich deposit of mica encountered in these workings was mined out. A quantity of mica that would yield scrap and small sheet remained around the workings.

During the last few years work has been concentrated on a deposit in a hill about 100 yards southwest of the camp and about 100 feet higher. A tunnel has been started in the hillside toward the "vein" and a shaft 25 feet deep and 12 feet across sunk near the summit of the hill. Massive coarse pegmatite containing crystals of feldspar 2 to 3 feet across was encountered. Most of the mica appears to come from a streak about 8 feet across, with a north strike and west dip. The mica is more plentiful along the sides of this streak, especially in shoots that pitch to the south. Rough crystals of mica

12 inches across were seen in the shoots and larger ones are reported to have been found. The mica is of fair quality, and good sheets can be cut from many of the crystals. The thick sheets have a greenish color.

The mine is now owned by the New Mexico Mutual Mining Co., which has an office in Milwaukee, Wis. Mr. Leichtle, who owns an interest in the mine, is in charge. Little more than assessment work has been done for several years, and only small shipments of sheet mica have been made during this time. Two or three hundred tons of scrap mica have accumulated on the dumps and in the storehouses Small sheet mica could be cut from some of the scrap.

Holmes[59] mentions also other mines:

> Several other claims have been prospected recently near the Cribben, notably the Old Judge claim, probably one-half mile to the north.
>
> The Buckshot and Mica Producer claims, some 3 miles south of the Cribben, and the Petaca, Coyote, The Gulch, Bachelder No. 1, Bachelder No. 2, Summit, Keystone, Mica King, Fleming, Bobtail, and Young America, extending north of the Cribben for some 4 or 5 miles, have been opened up for mica to a small but varying extent and some of them are promising prospects. All yield mica of good quality, except that in many places it is badly ruled. The Old Black Horse (Sandoval or Kentucky) mine, some 3 or 4 miles northwest of the Cribben and on the slope of the canyon, is, next to the Cribben, the best-known and most extensively worked mine in the district, and it may be expected to yield in the future considerable quantities of good mica. The Highland mine, on top of a hill above the Sandoval, and the California, a short distance to the east of the Highland, have both yielded considerable quantities of mica of good quality and can be counted on for further developments in this direction.

Whether the names given include any of the deposits described below was not ascertained. It is possible that the names of some of the claims were changed when the claims changed hands.

The American Mica mine, formerly owned by the American Mica Mining Co., is now reported to have become the property of Mr. Leichtle. The mine is on the brow of a hill facing east. It was first opened by irregular stoping from the surface to a depth of 25 feet and for 40 feet along the vein. Later a tunnel about 200 feet long and 40 feet lower than the outcrop was run into the hillside to the south of the workings and an air shaft raised to the stopes.

The country rock at the mine is fine-grained gneiss, apparently coarser grained near the pegmatite. The pegmatite as exposed in the workings has a north strike and a dip of 20° W. The tunnel cuts through more than 30 feet of pegmatite, which, allowance being made for dip, would give a thickness of more than 10 feet. In texture the pegmatite ranges from moderately coarse rock to some that is very coarse, containing feldspar crystals as much as 2 feet thick. In the tunnel the mica was more plentiful near the footwall of the pegmatite, but some occurs in the interior of the mass. One crystal

measured 15 inches in diameter. The crystals are irregularly distributed in the vein zone but are fairly numerous. Some crystals occur in pockets or bunches and others in streaks in the pegmatite. The greater part of the mica from the upper workings is suitable for grinding only. It is nearly all small and some of it occurs in mashed lenticular pieces as much as 3 inches across. This mica has been partly hydrated and has a soapy feel. It occurs in an irregular vein, 3 to 6 feet thick, in the pegmatite. It can be obtained easily in large quantities and some of it has been shipped to Denver for grinding.

The Globe mica mine has been opened by three shafts—35, 30, and 25 feet deep—from which drifts have been run along the vein. The 30-foot shaft is about 200 feet S. 75° E. of the 35-foot shaft and the 25-foot shaft is about 50 feet farther away in the same direction. The 35-foot shaft has been equipped with a hoist, an air drill, and two 25-horsepower gasoline engines. From the bottom of the shaft a drift was run 12 feet east and another 30 feet west. At the end of the west drift a crosscut tunnel has been carried 16 feet south. The drifts are 6 to 8 feet wide and about 15 feet high, so that they might be called small stopes.

The country rock is quartz-muscovite schist, which strikes northwest and dips about 25° SW. The schist contains minor folds and crumplings that are visible in the mine workings as well as larger similar regional structural features. The pegmatite cuts the schist with a strike of N. 75° W. and a vertical or high north dip. The full thickness of the pegmatite is not exposed but is at least 30 feet near the main workings. From the 35-foot shaft an irregular streak of mica, from 3 to 8 feet thick, was followed in the drifts. This streak lies near the north wall of the pegmatite and has an irregular dip of 85° N. The quartz-muscovite schist wall rock is exposed at some places in the drifts. The crosscut tunnel from the end of the west drift follows a branch streak of mica. In parts of the main mica streak crystals of mica are plentiful and form nearly solid masses 2 or 3 feet across. Blocks of mica nearly 2 feet in diameter were seen in the vein, but most of the mica is badly ruled and broken, so that only a small proportion of it could be cut into sheets. The feldspar occurs in large masses and crystals and consists of both pink microcline and white albite. Some of the masses of feldspar measure 10 feet across. The pink microcline occurs in the largest crystals. The streak of mica is separated from the north wall of the pegmatite by an irregular sheet of massive feldspar. Irregular masses and sheets of quartz occur in massive feldspar on the south side of the streak of mica.

In the 30-foot and 25-foot shafts relations similar to those in the main workings were found. A streak of mica 2 to 4 feet thick, with a

high north dip, occurs in massive feldspar. Segregations of quartz, some of them 3 or 4 feet thick, lie along the south side of the streak. The mica is of about the same quality as that of the main workings.

A 20-foot shaft has been sunk on a mica vein a quarter of a mile north of the Globe, on the Peacock claim. The name chosen for this claim is an allusion to the iridescent tarnish on seams of limonite found in the workings. A streak of mica 1½ to 3 feet thick was exposed in the shaft. Nearly all the mica is small, and some of the crystals are bunched together in almost solid masses.

Two prospects for mica have been opened by Antonio Joseph in the foothills of the mountains west of Caliente River. One of them is in the walls of a gulch about 1½ miles north of Ojo Caliente and half a mile west of the river. It has been opened on each side of the gulch. The other prospect, which is the more promising of the two, is about half a mile northwest of this one, in the east end of a ridge between two draws tributary to the same gulch. Here several openings have been made in the hillside on the spur of the ridge and on the south side. The larger opening is a cut 15 feet long, from which an 18-foot tunnel has been carried and there is a 12-foot shaft at the end of the tunnel.

The country rock of the region consists of mica, cyanite, quartz, garnet, and hornblende schist and gneiss, granite, pegmatite, and basalt. The schist and gneiss have been much folded, and the axes of the larger folds are crossed by smaller flexures. The general strike near the mica deposits is N. 45°–60° E., with a vertical to west dip, but large variations from this attitude occur. Pegmatite is common in the gneiss and schist of this region.

At the best prospect a mass of pegmatite at least 100 feet wide crops out across the end of the ridge, with a probable northeast strike. This pegmatite shows the usual variations in composition and texture, part of it containing feldspar and quartz, with or without mica, in granular mixtures and part containing segregations of these minerals. The feldspar is gray and pink to red and is chiefly of the potassium variety. The mica occurs in pockets and streaks as much as 20 feet thick in the pegmatite. The streaks have an approximate northeast strike and are richer in mica in some parts than in others. A large quantity of mica is exposed in the main working. Most of it is in small crystals, but some crystals 12 to 18 inches across and 4 to 12 inches thick were seen. Nearly all were so badly crushed and cut by "ruling" and irregular fractures that only small perfect sheets, not more than 2 or 3 inches across, could be obtained from them. The mica from this deposit would be valuable chiefly for grinding and for small sheets. The mica is in greenish sheets a sixteenth of an inch or more thick, and some of it contains specks

of magnetite. From 50 to 100 tons of scrap and small sheet mica have accumulated on the dumps.

At the other locality a mass of pegmatite 8 to 15 feet thick crops out on each side of the gulch, with a strike of N. 40° E. and a nearly vertical dip. This pegmatite contains streaks of mica gneiss from 1 inch to 2 feet thick. The crystals of mica are more plentiful near these inclusions. Only small crystals of mica, 1 to 4 inches across, were seen, and many of these were crushed and ruled into small pieces.

Deposits of mica were prospected in Rio Arriba County in 1913 and 1914 by W. J. Nelson, formerly of St. Joseph, Mo., but later of Petaca, N. Mex. The deposits are 5 miles west of Petaca and northwest of the Cribbenville mine. Large deposits with rich outcrops are reported. A specimen sent to the Geological Survey measured about 5½ by 9 inches. It was somewhat ruled, so that it would yield only smaller sheets of three or more sizes measuring up to 2½ by 3 inches. It had a fine smooth cleavage and split in flexible sheets of extreme thinness. The mica is nearly clear, having only slight cloudy inclusions.

SAN MIGUEL COUNTY.

Mica deposits were reported in the Glorieta Mountains of San Miguel County in the early days of mica mining, but regular prospecting had been abandoned for many years prior to 1909, when H. S. Anderson opened some of the deposits and made a shipment to Chicago. In 1910 the claims located by Mr. Anderson were taken over by the Anderson Mica Mining Co., of Topeka, Kans. Difficulties were encountered during the operation of the company and a lease of the property to the Topeka Mica Manufacturing Co. led to litigation. The settlement of the dispute left Mr. Anderson in possession of the property, and a new company, the San Miguel Mica Co. was formed to work the deposits.

The claims of the San Miguel Mica Co. are in the southern part of the Glorieta Mountains, about 10 miles by road northeast of Ribera (formerly San Miguel station). A number of claims have been located, but only two, equipped with shafts and larger developments, have been opened.

The following notes on the geology of the deposits have been abstracted from reports of mining engineers who have examined the property: The country rock is highly foliated muscovite schist, which varies in strike from east and west in the southeastern part of the property to nearly north and south in the western part. The dip of the mica schist is mostly high, ranging from 45° to 80°.

The pegmatites are conformable with the foliation of the schist. The deposits opened for mica range from 4 to 12 or more feet thick and in places contain a large proportion of this mineral.

The bulk of the mica output is scrap, suitable only for grinding, but some sheet mica is obtained. Specimens of the sheet mica submitted to the Geological Survey show that most of it would be suitable for punching into washers or trimming into sheets 1½ by 2 inches to 2 by 3 inches. One piece would trim into a sheet 2 by 6 inches or into two imperfect sheets, one 3 by 3 and the other 2 by 3 inches. The mica is specked with thin films of magnetite, which in places have oxidized to reddish and brownish stains of hematite and limonite. A large part of it, which might have been fit for making sheet mica, has been ruined by excessive ruling and crumpling, so that it is suitable only for scrap or for punching.

NEW YORK.

GENERAL FEATURES.

Mica has been found at several places in New York State and has been prospected or worked on a small scale at a few places. Part of the output has been obtained as a by-product in quarrying feldspar, but this part is chiefly scrap mica, suitable only for grinding. Sheet mica is reported to have been obtained from St. Lawrence County.

None of the mica deposits in New York have been visited by the writer. E. S. Bastin[60] has visited the feldspar quarries in which mica has been found, and the descriptions of the deposits in Saratoga and Westchester counties are taken from his report. Feldspar is quarried from pegmatite in Fulton and Essex counties, but Bastin observed little mica in them. An early report[61] mentions the discovery of mica at Chester, in Warren County.

ST. LAWRENCE COUNTY.

A deposit of phlogopite mica was operated in St. Lawrence County during part of 1909 and 1910 by Henry Brewster, of Syracuse, N. Y. The mine is about 1½ miles from Oswegatchie, near the main highway from that place to the village of Fine, on the south side of Oswegatchie River. Mr. Brewster states that the work done during the autumn of 1909 consisted of an open cut 8 feet wide and

[60] Economic geology of the feldspar deposits of the United States: U. S. Geol. Survey Bull. 420, pp. 57, 60, 1910.

[61] Eng. and Min. Jour., vol. 36, p. 88, 1883.

20 feet deep. Mica is obtained in crystals measuring as much as 8 inches across.

SARATOGA COUNTY.

BATCHELLERVILLE QUARRY.

The Batchellerville mica quarry, operated by the Claspka Mining Co., of Trenton, N. J., is 2 miles north of Batchellerville, in the town of Edinburg, on the east side of the Day-Batchellerville road. Two openings have been made. The pegmatite in the main quarry is very coarse grained. Quartz occurs in pure masses several feet across and in graphic intergrowth with feldspar. Light-gray microcline feldspar, with small quantities of finely intergrown albite, occurs in nearly pure masses as much as 4 feet across. The finer-grained pegmatite contains crystals of mica, some of which are 16 inches wide and 8 inches thick. Some of the crystals are tapering and others are sharply outlined six-sided or diamond-shaped prisms, but Bastin did not observe any with sufficiently good cleavage for use as sheet mica, all being suitable for grinding only. Other minerals of the pegmatite are biotite and beryl. The beryl occurs chiefly in translucent dark bluish-green crystals. One observed by Bastin measured 8 inches in width and 30 inches in length.

WESTCHESTER COUNTY.

KINKEL QUARRY.

The Kinkel quarry is on the east and northeast slopes of a hill about three-quarters of a mile southeast of Bedford. Four quarries have been opened, each extending from northeast to southwest probably along the strike of the pegmatite. In one of the middle openings the pegmatite consists chiefly of quartz, most of which is white, but which here and there assumes a beautiful rose tint. In the other quarries most of the pegmatite consists of feldspar. Pinkish microcline, some graphically intergrown with quartz, and white albite are the principal varieties of feldspar. Other minerals are muscovite and biotite mica, black tourmaline, beryl, and a little magnetite, garnet, and columbite.

The mica is nearly all associated with the feldspathic constituents of the pegmatite, but some of it lies between the large masses of feldspar and quartz. Many of the mica crystals lie with their cleavage perpendicular to the feldspar-quartz contact. Most of them are less than 5 inches in diameter and have A structure. Bastin saw no sheet mica and doubts whether there was sufficient scrap mica to pay for mining.

NORTH CAROLINA.

GENERAL FEATURES.

Mica mining was an ancient industry in North Carolina. Traces of the old pits and trenches dug by the aborigines may still be found, but they were much plainer when the modern period of mica mining was begun, in 1867. Mention of this older mining has been made by W. C. Kerr,[62] W. B. Phillips,[63] and others. Kerr speaks of the large operations of the ancient mica miners and suggests that they were probably the work of the so-called mound builders, although no mounds were build in the mica regions of North Carolina. Phillips speaks of the prehistoric mica miners as disposing of their mica, or of part of it at least, to the mound builders, and states that large sheets were found in some of the old mounds. He also comments on the ability of these ancient miners to find the valuable deposits and to extract the mica. Their work was limited chiefly to the upper, decomposed parts of the pegmatite; they attempted very little hard-rock mining. Only stone hammers and axes have been found around the old workings, but evidence that other implements were used in mining has been observed. Phillips states that about 1,800 feet of large pits and trenches had been dug at the Silvers or Sink Hole mine by the aborigines. Some of these workings were 20 feet deep, and the débris removed from them was covered with large trees, showing their great age.

C. D. Smith[64] has furnished an interesting description of one of the ancient mica mines near Franklin, and part of his article is quoted below under Macon County.

Modern mica mining in North Carolina was begun in 1867 by L. E. Persons, of Philadelphia, previously of Vermont. Mr. Persons's attention was directed to Jackson County by some one in Philadelphia who had seen a crystal of mica exhibited at the State fair in Columbia, N. C., in 1858, by D. D. Davies, of Webster. In the autumn of 1867 Mr. Persons went to Jackson County and learned from Mr. Davies the location of favorable prospects for mica in Jackson and Haywood counties, which he soon opened.[65]

Mica mining was begun almost as early in other counties. According to W. B. Phillips, Thomas L. Clingman opened a few prospects in Cleveland County late in 1867 but did not continue working

[62] The mica mines of North Carolina: Am. Inst. Min. Eng. Trans., vol. 8, pp. 457–462, 1880; Eng. and Min. Jour., vol. 31, pp. 211–212, 1881.

[63] Mica mining in North Carolina: Eng. and Min. Jour., vol. 45, pp. 286, 306, 322, 382, 398, 418, 436, 1888.

[64] Ancient mica mine in North Carolina: Smithsonian Inst. Rept., 1876, pp. 441–443.

[65] This information was furnished by Judge D. D. Davies and Mrs. John L. Richardson, daughter of L. E. Persons, in a certified statement dated Mar. 22, 1907.

them. In 1868 he opened the Silvers or Sink Hole mine in Mitchell County, looking for silver. Fine mica was found, but none of it was shipped. After the prospect was abandoned a crystal of the mica was carried by a stock drover to Knoxville, Tenn., where J. G. Heap, of Heap & Clapp, dealers in stoves, recognized its value, and that firm went at once to Mitchell County and was soon mining several deposits, including those worked by the Clarissa, Deake, and Flat Rock mines. After Heap & Clapp had shown the value of their deposits other mines were opened. Some of the better of these were the Ray, Westall, Joe Gibbs, Young, and Bailey Mountain mines.

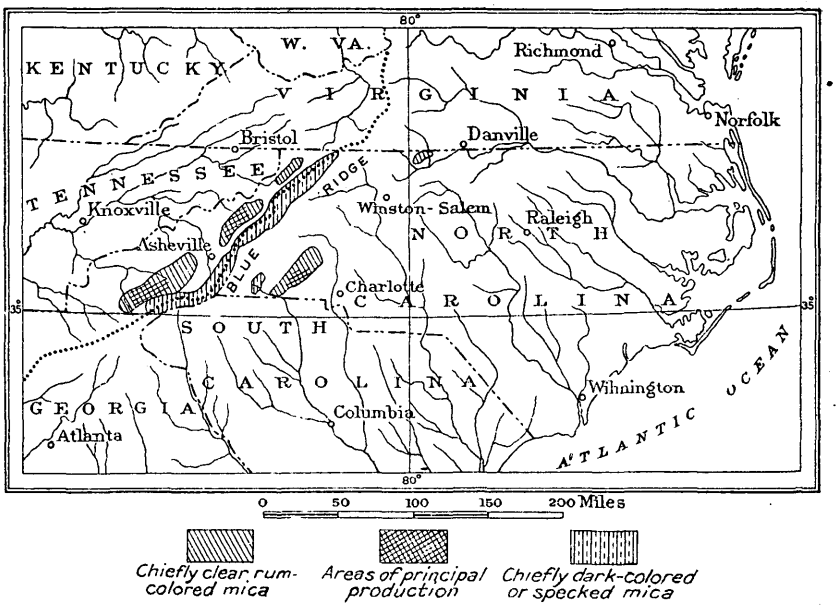


FIGURE 44.—Map showing areas in North Carolina in which mica has been mined.

Phillips estimates that the bulk of the 400,000 pounds of mica mined in North Carolina from 1868 to 1882 came from the Heap & Clapp properties. This mica must have been worth at least $800,000, as most of it brought from $2 to $11 a pound.

Mica mining has continued in North Carolina since 1867. The bulk of the output once came from a number of large mines, but now much of it is obtained from numerous small mines or prospects which are worked more or less intermittently. In some years the output is made by 75 to 100 different mines and prospects.

Mica deposits occur in more than 20 counties of North Carolina, chiefly in the western part. (See fig. 44.) The principal mines are in a belt nearly 100 miles wide, bounded by the State lines on the south, northwest, and north. A few scattered deposits occur far-

ther east, in the Piedmont Plateau region near Raleigh and near Warrenton, close to the border of the Coastal Plain. The main mica belt may be subdivided into three smaller broken belts—the Cowee-Black Mountain belt, the Blue Ridge belt, and the Piedmont belt. The Cowee-Black Mountain belt lies northwest of the Blue Ridge Mountains and extends almost across the State, parallel to and near its northwestern border. It includes part of Macon, Jackson, Transylvania, Haywood, Buncombe, Yancey, Mitchell, Watauga, and Ashe counties. The Blue Ridge belt follows the Blue Ridge through the State and extends several miles to the southeast, among the foothills. It is less productive than the other two, but it includes mines in Jackson, Transylvania, McDowell, Caldwell, and Wilkes counties. The Piedmont belt lies in the Piedmont Plateau, southeast of the Blue Ridge. In this belt mica mines have been worked in Rutherford, Burke, Cleveland, Gaston, Lincoln, Catawba, and Stokes counties. Mica deposits of commercial value have not been found in unbroken succession in any of these belts.

The quality of mica obtained varies considerably from place to place, though the quality of that mined in a single belt or in adjacent parts of the same belt is generally very similar. The mica of the Cowee-Black Mountain belt is clear and usually rum colored; that from the Blue Ridge belt has a dark smoky-brown or greenish-brown color and much of it is more or less specked. Most of the mica in the Piedmont belt, especially that mined in Cleveland, Gaston, and Lincoln counties, is of good quality and similar to that in the Cowee-Black Mountain belt, but in some places it is affected by geologic conditions, such as the presence or absence of granite near by.

The Cowee-Black Mountain and the Blue Ridge mica belts are in the heart of the Appalachian Mountains. The mica deposits in these belts lie at elevations between 1,500 feet and more than 6,500 feet above sea level. Some are high up on rugged slopes or summits, where the soil is thin. Others are on the gentle slopes of valleys or on former plateaus or terraces, under a deep cover of residual clay. Many of the deposits present ideal conditions for mine drainage, which is important, for the rainfall in the region is great and the ground water does not lie deep. The deposits in the Piedmont belt are in the low but locally steep ridges or in the few hills or mountains that stand well above the general level of the plateau. The plateau lies from 800 to 1,500 feet above the sea in the mica region and is dissected by river and creek valleys 200 to 300 feet deep. The sky line seen from any prominent ridge is approximately level, though mountains or peaks rise above it at intervals. The problem of mining mica from some of the deposits in the Piedmont belt is difficult on account of their occurrence in hills that have slight ele-

vation and gentle slope, so that the mines can not be drained naturally.

The name and location of many of the mica mines and prospects in North Carolina is shown on Plate XIX.

OCCURRENCE OF DEPOSITS.

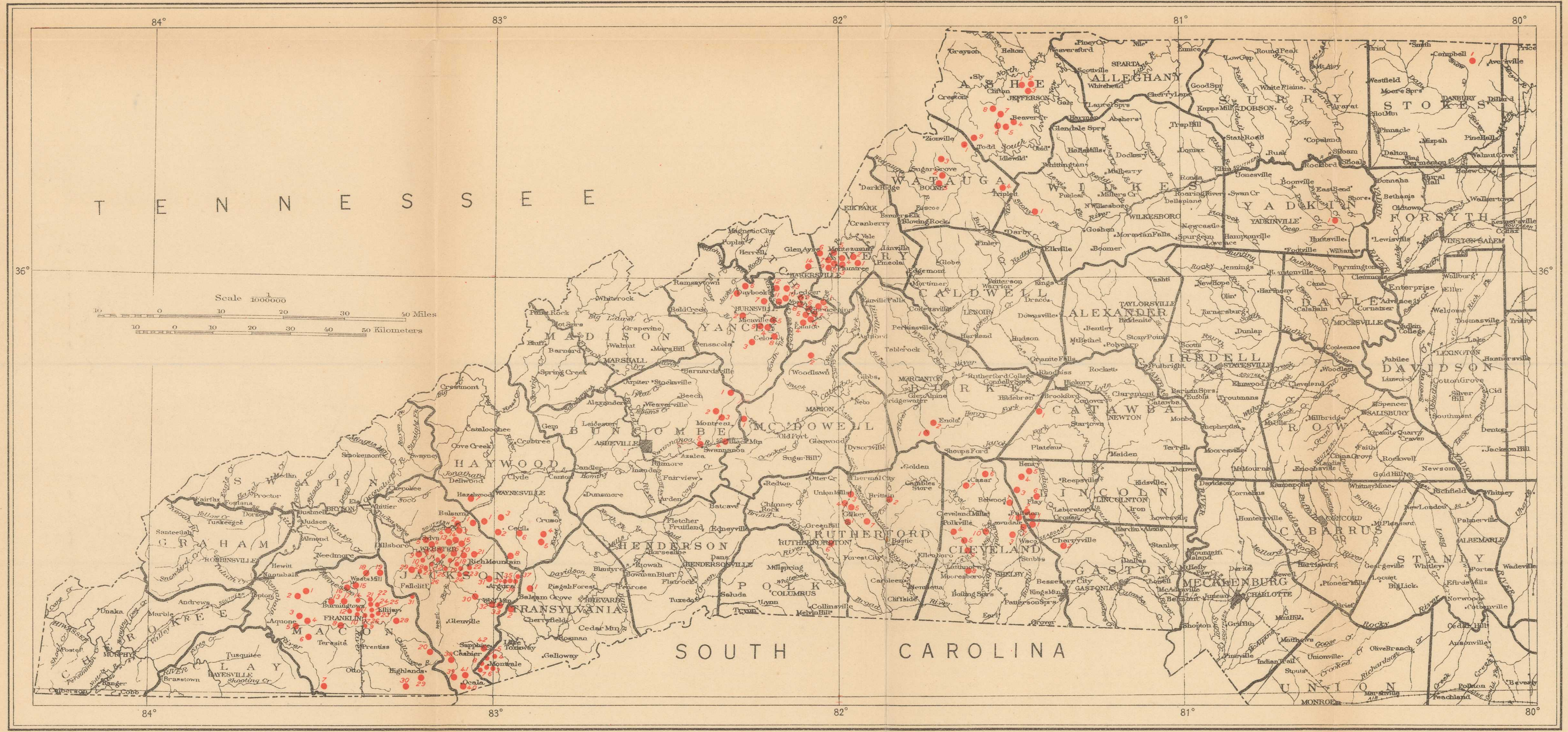
The mica deposits of North Carolina have been found in highly metamorphic rocks, probably all of Archean age. These rocks are mica, garnet, kyanite, staurolite, hornblende, and granite gneisses and schists. Other rocks in the region, also of Archean age, are granite, diorite, and peridotite and the soapstone and serpentine derived from them. Younger granite, volcanic rocks, diabase, and sedimentary deposits occur in parts of the region. The gneisses and schists have been so much folded, faulted, mashed, and recrystallized that it is at some places difficult to determine whether the original formations were igneous or sedimentary.

Most of the mica deposits occur in two formations, mapped by Keith[66] as the Carolina gneiss and the Roan gneiss. The Carolina gneiss includes most of the gneisses and schists mentioned above that are not hornblendic. The Roan gneiss is composed of hornblende gneiss and hornblende schist but includes smaller beds of mica gneiss and mica schist. By far the most extensive formation in the mica region is the Carolina gneiss, which is also the oldest formation in the region and is intruded by younger igneous rocks, such as hornblende gneiss and schist, peridotite, granite gneiss, and diabase. All the formations have been gashed and cut by later igneous rocks into irregular-shaped masses, in many places forking out into long tongues or occurring as long, narrow streaks in the intrusive rocks, or vice versa. The diabase rocks, which are probably of Triassic age, cut across the strike of the older formations in long, narrow dikes. The Carolina and Roan gneisses have been interbanded with and cut at all angles by numerous streaks of granitic or pegmatitic material. These streaks vary in thickness and locally pass into mica-bearing pegmatites. At some places this pegmatization is so thorough that mica gneisses become strikingly like granite gneisses.

MINERALS ASSOCIATED WITH PEGMATITE.

The bodies of mica-bearing pegmatite in North Carolina have yielded many accessory minerals, some of which are of commercial

[66] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Cranberry (No. 90), Asheville (No. 116), Mount Mitchell (No. 124), Nantahala (No. 143), Pisgah (No. 147), and Roan Mountain (No. 151) folios.



MAP OF WESTERN NORTH CAROLINA SHOWING LOCATION OF MICA MINES AND PROSPECTS

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

LIST OF MINES AND PROSPECTS

ASHE COUNTY.

1.–3. Little Phoenix, Tarkington, and Foster mines (Witherspoon mines).
4. Goodman mine.
5. South Hardin mine.
6. Harris or Duncan mine.
7. North Hardin mine.
8. Hamilton mine.
9. Walnut Knob mine.

AVERY COUNTY.

1. Pyatt and Vance mi
2. Johnson mines.
3. Plumtree mine.
4. Milton English and White Rock mines.
5. McCoury mines.
6. Powdermill Creek mines.
7. Meadow mine.
8. Doublehead and Alfred or Vance mines.
9. Charlies Ridge mine.

BUNCOMBE COUNTY.

1. New Balsam Gap mine.
2. Brushy Mountain mine.
3. Connally and W. H. Burnett mines.
4. Gustavino and Reese mines.
5. R. M. Davidson mines.

BURKE COUNTY.

1. Buzzard Roost Knob prospect.
2. Burkmont prospect.

CATAWBA COUNTY.

1. J. E. Burleson prospect.

CLEVELAND COUNTY.

1. W. H. Thompson or Wyatt mine.
2. Calvin Carpenter mine.
3. Fraser-English prospect.
4. M. M. Mauney mine.
5. S. J. Green mine.
6. Indian Town mines.
7. Casar mines.
8. Hambrick, Ellis, and other mines.
9. Sam Putnam, Tom Cabaniss, and Maynard Washburn mines.
10. W. F. Gold mine.
11. J. H. Royster mine.

GASTON COUNTY.

1. Mauney Carpenter mine.
2. M. M. Carpenter mines.

HAYWOOD COUNTY.

1. Spruce Ridge mine.
2. Shiny mine.
3. Big Ridge mine.
4. Shining Rock prospect.
5. Middle Old Field Knob prospect.
6. Mark Reece mine.
7. I. T. Wells prospect.
8. Ethan Cook mine.

JACKSON COUNTY.

1. Big Flint mine.
2. Piney Mountain mine.
3. Ruby City mine and Sugarloaf Mountain prospect.
4. Ocher Hill mine (marked but not numbered).
5. Tustin kaolin and mica mine.
6. Painter mine.
7. E. D. Davis prospect.
8. George White prospect (marked but not numbered).
9. Adams mine.
10. Bob Ashe mine.
11. John Long mine.
12. C. D. Bryson mine.
13. Wayehutta kaolin and mica mine.
14. Rock mine.
15. Sheep Mountain mine, Wolf Pen Gap Trail prospect, and Hamp Woods prospect.
16. Cedar Cliff mine.
17. Leon Hooper mine.
18. Coward Mountain mine.
19. Brown's Coward Mountain prospect.
20. Abbs Creek mine.
21. Frady Creek mine.
22. Lewis Queen mine.
23. J. B. Price mine and A. L. Lovedahl prospect.
24. Andy Nicholson mine.
25. East Laport mine and Roda kaolin and mica mine.
26. Cox & Davies mine.
27. Mrs. Keller's mine.
28. Presley mine and Spence prospect.
29. Gregory mine.
30. Island Ford mine.
31. Freeman Baird mine.
32. Jim Wood mine.
33. A. E. Galloway mine (marked but not numbered)
34. James Reece mine.
35. Albert Brown prospect.
36. Camp Mountain mica and kaolin mine.
37. Pinhook Gap mine.
38. Thomas Grimshawe mine.
39. D. L. Watson mine.
40. J. H. Rochester mine.
41. Jake Rice mine.
42. Rice mica and beryl mine.

LINCOLN COUNTY.

1. Thomas Baxter and Frank Baxter mines.
2. I. K. Wilson prospect.
3. W. A. Thompson and Joe Stamey mines.
4. M. M. Hull mine.
5. John Dillinger mines.
6. D. C. Heavner mine.

McDOWELL COUNTY.

1. Sourwood Gap prospect.
2. Prospect northwest of Woodlawn.

MACON COUNTY.

1. Burningtown or Poll Miller mine.
2. Ruth Stalcup mine.
3. Turkey's Nest and Lyle Cut mines.
4. Wayah Bald mine.
5. Roaring Fork mine.
6. Thorn Mountain mines.
7. Winding Stair mine.
8. Dobson mine.
9. I. A. Deal prospect.
10. Smith or Baird and C. T. Blaine mines.
11. Johnston mine.
12. Winecoff and Harris mines. Raby-Sweet, Iotla, and N. L. Bernard mines.
13. Chalk Hill mine.
14. Iotla Bridge kaolin and mica mine.
15. Neal Bryson mine.
16. James Bryson and West mica and kaolin mines.
17. Hall and Welch mines.
18. Boyd Knob mica and kaolin mine.
19. Beasley No. 1 mine. Beasley No. 2 mine.
20. Campbell or Higdon mine.
21. Lyle Knob mine.
22. Berry and Sanders mica and kaolin prospects.
23. L. J. Bailey kaolin and mica mine.
24. Fox mine.
25. Elmore mine.
26. Kasson or Holbrook mine. Quizzenberry, Ledford, and Mill Knob mine.
27. Moore or Cabe mine.
28. Corundum Hill mica mine.
29. Bascom mine.
30. A. W. Young mine.
31. Mines along Cowee Mountains.

MITCHELL COUNTY.

1. Knob mine and Survey prospect.
2. W. W. Wiseman and Harris Clay Co. mines.
3. Z. T. McChone mines.
4. Chalk Mountain mine.
5. F. M. Tolley mine.
6. Deake, Bill Willis, and Westall mines.
7. Blalock mine.
8. Flat Rock mine.
9. Edgar Bros. kaolin and mica mine.
10. Gibbs Green mine.
11. Mines of Carolina Mineral Co.
12. Sink Hole and Randall mines.
13. Buchannan mine.
14. Hawk, Clarissa, and Cloudland mine.

RUTHERFORD COUNTY.

1. Isinglass Hill mine.
2. Cherry Mountain prospect.
3. Prospect near Union Mills.
4. Allen and J. Odom prospects.
5. Joseph Groves prospect.
6. W. T. Wilkins prospect.
7. W. H. Marvill prospect.

STOKES COUNTY.

1. Joe Hawkins and Steele mines.

TRANSYLVANIA COUNTY.

1. Bee Tree Fork mine.
2. Chestnut Ridge mine.
3. Tallow Face mine.
4. Reed mine.
5. W. J. Nickelson mine.
6. Morning Star mine.
7. Big Jumbo mine.
8. Little Jumbo mine.

WATAUGA COUNTY.

1. Dobbin, Clawson, and Todd mines.
2. Arney Foster mine.
3. C. C. Green prospect.
4. Locke Green mine.
5. F. A. Linney mine.

WILKES COUNTY.

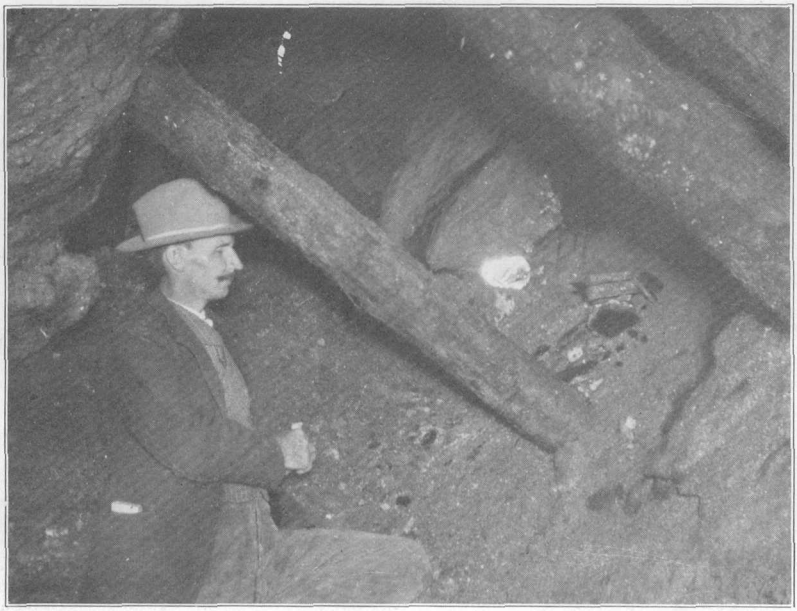
1. Joel Triplett mine.

YADKIN COUNTY.

1. Hauser mine.

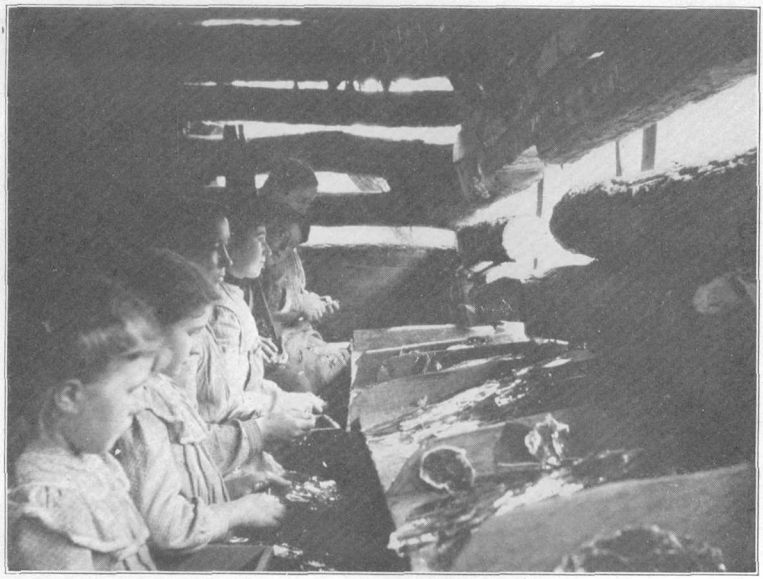
YANCEY COUNTY.

1. Green Mountain and Letterman mines.
2. Ray mine.
3. Cattail Branch mine.
4. Gibbs mine.
5. Poll Hill mine.
6. Hensley mine.
7. Young mine.
8. Bailey Mountain mine.
9. Aley mine.

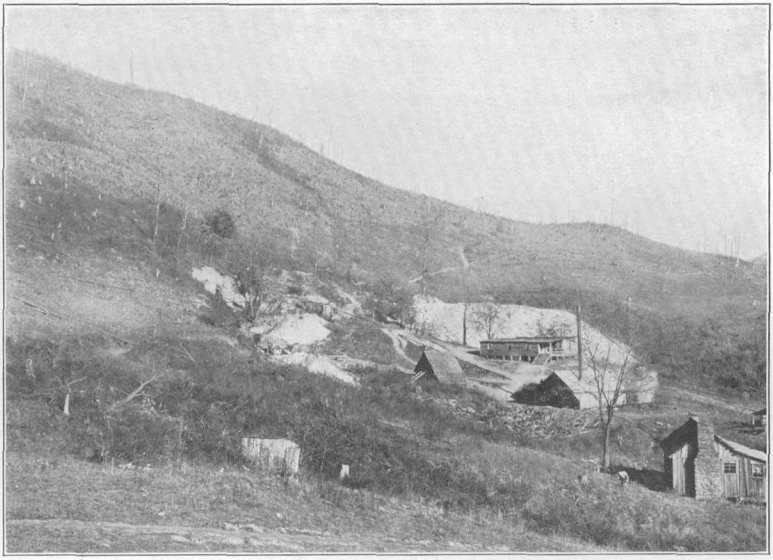


A. VIEW IN STOPE OF NORTH HARDIN MICA MINE, ASHE COUNTY, N. C.

Loose masses of mica crystals between stulls.



B. MICA-TRIMMING SHOP OF WALNUT KNOB MICA MINE, ASHE COUNTY, N. C.



A. VIEW NORTHWARD TOWARD MEADOWS MICA MINE, AVERY COUNTY, N. C.

B. PEGMATITE SHOWING FINE-GRAINED CONTACT NEAR WALL, AT McKINNEY OR POWDERMILL CREEK MICA MINE, AVERY COUNTY, N. C.

value, and some bodies that do not contain valuable mica have yielded other minerals that are of more or less value. Dr. Joseph Hyde Pratt, State geologist of North Carolina, has kindly prepared the following complete list of minerals associated with pegmatite in that State. Asterisks are placed before the names of minerals that have been found in quantity and of quality sufficient to give them commercial value:

Minerals found in the pegmatites of North Carolina.

Actinolite.
*Albite (feldspar).
Allanite.
*Almandite (garnet).
Andradite (garnet).
Apatite.
*Auerlite.
Autunite.
*Beryl (emerald, yellow, blue, and aquamarine).
*Biotite (mica).
Brookite.
*Cassiterite.
Chabazite.
Columbite.
*Corundum.
Enstatite.
Epidote.
Eucryptite.
*Feldspars (albite, oligoclase, orthoclase, microcline).
Fergusonite.
Fluorite.
Gadolinite.
Garnet (almandite, andradite, pyrope, spessartite).
Graphite.
*Gummite (uranium ore).
Hatchettolite.
Hematite.
Hiddenite (variety of spodumene).
Hyalite (variety of opal).
Ilmenite (menacconite, titanic iron).
Iolite.
*Kaolin.
Kyanite.
Limonite.
Magnetite.
Menacconite (ilmenite).
*Mica (biotite, muscovite).
Microcline (feldspar).
Microlite.
Molybdenite.
*Monazite.
Nivenite.
*Oligoclase (feldspar).
Phosphuranytile (uranium mineral).
Purpurite.
Pyrite.
Pyrope (garnet).
Pyrophyllite.
Pyrrhotite.
*Quartz (massive, crystallized, and smoky).
Rogersite.
Rutile.
*Samarskite.
Spessartite (garnet).
Sphene (titanite).
Spodumene (hiddenite).
Tantalite.
Thulite (variety of zoisite).
Titanite (sphene).
Topaz.
Tourmaline (black).
*Uraninite (pitchblende).
*Uranium minerals (autunite, gummite, phosphuranytile, uraninite, uranotil).
Uranotil.
Xenotime.
Yttrialite.
*Zircon.
Zoisite (variety of thulite).

PRODUCTION.

For several years North Carolina has produced more mica than any other State, and the value of its product has ranged from one-half to two-thirds of that of the total output of the United States every

year since 1900 except 1908. The production since 1906 is given in the following table:

Mica produced in North Carolina, 1906–1915.

Year.	Sheet.		Scrap.		Total value.
	Pounds.	Value.	Short tons.	Value.	
1906	800,440	$205,756	1,129	$11,940	$217,696
1907	645,221	209,956	1,371	15,250	225,206
1908	599,234	114,540	1,308	13,330	127,870
1909	1,296,274	122,246	2,607	26,178	148,424
1910	455,020	193,223	3,074	37,237	230,460
1911	454,653	187,501	2,347	29,798	217,299
1912	489,599	219,874	2,492	36,675	256,549
1913	803,462	236,674	2,729	37,239	267,913
1914	274,121	171,370	1,789	23,900	195,270
1915	281,074	266,650	2,840	33,943	315,017

ASHE COUNTY.

HISTORY OF MINING.

A number of mines in Ashe County have produced good mica in the past and some are still producing it. Considered geographically the mines in the county may be divided into three groups—those northeast of Jefferson, those west of Beaver Creek, and those northwest of Elk Crossroads. Among those northwest of Jefferson are the Little Phoenix, the Tarkington, and the Foster mines. The mines west of Beaver Creek that have been operated on a large scale are the Harris, the Hamilton, and the two Hardin mines. The largest producer in the region northwest of Elk Crossroads is the Walnut Knob mine.

The Little Phoenix and the Walnut Knob mines are said to have been worked in prehistoric times by the aborigines, and the remains of the old workings are still pointed out to the visitor. Mica was first mined in Ashe County by white people probably at the Tarkington mines, between 1870 and 1875, and most of the mica mines in the county were opened between 1880 and 1890. All the mines in the county have been idle during certain periods. The Goodman, the Hamilton, and the two Hardin mines were operated by the Blue Ridge Mica Co. between 1900 and 1902. The mines in Ashe County were then idle until 1906, when Theodore Westall reopened the Walnut Knob mine and worked the dumps at the Harris, North Hardin, and Hamilton mines for small-sheet mica. In 1907 the Hardin and Hamilton mines were reopened by the Johnson-Hardin Co.

LITTLE PHOENIX MINE.

The Little Phoenix mine, now owned by W. H. Witherspoon, is 2¼ miles N. 60° E. of Jefferson, on the east side of Little Phoenix

Mountain. The mine is on a rather steep hillside and has good facilities for opening and draining. The mass of pegmatite worked was mined by the aborigines along its outcrop, which follows the outcrop of a ledge of massive white quartz up the slope of the hill. The remains of the aboriginal workings can still be seen. The mine has not been operated for twenty years, and the formations are therefore poorly exposed. The workings consisted of three shafts and a few test pits, sunk a little south of the outcrop. These shafts are said to have been connected at a depth of 70 feet by a tunnel.

The pegmatite strikes about N. 75° E. and dips about 60° S. It lies in mica gneiss that includes bands of hornblende gneiss. The ledge of massive quartz along which the aborigines made their openings probably represents the footwall of the pegmatite, and the part of the mass that is richest in mica lies next to this wall. The mica is of good quality. Garnet and beryl were found in the mine, most of the beryl in the massive quartz. Crystals of beryl as large as a man's arm are reported to have been found.

TARKINGTON MINE.

The Tarkington mine, now owned by W. H. Witherspoon, is about 300 yards southwest of the Little Phoenix mine, about 2 miles N. 60° E. of Jefferson. The workings are old and have fallen in badly. They consist of several cuts and a shaft in a distance of 150 feet and a crosscut trench about 100 yards farther southwest. The mine is on a hillside and could be opened by a crosscut and drainage tunnel. The pegmatite appears to be conformable with the inclosing hornblende gneiss, the country rock. Mica of good quality and crystals of beryl are said to have been found.

FOSTER MINE.

The Foster mine is about half a mile southeast of the Little Phoenix mine, or 2⅓ miles N. 65° E. of Jefferson. It has been opened by a crosscut about 20 feet wide. A mass of pegmatite 15 feet thick is exposed between walls of hornblende gneiss. The gneiss strikes N. 55° E. and dips 50° SE. Pegmatite is plentiful in the country rock near this mine.

HAMILTON MINE.

The Hamilton mine is on the west slope of a mountain 2 miles northwest of Beaver Creek. It was reopened by the Johnson-Hardin Co. in 1907, since the accompanying notes were taken. The deposit was opened by two tunnels run into the hillside along the vein. In the upper and earlier one a shaft or winze was sunk 35 feet from a point about 20 feet in from the mouth of the tunnel. From the bottom of this shaft a curved tunnel was cut on vein material. The

second tunnel was run at a lower level for a distance of 75 feet about south and did not connect with the upper one. This tunnel did not follow the pegmatite closely, but seemed to cut across its strike at a small angle. The strike of the pegmatite appeared to be about N. 10° E. and the dip nearly vertical or to the east. The pegmatite is composed of feldspar and quartz in fairly coarse aggregates, with both muscovite and biotite in good-sized sheets. The muscovite mica is of excellent grade and has a clear light to dark rum color. The larger blocks of mica yielded sheets 6 by 8 or 8 by 10 inches, but the principal output was in smaller sizes. The biotite occurs in sheets of nearly equal size, and some of it is intimately intergrown with muscovite, the two having the same cleavage plane.

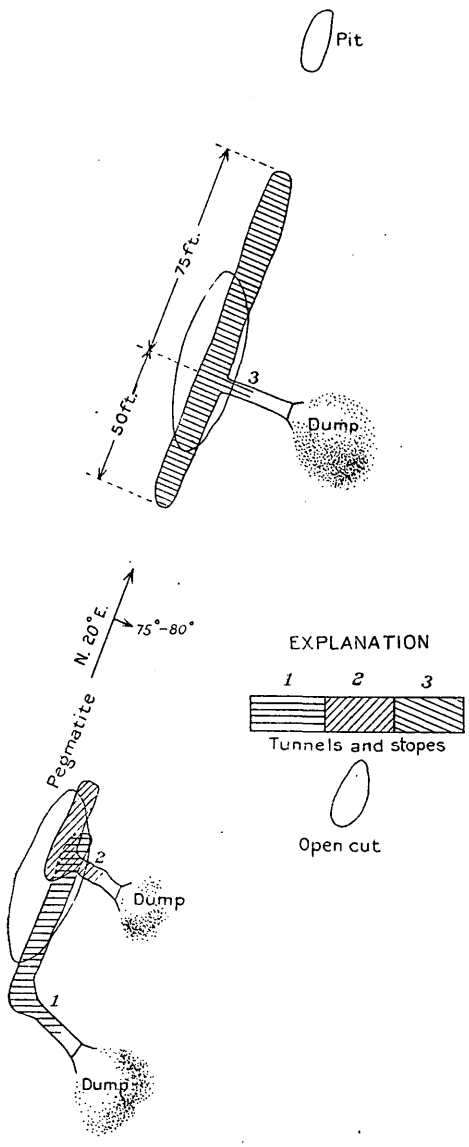


FIGURE 45.—Plan of North Hardin mine, Ashe County, N. C.

NORTH HARDIN MINE.

The North Hardin mine is in a ridge about 1½ miles west of Beaver Creek. It has been worked on a large scale and more systematically than most other mica mines in North Carolina. The mine was operated by two open cuts and other pits, three crosscut tunnels to the "vein," two shafts, and considerable drifting and stoping on the vein. These workings have proved the continuity of the pegmatite for a length of more than 100 yards and have shown that it ranges in thickness from 3 to 8 feet. The country rock of the region is hornblende gneiss, but the mica deposit is in a smaller belt of biotite (probably granite) gneiss. The strike of the

pegmatite is about N. 20° E. and the dip is 75°–80° E. At a place about 80 yards north of the main workings a shallow shaft was sunk in line with the "vein" on a small streak of pegmatite 18 inches thick, which was probably the main "vein" pinching out. Figure 45 shows the extent of the work open for examination at the time of visit. A large part of the stoping and drifts had caved in and could not be seen. The greater part of the vein above the tunnels shown in the figure had been removed, however, and future work should be directed to vein matter between old workings and to lower depths, easily attained with facilities for draining. Tunnel No. 3 is probably 50 feet higher than No. 1. The mine produced a large quantity of small block mica, yielding sheets 1 inch by 2 inches and 3 by 4 inches. A number of larger blocks, yielding sheets 6 by 8 and more inches square, were found with the smaller material. Many small blocks of mica and one crystal more than 10 inches thick and a foot wide were seen in the "vein," embedded in feldspar. A view in one of the stopes (2) is shown in Plate XX, *A*. A small mica crystal about 6 inches thick, of unusual perfection, has been split into several pieces and left near the place where it was found along the footwall. The mica has a beautiful clear rum color and is of the best grade. Most of the blocks yield sheets of perfect quality.

SOUTH HARDIN MINE.

The South Hardin mine is near the top of a small mountain or hill about 1½ miles southwest of Beaver Creek. The first openings made here were small pits, trenches, and a tunnel along the "vein." The surface workings were at the summit of the hill, and the tunnel was on the outcrop about 40 feet lower down to the northeast. The mine was later operated by a 30-foot shaft near the top of the hill and an open cut on the "vein," about 75 feet long and 10 to 20 feet deep.

The country rock of the region, like that at the North Hardin mine, a mile to the northwest, is hornblende gneiss. The mica-bearing pegmatite is inclosed in a smaller mass of biotite-mica gneiss that is included in the hornblende gneiss. The pegmatite is conformable with the schistosity of the inclosing formations, which strike due northeast and dip 50° SE. at this point. The pegmatite is about 7 feet thick as exposed at the surface. The interior is fine grained or is like coarse granite, but along the walls the crystallization is much coarser. Most of the mica obtained is reported to have been taken from the footwall, along which sheets of massive quartz, some of them 2 feet thick, were found. It is said that the pegmatite that lay below a depth of 15 feet was coarse grained and contained more mica than that found nearer the surface. The mica was of clear rum color and of the best quality.

The quartz streaks along the footwall of the pegmatite contained crystals of beryl that ranged in diameter from less than an inch to 6 or 8 inches. These crystals were of good golden and aquamarine color though cloudy and only translucent. They made attractive gems for scarf pins, cuff buttons, and like ornaments, when cut en cabochon.

HARRIS OR DUNCAN MINE.

The Harris mine is 200 or 300 yards southwest of the North Hardin mine, or about 1½ miles west of Beaver Creek. The large dumps show that considerable work was done here in the early days of mica mining in Ashe County. The mine was operated by two shafts, one reported to be 90 feet deep, and several open cuts and trenches. During 1906 and 1907 the dumps were carefully worked over for small-sized sheet mica. The mica has a clear light rum color and is of the best quality.

GOODMAN MINE.

The Goodman mine is about three-quarters of a mile southeast of Beaver Creek. No work has been done at this mine in recent years, and the openings have fallen in badly. The country rock at the mine is mica gneiss and strikes about northeast. There was much feldspar and quartz and 2 or 3 tons of scrap mica on the dump in 1904. The mica was partly specked, and only small blocks, none more than 6 inches in diameter, had been left.

WALNUT KNOB MINE.

The Walnut Knob mine is 2 miles N. 40° W. of Elk Crossroads and three-quarters of a mile south of Black Mountain. The mine has been operated at different times, and the remains of prehistoric workings can be seen around it. The principal recent workings at the time the mine was examined, in 1906, when it was worked by Theodore Westall, were two shafts, one about 35 feet deep, several open cuts, and a 50-foot tunnel run from the hillside below.

The body of pegmatite is irregular in form, but its general course, which conforms with that of the schistosity of the inclosing mica gneiss, is nearly northeast and it dips about 75° SE. In the deeper shaft its course is conformable with the schistosity of the mica gneiss to a depth of about 25 feet, where it is offset or elbows out to the northwest about 15 feet and cuts across the mica gneiss, as shown in figure 46, A. A few feet northeast of the shaft, in a room worked out of the pegmatite, the latter is seen to pinch out as shown in figure 46, B. The tunnel southeast of the shaft encounters pegmatite, however, which may be another mass or a branch of the main body. Broken outcrops of pegmatite appear on the surface for 75 feet.

These outcrops probably do not come from a single large mass below but from streaks of pegmatite in the mica gneiss. On the northwest side of this outcrop there are masses of white quartz containing mica. Very little quartz was encountered in the workings. The streak of mica last developed followed the west wall of the pegmatite in the shaft and was from 1 foot to 4 feet thick. The mica has a clear yellow-brown to light rum color and is of the finest quality. It was roughly split by girls in a shop at the mine before shipment. A view of the trimming shop is shown in Plate XX, *B*. Beryl that is almost of gem quality and columbite are said to have been found.

About 100 yards southwest of the main workings an incline about 30 feet long was sunk on the west wall of an irregular mass of pegmatite. The biotite gneiss at this point strikes about north and has a variable dip. The east wall of the pegmatite as exposed dips 45° E. and may be another body of pegmatite or a part of the irregular mass. Streaks of mica were found along both walls. A streak of biotite gneiss is included in the pegmatite about 2 feet from the east wall, parallel to it. The streak of mica on this side lies between the biotite gneiss and the wall and is very rich in small-sized mica.

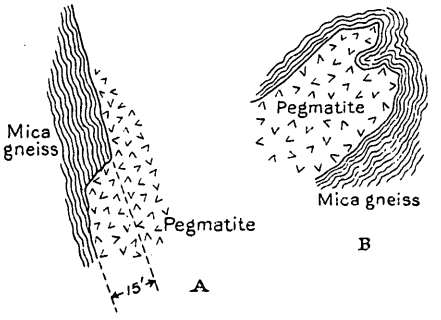


FIGURE 46.—Plan of Walnut Knob mica mine, Ashe County, N. C. A, Offset in pegmatite; B, pinch in one arm of pegmatite.

Two other mica prospects have been opened southeast of the Walnut Knob mine, one a third of a mile and the other a half a mile away. At the first prospect, owned by Graham & Westall, the pegmatite is included in biotite gneiss (granite?), which strikes N. 30° E. and dips 70° SE. At the other prospect, on G. H. Danbury's land, the pegmatite includes massive white quartz. John Ray is reported to own a mine about half a mile south by west of the Walnut Knob mine, close to the Watauga County line.

AVERY COUNTY.

MEADOWS MINE.

The Meadows mine is a little more than 1 mile N. 32° W. of Plumtree, at the foot of a steep mountain slope on the west side of North Toe River valley. It is an old mine, first opened by Sam Landers about 1875, and has been worked intermittently during many years. It is owned and operated by W. W. Avery, of Plumtree. The workings consist of the openings shown in figure 47.

The mine is equipped with steam engine, hoists, air compressor and drills, and trimming house. The fuel is cordwood, which is obtained from the mountain side to the west and slid down several hundred feet in a board flume or chute to a point near the engine house. A general view of the mine taken about 150 yards to the south is shown in Plate XXI, *A*.

The country rock is muscovite-biotite gneiss, which is highly schistose near the pegmatite, and which strikes east and has a variable

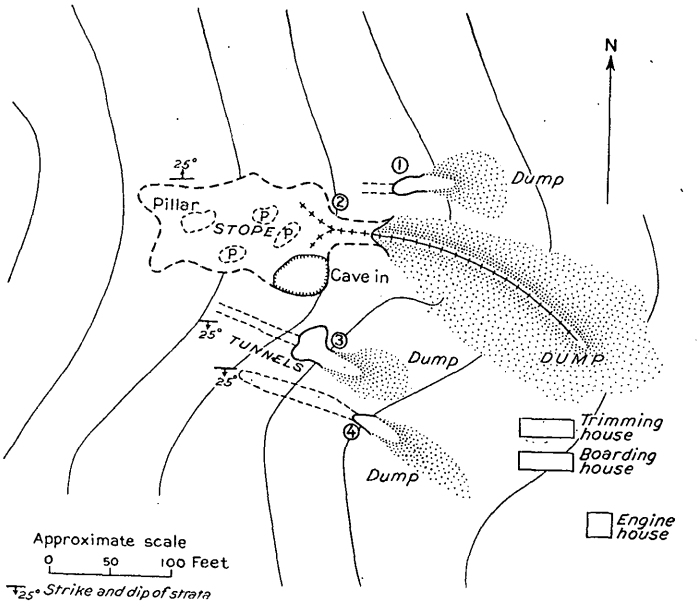


FIGURE 47.—Plan of Meadows mica mine, 1 mile north of Plumtree, N. C.

1. Small open cut with a tunnel from the west end, now caved in; little to be seen.
2. Short tunnel opening into a large stope nearly 200 feet long and 100 feet wide. This stope is on an incline from 20° to 25° N. and contains some rooms 20 feet high. Pillars were left where necessary to support the roof. A mine car and track are used to carry waste rock to the dump. The stope north of the entrance is lower than the tunnel and that south is higher.
3. Large tunnel or stope from the west side of a small open cut. The tunnel is about 75 feet long.
4. Tunnel about 100 feet long. This tunnel is about 35 feet lower than tunnel No. 3 and about 45 feet lower than the main working or No. 2.

dip. The pegmatite is in part conformable with the inclosing gneiss, striking east. It is a large folded bed, and the axis of the fold lies along the south side of the large stope in working No. 2. On the north side of this axis the bed dips north at an angle of about 25°; on the south side it dips about 25° south. The pegmatite is at least 20 feet thick in the upper part of workings No. 2 and in workings No. 3. It pinches to a thickness of 2 feet at the bottom of the large stope No. 2. Small overlapping lens-shaped bodies of pegmatite are in-

closed conformably in the gneiss near the large mass of pegmatite. The lowest tunnel, No. 4, cuts the pegmatite on its dip to the south.

Streaks of mica were found near both the footwall and the hanging wall. These were reported to be equally rich. Good mica was found also in the mass of the pegmatite between these streaks, and a few crystals lie close to the mica gneiss walls. The mica averages a good size and crystals are found more than 20 inches in diameter. It has a brownish color and some of it is partly specked. Clear mica is reported to have been obtained from tunnel No. 3, but most of that from the large stope is more or less specked. The crystals have a good flat cleavage and the mica is flexible, making it adaptable to electric use.

DOUBLEHEAD MINE.

The Doublehead mine is about 1 mile N. 70° W. of Plumtree. According to information furnished by Ben Aldrich in 1896 the deposit of mica here was found by George Shade about 1870, and was opened by C. W. Burleson. A few years later it was profitably worked by Ben Aldrich, and in 1891 by W. W. Avery. Since that time it has been worked in a small way at intervals.

The mine consists of open cuts, pits, and tunnels dug continuously for a distance of nearly 200 yards in a N. 25° E. direction along the west slope of a hill. The country rock is biotite gneiss, which has a variable dip and strike. Near the north end of the workings the gneiss strikes north and dips 50° W. in one opening. Near the south end a strike of N. 25° W. and a variable dip approximating about 25° NE. were measured. The pegmatite is not conformable or is only partly conformable with the inclosing gneiss. In places it is lentic-

According to Capt. Isaac English this deposit was opened by Col. Milton English and C. W. Burleson. It was operated nearly continuously for eight years and has since been intermittently worked by others. Capt. English said that the output up to 1896 had sold for more than $100,000, but Mr. Benson Grindstaff placed it at $37,000.

ular and the openings do not all appear to be on the same mass. The mica, though clear, has a dark-brownish rum color. Pegmatite that seems to contain mica crops out to the north, along the top of the ridge in which the Doublehead mine has been dug.

ALFRED OR VANCE MINE.

The Vance mine, or the old Alfred mine, is half a mile west of Plumtree in a hillside at the level of a small stream. The workings extend for about 250 feet along the outcrop and are chiefly open cuts. The more recent workings are an open cut and an incline on the south-

east end of the outcrop. A bucket pump operated by a water wheel in a branch near by was used to keep the mine dry.

The country rock is biotite gneiss striking N. 30° W. and dipping about 35° SW., and with it the pegmatite is conformable. Where exposed in the open cut the pegmatite is about 12 feet thick. The mica has a dark greenish-brown color and some is partly specked. The quantity found is said to be satisfactory.

MILTON ENGLISH MINE.

The Milton English mine, which is about a mile northeast of Plumtree, furnishes some striking examples of the occurrence of typical pegmatite in lenses. The pegmatite lies in one of the smaller bodies of biotite gneiss that are included in the large area of hornblende gneiss which forms the country rock of the region. The rocks exposed in the mine lie nearly horizontal, showing only a few gentle monoclinal folds, which dip southward.

A tunnel has been driven southward for a distance of more than 450 feet, and from this tunnel drifts have been run both to the east and to the west for distances of 25 to 60 feet. The tunnel was carried back by a series of rooms, some of them about 25 feet wide where the "vein" was very rich. The size and shape of these rooms depended on the size of the pegmatite lenses that were removed in mining the mica. In some places all the pegmatite had been removed on one side of the room or the other. In other places a streak a few inches thick was left in the walls, showing where the lens had pinched down from the height of the room to a few inches. Cross sections of the lenses of pegmatite can be seen in the walls and faces of the workings. Some are 6 to 10 inches thick and 2 feet long; others are 5 or 6 feet thick and of proportional or even greater length. These lenses overlap or lie parallel to one another. Many of them lie in the same stratum of gneiss, though they may be several feet apart. A thin seam or parting that contains in places a little pegmatite can generally be traced between two such lenses. Here and there the pegmatite occurs in sheets or streaks, which in places bulge out into lenses. These streaks may pinch down to mere threads, but when followed a little way they open out into lenses. The full thickness of the belt of overlapping and parallel pegmatite lenses and streaks is generally less than 8 feet. The mica gneiss curves around swells and bulky parts of the lenses.

From the mouth of the tunnel the outcrop of the pegmatite has been traced both east and west for some distance around the mountain side. A diabase dike, which the miners call "the iron bar," follows the pegmatite back as far as work has been carried. It is very irregular, cutting into the pegmatite in one place and then not appearing again for some distance.

The texture and composition of the pegmatite are those of very coarse granite. The three consistuent minerals are thoroughly mixed and have separated out in large masses. Even in lenses only 10 inches thick mica crystals 5 or 6 inches in diameter have been found. The quality of the mica is excellent. The color is a clear light rum when the sheets are about one-eighth of an inch thick. The lamination is perfect, and beautiful sheets for glazing can be obtained. The yield of mica is satisfactory in view of the quantity of rock removed, and a fair proportion of the larger sizes is found.

PLUMTREE MINE.

The Plumtree mine is half a mile east of Plumtree, on Plumtree Creek. The deposit mined was discovered by C. W. Burleson about 1870 and was worked by him for about six months. It was later worked by Col. English, Col. Rorison, W. W. Avery, and others, and after a period of idleness was reopened in 1906 by Burleson Brothers. The "vein" was exploited by an open cut on the outcrop, a 30-foot incline, and a tunnel or drift run from a lower level. The country rock is mica gneiss interbedded with hornblende gneiss, and the wall rock is mica gneiss. The pegmatite, which is nearly conformable with the inclosing formations, strikes about N. 25° W., and dips 10°–25° NE. It is 18 inches to 4 feet thick. The mica streak lies near the hanging wall and in places is separated from the wall by a vein of quartz 3 to 5 inches thick. The crystals of mica are large, some weighing as much as 50 pounds. Many are badly crushed and crumpled and are suitable only for grinding. The quality of the sound crystals is good. The sheets have a greenish cast and are in places slightly specked.

JOHNSON MINE.

The Johnson mine is 2 miles east of Plumtree, on Plumtree Creek. The country rock at this mine is hornblende gneiss, biotitic near the contact with the pegmatite. The pegmatite is nearly conformable with the inclosing gneiss, which lies almost flat at some places and has gentle rolling folds in others. The pegmatite ranges in thickness from a few inches to 7 feet and is reported to be richest in mica where it is 2½ and 4 feet thick. The main opening consists of a tunnel about 100 feet long, running N. 30° W. for 80 feet and then due north for 20 feet. The pegmatite in the last 30 feet of this tunnel is 7 feet thick and carries little mica. Other tunnels have been run, following the deposits of the best mica. The rolling structure of the formation can be seen from the two dips and strikes. At the entrance to the main tunnel the strike was about N. 70° E. and the

dip 20° N. A little way in the rock was nearly flat, and near the end of the tunnel the strike was due north and the dip 15° W.

The mica obtained from this mine is of the finest quality and has a rich rum color. One block is reported to have been worth more than $100.

CHARLIES RIDGE MINE.

The Charlies Ridge mine is 1½ miles west by south of Plumtree and half a mile west of Spear, about 200 yards southeast of the Justice mine. It was discovered about in 1882 or 1883 by Ben Aldrich and was worked by him for about six months. It has been operated at different times by Samuel Landers, Col. Irby, and W. W. Irby.

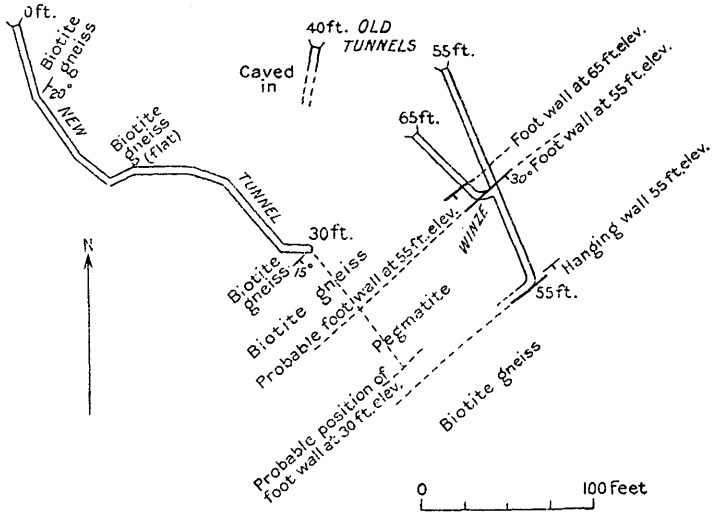


FIGURE 48.—Plan of Charlies Ridge mica mine, near Spear, Avery County, N. C. Figures give elevations above mouth of new tunnel. The position of the pegmatite is shown on the 55 and 65 foot levels; also the probable position at the level of the end of the new tunnel.

During 1905 and 1906 it was reopened by A. Miller, C. W. Wisler, and J. W. Walters. The earlier work consisted of three tunnels and some pits. The new work consisted of a tunnel about 230 feet long at the time it was visited in 1906. This tunnel was expensive, having been run through very hard rock in a devious course at the rate of about 3 feet a week. A plan of the workings showing the position of the pegmatite is given in figure 48. The elevation of the mouth of the new tunnel is given as zero, and the other three were run in about 40, 55, and 65 feet higher up and to the east. The new tunnel rises nearly 30 feet from its mouth to its head and would have to be driven about 80 feet farther S. 40° E., to strike the "vein."

The country rock is biotite gneiss, whose dip and strike vary, though in general the strike is northeast and the dip southeast. The

mass of pegmatite is large and is richer in mica near its walls than in the interior. A streak of highly foliated biotite schist 3 to 6 inches thick extends along the walls.

JUSTICE MINE.

The Justice mine is 1½ miles west by south of Plumtree and half a mile west of Spear, about 200 yards northwest of the Charlies Ridge mine. It was discovered prior to 1875 by John Justice and worked by him for two years. He employed about half a dozen men to drive tunnels and to sink a shaft, which was 55 feet deep. The "vein" was 10 to 12 feet thick but did not yield mica of the best quality. A large quantity of mica was removed, but as the market for the poorer grades was not good then the mine did not pay well.[67]

The mine was reopened in 1906 by Dr. Buchanan, who drove in a tunnel nearly 200 feet to find the old workings. The work was not easy for the formation was soft and caved badly. The country rock at the mine is garnetiferous biotite gneiss in which the garnets are very small. The mica is slightly specked but suitable for electrical uses.

PYATT AND VANCE MINES.

The mines of D. N. Pyatt and Matilda Vance are nearly 4 miles east by south of Plumtree, on the summit of the Blue Ridge Mountains. The Vance mine is about 75 yards N. 50° E. of the Pyatt mine. Both mines have been worked intermittently by D. N. Pyatt. In the Pyatt mine four parallel streaks of pegmatite were found in one place and two streaks in another. The strike of the formations at the first place is N. 75° E. and the dip 40° N. In the second opening the strike was more nearly northeast. The Pyatt mine consists of several pits and shallow shafts, none more than 20 feet deep, and three short tunnels. The Vance mine consists of pits only. The mica obtained at these mines is of a dark brownish-green color, and part of it is much specked with magnetite.

Dark-colored and black specked mica of quality similar to that at the Pyatt and Vance mines is said to have been found at the Lineback mine, which is 3 miles north by east of them.

McKINNEY OR POWDERMILL CREEK MINE.

The McKinney mine is about 3 miles northwest of Plumtree, on the north slope of a mountain south of Powdermill Creek. The workings consist of an open cut nearly 100 feet along the strike of the "vein" and not more than 15 feet deep in any part. The pegmatite lies in a streak of biotite gneiss a few yards north of its con-

[67] Information furnished to J. A. Holmes by John Justice in 1896.

tact with hornblende gneiss, which forms the country rock of the region. The pegmatite is conformable with the gneiss and strikes due east at the west end of the cut and about N. 80° E. in the eastern part. Its dip is about 80° S. Its width averages about 6 feet, though it increases to 8 feet or more near the middle of the cut. At a point near the west end the south wall elbows out, causing the pegmatite to pinch abruptly from 6 to 4 feet. In general, however, the variations in size are more gradual. The pegmatite has been traced by prospect pits for some distance farther east.

The texture of the pegmatite is that of coarse granite, except for a width of a few inches along the contact, where it is very fine grained and of dark color, there preserving a marked contrast to the rest of the mass. A view along the contact of the pegmatite is given in Plate XXI, *B*. The feldspar is chiefly plagioclase. The mica generally occurs near one wall or the other, though some large blocks lie near the middle of the "vein." It has a rather dark brown color and part of it is somewhat specked. It is fairly plentiful, however, and blocks of good size are frequently obtained.

McCOURY AND OTHER PROSPECTS.

The T. H. McCoury mica mine is on the southwest side of Roaring Creek, about a quarter of a mile above its mouth on North Toe River, 2½ miles north of Plumtree. A 50-foot tunnel has been driven N. 50° W. slantwise across the hornblende gneiss country rock and the inclosed pegmatite. The pegmatite is about 5 or 6 feet thick, strikes 70° W. and dips 25° S. The mine was reopened during 1906. The mica is dark-brown. A prospect about half a mile southeast of the other was opened by McCoury in 1906. The mica found has a dark rum color. It is said that about $450 worth of mica was taken from this mine during the summer.

A dark green mica is reported from a mine owned by A. L. Miller and operated in 1906 by Mark Buchanan, on North Toe River half a mile above the mouth of Roaring Creek.

Two other mica prospects were reported on the top of the ridge or spur running east from Little Yellow Mountain toward the mouth of Roaring Creek. One of these, owned by J. S. Pritchard, is half a mile and the other is 2¼ miles due west of the mouth of Roaring Creek.

BUNCOMBE COUNTY.

NEW BALSAM GAP MINE.

The New Balsam Gap mine is near the head of North Fork of Swannanoa River, about a mile southeast of Balsam Gap. The mine is on the face of a cliff about 70 feet high, a few feet from a water-

fall. The "vein" was worked by an open cut at the foot of the cliff, about 60 feet long. A tunnel or stope 15 or 20 feet high was then driven back under the cliff on the "vein" for 70 feet. The pegmatite was removed to its full width, 6 to 8 feet, and the waste was left to accumulate in the bottom of the tunnel for stoping out the "vein" above. The country rock is much-folded biotite gneiss, striking north and dipping high and irregularly to the west. The pegmatite cuts across the schistosity of the country rock with a strike of N. 45° E. and a nearly vertical dip. The pegmatite is very irregular in size and at one place in the roof of the tunnel pinches down to

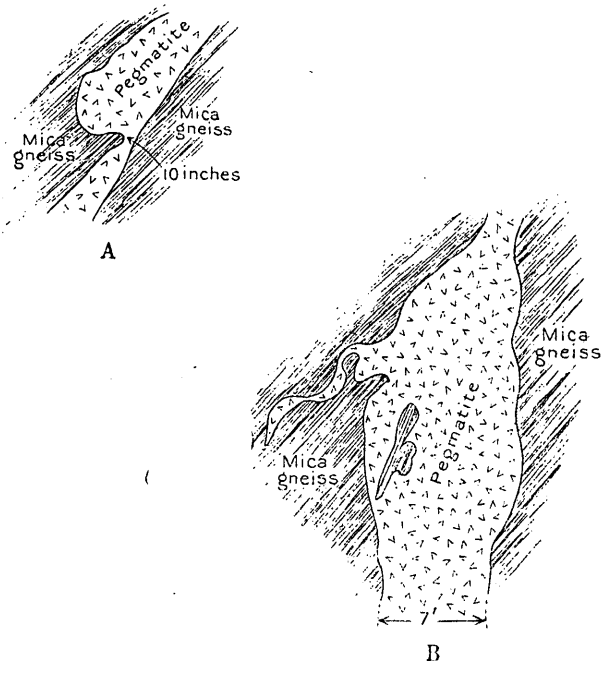


FIGURE 49.—Plan of New Balsam Gap mica mine, Buncombe County, N. C. A, Section showing pegmatite pinched down to 10 inches and elbowing out abruptly; B, irregularity of pegmatite exposed in end of tunnel; lenticular-shaped cross section with small side stringer and horse of mica gneiss.

a width of about 1 foot, but abruptly elbows out again to a width of several feet, as shown in figure 49, A. The irregularity of the pegmatite is further shown by the exposure in the end of the tunnel, of which figure 49, B is a vertical cross section. The pegmatite pinches down in its upper part, is large in the middle, and smaller again at the bottom. There is an elbow in the "vein" on the west side, where a small arm of pegmatite branches off into the mica gneiss. An irregular horse of gneiss was included in the "vein." The pegmatite is composed of the usual minerals, which are in places segregated out into coarse masses. The quartz and feldspar occur in masses 2 or 3 feet thick, and the mica is richer in some places than in others. At

one place in the roof where the pegmatite pinched down to a width of 2 feet it carries abundant mica. The mica is good and is associated with some biotite.

CONNALLY MINE.

The Connally mine is 4 miles north by west of Black Mountain station, on the east side of North Fork of Swannanoa River. The country rock is diorite or hornblende gneiss, carrying bands of mica gneiss. The mine formerly consisted of cuts and shafts on the hillside about 100 yards above the entrance to a new tunnel. The outcrop of the pegmatite at the old workings was marked by much

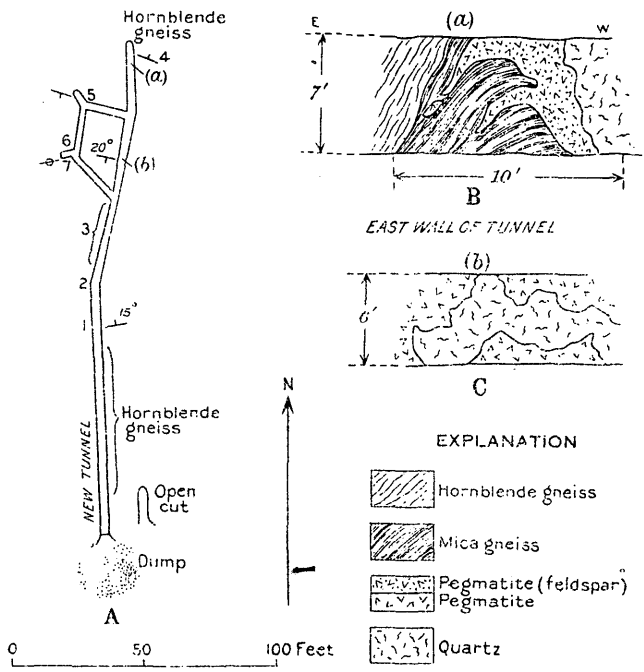


FIGURE 50.—A, Plan of Connally mine, Buncombe County, N. C.; B, section in east wall of tunnel at (*a*) in A.; C, section in east wall of tunnel at (*b*) in A. See text for explanation of reference figures.

massive quartz. A new shaft sunk near the old workings encountered pegmatite. The new tunnel was driven eastward for nearly 200 feet. Side tunnels were run near the end, as shown in figure 50, A. At 1, figure 50, A, a small lens or streak of pegmatite cuts across the hornblende gneiss walls of the tunnel. At 2 there is a vertical contact of hornblende gneiss on the left and pegmatite on the right. For a number of yards at 3 there is hornblende gneiss in the bottom of the tunnel and pegmatite in the upper part. At 4 the pegmatite gives out and hornblende gneiss is encountered. The irregular nature of the contact here is shown in figure 50, B, which represents the section at (*a*) exposed on the east wall. The felds-

pathic part of the pegmatite forks into mica gneiss. At 5 and 8 there are irregular streaks of massive quartz. Between 6 and 7 there is a vertical contact between pegmatite and hornblende gneiss. At (*b*) another large irregular mass of quartz is included in or forms a part of the pegmatite. It is shown in cross section in figure 50, C, as it appears in the east wall of the tunnel.

The feldspar of the pegmatite is badly kaolinized, and it was the intention of Col. Connally to test the deposit for kaolin. The mica occurs chiefly in the kaolin along the masses of quartz and in many places is much crushed. The quantity of mica found in the new tunnel was not large, but the old workings on the hill above are reported to have yielded well. The mica obtained was of clear light-rum color and good quality.

W. H. BURNETT MINE.

The Burnett mine is about 200 yards north of the Connally mine. The pegmatite here was worked by an open cut a number of years ago. The country rock is hornblende gneiss and interbedded mica schist striking N. 10° E. and dipping 80° W. It is said there were prehistoric workings at this mine.

BRUSHY MOUNTAIN MINE.

The Brushy Mountain mine is about a mile west of the Connally and Burnett mines, on the end of Brushy Ridge. It is reported to have been a good producer and was in operation about 1874 or 1876, when it was visited by Prof. Kerr. The last work was done on this mine about 1894. Other prospects for mica are reported in the mountains near this mine, and another old mine, the Bee Tree Mountain mine, has been opened more recently about 2 miles to the west.

R. M. DAVIDSON MINE.

The Davidson mine is on the Alexander place, 1 mile northeast of Swannanoa. The workings are old and consist of an open cut, a shaft, and a tunnel. Of the little scrap mica left around the mine the greater part was A, though some was clear, had good cleavage, and was of nearly the size of the hand.

Considerable work is reported to have been done at the Glass mine, about 2 miles north by east of Swannanoa.

GUSTAVINO MINE.

The Gustavino mine is a mile south of Black Mountain station. It was worked by an open cut, which was 18 feet deep in the deepest part and about 100 feet long, and two shafts run from the bottom of the cut. The "vein" is conformable with the inclosing mica schist, strikes N. 35° E., and dips about 70° E. Only a little mica was seen

on the dump, but that was of light color and apparently of good quality.

Mica and gem aquamarine beryl are said to have been found on the land of J. F. Reece, 1½ miles southeast of Black Mountain station. Considerable work is reported to have been done on the old Bearden mine, about 1 mile north by east of Montreat, and a new promising prospect is reported about half a mile south of Montreat on a spur of the Blue Ridge Mountains.

BURKE COUNTY.

BUZZARD ROOST KNOB PROSPECT.

A deposit was opened some years ago on the ridge half a mile east of Buzzard Roost Knob, 8¼ miles S. 15° W. of Morganton, in the South Mountains. The workings consisted of an open cut with a short tunnel. The country rock is mica gneiss, which strikes N. 30° E. and dips irregularly to the southeast. The pegmatite cuts the gneiss with a northerly strike. A ledge of massive white quartz about 2 feet thick forms a prominent part of the pegmatite. Clear, light-colored sheets of mica 2 inches across were seen around the dumps.

BURKMONT PROSPECT.

A small pit was opened in a mica deposit a quarter of a mile south of the top of Burkmont Mountain, 5½ miles S. 10° W. of Morganton. Clear light-colored sheets of mica 3 to 4 inches across were left around the prospect.

In another prospect, 1¼ miles S. 10° W. of Burkmont Mountain, a little mica was found, most of it of small size but of good quality. Beryl crystals an inch in diameter, some of which were translucent to transparent light green and yellowish green and a few gold-colored, were also found.

A small mica prospect has been opened on the side of Ironmonger Mountain, west of Mitchell Gap, 4½ miles southeast of Morganton. Small crystals of mica of fair quality were found.

CATAWBA COUNTY.

Mica is reported to have been worked on a small scale north of Henry, near the Lincoln County line. The prospects are on the continuation of the belt extending from the northwest corner of Gaston County across Lincoln County. Another prospect was opened in 1916 by J. E. Burleson, of Spruce Pine, N. C., about a mile northwest of Baker Mountain, or about 6 miles southwest of Hickory. Clear rum-colored mica was found.

CLEVELAND COUNTY.

W. H. THOMPSON OR WYATT MINE.

The W. H. Thompson mine is 2¾ miles north of Fallston. It was opened by several shafts and by tunnels carried from them. Much material has been removed, and as the rock is soft and the timbering was probably scant most of the workings have fallen in, causing the ground above them to subside several feet. The openings lie within an area measuring about 60 yards east and west by 20 yards north and south. The country rock is garnetiferous mica gneiss carrying kyanite in places. The garnets have not weathered so fast as the rock and remain thickly scattered through the residual soil near the mine. Some of them measure as much as 1½ inches in diameter. The products of this rock weathering consist chiefly of clay through which abundant rusty garnets, fragments of hematite, and tufts of kyanite impregnated with hematite are scattered. The strike of the rock near the mine is nearly east and west with variations to the northwest in places, and the dip is nearly vertical. In two of the shafts and in the tunnels on the north side of the deposit there were ledges and streaks of quartz in the large kaolinized feldspar formation exposed. Blocks of mica several inches in diameter had been left in the wall and on one of the masses of quartz. Small blocks were included in the quartz itself. The pegmatite appears to occur in a short deposit more than 50 feet thick. An opening made about 20 yards east of the main workings exposed a small body of pegmatite 2 or 3 feet thick that has a northwest strike, thus cutting across the apparent strike of the main mass.

The mine has produced a large quantity of good-sized mica of clear rum color and excellent quality. The chief difficulties encountered in mining were caving formations and the quantity of water that had to be pumped from the workings. The last work was done about 1904 and 1905 by J. E. Burleson, of Spruce Pine, N. C., who reported obtaining about $15,000 worth of mica.

CALVIN CARPENTER MINE.

The Calvin Carpenter mine is 1 mile south by west of the southwest corner of Lincoln County. Some of the workings were opened long ago. The principal work consists of shafts and pits on a pegmatite "vein" striking N. 60° W. and dipping vertically. Another deposit of pegmatite was prospected by pits about 75 feet to the north. These deposits are inclosed in mica gneiss, into which much granite has been intruded. The south "vein" is about 8 feet thick. A streak of massive quartz about 2 feet thick is inclosed in the kaolinizing feldspar. Part of this quartz is highly translucent to

nearly transparent. Little could be learned about the quantity of mica obtained, but a study of the small crystals left around the mine showed that it is clear rum-colored mica of good quality.

FRASER-ENGLISH PROSPECT.

A prospect was opened by Fraser & English a little more than half a mile south by east of Beam Mill. A crosscut trench 12 feet deep was run for about 90 feet and a shaft was sunk at the inner end of it. The country rock is interbedded biotite gneiss and mica schist. Some beds of the gneiss resemble quartz diorite. The formation is nearly flat, but shows small rolls or folds. The pegmatite cuts across the gneiss with a strike of N. 30° E. and an irregular northwest dip, elbowing out at some places into the gneiss from a few inches to a foot. The pegmatite is 8 to 10 feet thick. The feldspar has partly kaolinized. Quartz occurs in irregular segregations, and there is one veinlike streak in the interior. The mica has a clear rum color, but at the time of examination only rather small crystals had been found.

M. M. MAUNEY MINE.

The Mauney mica mine is about 1 mile southwest of the old Camp Call post office, or 9 miles northwest of Shelby. It was first worked more than 35 years ago and has not been worked within 20 years. The country rock is much crumpled mica schist-gneiss having a general strike of about N. 45° W. The pegmatite cuts across this with a strike of N. 20° E. and a nearly vertical dip. The part exposed in the old workings is composed of a band of quartz about 5 feet thick with 2 to 4 feet of feldspar, quartz, and mica on each side. The mine was worked by an open cut 20 feet deep and 40 feet long and a shaft with tunnels, both now fallen in. All the mica on the west side of the quartz ledge in the bottom of the open cut was removed but only part of that on the east side. The mica is of fine quality and has a clear rum color. Specimen sheets measuring a foot across have been kept in the Mauney home.

S. J. GREEN MINE.

The Green mine is about 7 miles northwest of Shelby. It was worked first in the seventies and again later. The workings have fallen in badly. The country rock is mica schist-gneiss striking north and dipping 70° W. The vein of pegmatite strikes about N. 70° E., as shown by the position of 8 or 10 shafts and pits with tunnels. These workings are all within about 60 yards of one another. Streaks of massive quartz as much as 3 feet thick were encountered in the pegmatite. In one of the workings the material was obtained from the north wall of one of the quartz ledges. The peg-

matite is rich in feldspar, which is more or less kaolinized in places. The mica is of good quality and has a clear rum color.

INDIAN TOWN AND CASAR MINES.

The Indian Town and Casar mines are at the north end of Cleveland County, 3 miles east by north of Casar and on the southeast side of Casar, respectively. The Indian Town mines cover an area of more than a square mile and consist of about a dozen small open cuts or shallow shafts, which have caved in badly. The same may be said of the deposits near Casar and of one near Carpenter Knob, 5 miles east of Casar. The country rock of this general region is a highly schistose gneiss, of which mica, kyanite, and garnet are the constituent minerals. The gneiss in this region has been much folded and crumpled and at some places has been intruded by granite. The pegmatite bodies opened for mica appear generally to cut across the schistosity of the gneiss, though at some places they are conformable with it. They range in thickness from 2 to 15 feet and are rather irregular in shape. In most of the deposits masses of quartz are encountered, generally in the form of ledges or veins in the pegmatite. Few large bodies of feldspar or its alteration product, kaolin, are found with the mica. Much of the mica obtained in this region is of excellent quality and has a rich rum color. Part has A markings, but large sheets have been cut between the A lines.

E. C. HAMBRICK MINE.

The Hambrick mine is 4 miles west of Shelby. It was worked by an open cut, a 45-foot shaft, and a tunnel. The "vein" has an easterly strike and cuts kyanite-mica schist-gneiss wall rock unconformably. The mica is clear and of good quality. It is said there was a large output, though mining was hindered greatly by water. Other prospects have been found on the place.

E. R. ELLIS MINE AND OTHERS.

The Ellis mine is 4½ miles west of Shelby. It was worked by several shafts, one to a depth of 50 feet. The mica was much ruled, and some had the A structure strongly developed. Other mica prospects are reported on the land of Mrs. McFall and Burl Blanton north of the Ellis mine, and on the land of Coach McSwain and R. McSwain, 5 miles west of Shelby.

SAM PUTMAN MINE.

The Sam Putman mine is 5½ miles northwest of Shelby. It was last worked about 1892. The workings consist of an open cut along the "vein," a shaft in the bottom of the cut, three other shafts,

tunnels, and a pit. The country rock is mica gneiss, which strikes northeast and dips 30° SE. The work on the "vein" was carried N. 70° E. The mica is of fine quality and is said to have included sheets measuring 18 by 22 inches. About 20 feet north of the main "vein" another smaller "vein" has been opened, which yielded poorer mica and more of the A variety.

A quarter of a mile west of this mine another deposit was opened by a cut 60 feet long and 18 feet deep in the deepest part on a pegmatite running N. 70° E. The wall rock is mica gneiss, which strikes north and dips from vertical to east. The mica is said to have been of good quality, and a crystal of beryl measuring 3 by 15 inches is reported to have been found.

Two other openings for mica have been made on Putman's place, in one of which a quartz ledge formed the prominent feature of the "vein."

TOM CABANISS MINES.

Several mica mines and prospects have been opened on the Tom Cabaniss place, about 5 miles northwest of Shelby, since 1870. None of these have been worked since 1898, and nearly all have fallen in badly. Window panes made of sheets of clear, light-colored mica, measuring 10 by 12 inches, were seen in the Cabaniss house. These sheets are said to have been in service for 35 years at the time of the examination, in 1906.

Mica prospects and mines are reported on the old Abel Poston place, a quarter of a mile east of the Cabaniss home; on the lands of Joe and Charles Blanton, 4½ miles northwest of Shelby; on the lands of J. D. and W. P. Weathers, along the narrow-gage railroad from Shelby to Lawndale, about 4½ miles from Shelby; and on the land of Mrs. Jane Lutz, 5 miles north of Shelby.

MAYNARD WASHBURN MINE.

The Maynard Washburn mine is 5 miles west-northwest of Shelby. Many of the workings are old, but some were made about 1904. They consisted of three shafts, with tunnels, and two pits. There are two "veins," one of which, with a strike of about N. 70° W., carries a large streak of quartz as a wall on the south side and was opened by two shafts, each about 40 feet deep. The other "vein" was opened by a shaft and pit and is about 50 feet north of the main workings. Much of the mica on the dumps at this mine was of the A variety, though some of good quality was seen.

The old T. C. Eskridge mine, now A. Blanton's, is near the Washburn mine and has fallen in badly. The workings consisted of a shaft and a cut about 100 yards east of it.

W. F. GOLD MINE.

The Gold mica mine is 6½ miles north by west of Shelby on the road to Lawndale. There are two prospects here, one near the house and the other one-third of a mile to the south. The one near the house had been opened by a pit 12 feet deep, now nearly filled up. Part of the mica obtained from this place was badly A lined, but some good clear material was obtained.

At the mine one-third of a mile from the house the "vein" had been worked for 60 feet on the surface by ground-hog openings, and there was another pit 60 yards to the west. The country rock is kyanite-mica gneiss, which strikes north and dips 65° E. A granite mass lies to the north. The pegmatite cuts the gneiss with an east strike and vertical dip. The mica occurs along the walls of a large quartz ledge, which in some places is 8 feet thick. At the pit west of the main workings the gneiss strikes northwest and dips 50° NE. The mica obtained at this mine was of good quality and had a clear rum color.

Half a mile east of the Gold mine a 60-foot shaft is reported to have been sunk on a mica "vein" at the McAlister mine on Sam Putman's place. It is said that all the mica was mined and that kaolin was found at the bottom of the shaft.

J. H. ROYSTER MINE.

The Royster mine is about a mile northwest of the southwest corner of Lincoln County. Two prospects have been opened. The one farthest south exposed a promising body of pegmatite, which cuts across granite gneiss. The gneiss strikes N. 70° E. and dips 75° N. The operations consisted of two shaftlike open cuts, 20 and 25 feet deep. Mica of good quality was seen on the dump and large sizes are said to have been mined.

Mica has been found and work has been done intermittently at a number of other places in Cleveland County. V. A. Smith, of Golden, N. C., opened a prospect on the J. F. Morrison lands, about 4 miles east of Lattimore, early in 1916. A shaft was sunk to a depth of 35 feet and drifts were run from it in two directions. Mica that would cut into sheets measuring 10 by 12 inches is said to have been found.

GASTON COUNTY.

Mica was worked on the Mauney Carpenter place, close to the Lincoln County line, about one-third of a mile from the northwest corner of Gaston County. Other prospects have been opened in this vicinity. Considerable work has been done about 8 miles north of

Kings Mountain. M. M. Carpenter, of Kings Mountain, operated some of these mines between 1890 and 1900. He says that the work was rarely carried below water level. The occurence of the mica in this region is very similar to its occurrence in Lincoln and Cleveland counties. The country rock is generally mica gneiss, kyanitic, and garnetiferous in places. The pegmatite either cuts the schistosity of the gneiss or is partly conformable with it. Masses and streaks of quartz occur in some of the pegmatites and not in others. The mica obtained is generally the same fine clear rum-colored variety as that in the adjoining counties.

HAYWOOD COUNTY.

BIG RIDGE MINE.

The Big Ridge mine is about 6 miles south by east of Waynesville, high up on the southwest side of Lickstone Bald, at an elevation of about 4,500 feet. The mine is equipped with air drills and a steam pump. The mica-bearing pegmatite is conformable with the mica gneiss country rock and is folded with it into an anticline, the axis of which strikes about N. 80° E. and pitches 20° or more into the mountain side. The angle of the fold is not sharp, yet the legs dip about 45° a few rods from the axis. The workings consist of tunnels and drifts along the pegmatite, with stopes and raises between. On the north leg of the fold the "vein" has been removed for a depth of about 300 feet, but on the south leg it has been worked for only about 100 feet. The pegmatite is fairly regular in thickness and would probably average 8 feet in a large part of the mine. In certain places where the full width of the "vein" has been removed rooms 12 to 15 feet high were left. The greater part of the pegmatite has a coarse granitic texture. A peculiar graphic-granite texture has been observed in some parts of the pegmatite, caused by a parallel orientation of plates of biotite in a matrix of feldspar and quartz. A thin section cut from such a piece showed under the microscope, a semimicrographic arrangement of quartz in feldspar crystals. The feldspar is largely albite. A large quantity of biotite, probably one-fourth or one-third of all the mica in the "vein," is found with the clear mica, and in places the two form intergrowths with such other. Apatite, hornblende, and garnet are the accessory minerals. The mica is of clear light rum color and excellent quality. The mine has been worked for many years and has been a good producer, but in some years it is closed during part of the winter, as it is then difficult to keep up sufficient steam to run the air compressor because of the high elevation.

SHINY MINE.

The Shiny mine is near the head of Allen Creek, 1¼ miles north of Richland Balsam Mountain. It is 450 feet above the creek in the steep, cliff-like face of the west valley wall. Access to it was obtained over a rough trail and several sets of ladders. The workings consist of an open cut run northward for nearly 200 feet along the side of the mountain and in places 25 feet deep. The country rock is very hard garnet gneiss, which has a northerly strike and a nearly vertical dip. The pegmatite is conformable with this rock and pinches and swells from a few inches to several feet in thickness, and streaks branch out from it. The pegmatite contains masses and streaks of quartz. Pyrrhotite is scattered through both the country rock and part of the pegmatite. The mica is rather thick in parts of the "vein," though only small crystals were left exposed from the last operations. Sheets measuring 5 and 6 inches across were seen at the old trimming house in the valley below the mine. These sheets were of very good quality.

SPRUCE RIDGE MINE.

The Spruce Ridge mine is 6 miles south by west of Waynesville, in the point of a ridge leading northward from Spruce Knob on the Balsam Divide, between two forks of Allen Creek. The mine is an old one which was reopened and operated for a short time in 1905 by C. H. Wolford.

The deposit has been worked by a dozen or more pits, shafts, and ground-hog tunnels dug along the west face of the ridge. The country rock is mica gneiss. The mica occurs in streaks or leads in a large pegmatite mass, whose relation to the inclosing gneiss was not evident. Horses and streaks of schist are included in the pegmatite in places and have a variable strike, some striking N. 35° W. A number of the mica streaks extend in the same direction. The pegmatite is semidecomposed and rather soft. Mica occurs abundantly, though chiefly in small crystals. A few of the crystals would yield sheets 4 by 5 inches. The mica has a clear rum color and is generally of good quality.

I. T. WELLS PROSPECT.

The I. T. Wells prospect is 1¾ miles S. 75° E. of the top of Plott Balsam Mountain, on the south side of the prominent ridge extending eastward from that mountain. The prospect is at an elevation of about 4,000 feet on a steep hillside. Two small openings have been made, exposing a ledge of pegmatite about 4 feet thick, which is conformable with the inclosing rock. The country rock

is biotite gneiss containing a small amount of kyanite. It strikes about N. 40° E. and has a vertical or high easterly dip. The gneiss incloses small streaks of pegmatite conformable with its bedding. No work had been done on the prospect for more than a year at the time of the examinations, and only small crystals were seen on the dump or in the "vein." These crystals had a clear rum color and were of good quality. One crystal of mica was observed with ruling lines developed in three directions that cut portions of the mica into triangles.

MARK REECE MINE.

The Reece mine is on the east side of the middle prong of Pigeon River, $1\frac{3}{4}$ miles south of Three Forks. The operations consisted of three small open cuts on a line running east and west and apparently on separate streaks of pegmatite. The country rock is mica gneiss, which has a northeasterly strike. The pegmatite in the middle cut is inclosed conformably or nearly conformably with the gneiss and has a strike of N. 20° E. and a vertical dip. Streaks of mica schist and quartz are interbedded with it and small quartz veinlets cut across the formations about at right angles to the strike. The pegmatite exposed in the easterly cut was 8 feet thick and contained masses of quartz as much as 6 feet thick.

ETHAN COOK MINE.

The Ethan Cook mine is at the headwaters of Pigeon River, a little more than a mile northeast of Haywood Gap. The deposit lies in the bed of a small branch and has been worked by an open cut along its strike. The country rock is biotite-mica gneiss which strikes N. 25° E. and dips high to the northwest. The pegmatite is conformable with the inclosing rock and includes parallel streaks of quartz. The mica is in the part of the pegmatite that lies between the streaks of quartz. A quantity of good mica is said to have been taken from the small open cut. The mica has a clear rum color and flat cleavage.

MIDDLE OLD FIELD PROSPECT.

There is a mica prospect on the northeast side of Middle Old Field Knob, just south of Shining Rock Mountain, which has been worked by a small open cut. The country rock is biotite gneiss, which strikes N. 50° E. and dips 25° NW. The pegmatite, which cuts across the country rock with a similar strike but a steeper northwest dip, is 4 to 5 feet thick. Some biotite is associated with the muscovite, which is of very good quality. Only crystals yielding sheets of 2 by 3 inches were seen around the dumps, though good sheets several inches in diameter were reported to have been found.

The mica crystals are highly transparent transversely to the sheets as is evident in many of the small crystals.

SHINING ROCK PROSPECT.

The Shining Rock prospect is in the gap a quarter of a mile south of the summit of Shining Rock Mountain. It was opened by a pit several feet deep and wide. The country rock is mica gneiss and its relation to the pegmatite was not exposed in the working. An interesting feature at this place is the large ledge of massive white quartz that crops out for about a quarter of a mile along the top of the mountain. This ledge, which is 30 to 60 feet thick, extends down into the gap within a short distance of the mica prospect.

JACKSON COUNTY.

BIG FLINT MINE.

The Big Flint mine is about half a mile west of south of Wesner Bald and about 200 feet above one of the forks of Cabin Creek. The mine was named from the immense boulder-like mass of white quartz that marks its outcrop. Several "ground-hog" pits and tunnels have been made under the mass of quartz, to the west of it, and on the hillside below it. Large masses of quartz outcrop in the branch about 100 yards east of the mine. The country rock is mica gneiss, which strikes east and dips south. The "Big Flint" mass of quartz is about 40 feet across and at least 25 feet thick. It does not appear to be connected with any mass below, for excavations made under a large part of it from each side have encountered only kaolin and mica. The under side of this quartz mass is rounded and is composed of overlapping lenticular and shell-like masses of quartz from an inch or two to a foot thick. Fine partings of mica lie in the seams between these lenses. The feldspar, which is entirely altered to kaolin, is massive under the quartz. This kaolin also shows lens-shaped layers with parting seams or slips about parallel with those in the quartz. In the openings west of the quartz mass the feldspar is massive and contains streaks rich in small mica crystals. A wall of mica gneiss exposed here, probably a horse, strikes north and dips 45° E. The mica obtained from this mine is principally in small sizes but is of light color and good quality.

PINEY MOUNTAIN MINE.

The Piney Mountain mine is a mile north of Sugarloaf Mountain, in the summit of a small knob. The mine has been worked by open cuts, crosscut tunnels, drifts, stopes, and shafts. The positions of these workings are shown in figure 51. Work has evidently been done

on three separate "veins" with varying, nearly northerly strikes and approximately vertical dips. The westerly "vein" was followed from the open cut by a drift with a stope to the surface and a shaft in the bottom of the open stope. At the end of the drift the pegmatite was only 2 feet thick, but it was still fairly rich in mica. An open cut with a shaft in the bottom was made on the middle vein and a stope was driven southward from the cut. A crosscut tunnel was also run to the drift on the west "vein" for the easy removal of waste. The easterly "vein" was the first opened and the workings on it have fallen in badly. It is reported that the mica-bearing part was stoped out.

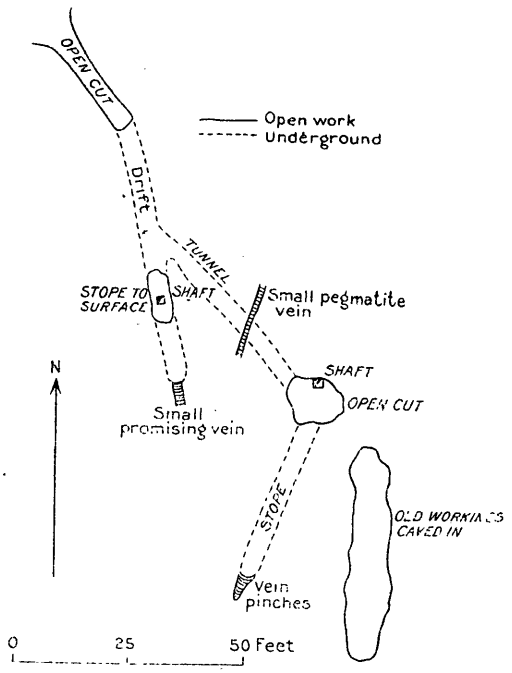


FIGURE 51.—Plan of Piney Mountain mica mine, Jackson County, N. C.

The country rock is mica gneiss. It is cut in various directions by small masses and streaks of pegmatite. The pegmatite worked for mica ranges in thickness from 1 foot to 12 feet. The pegmatite contains at many places a streak of quartz, which is oriented parallel with the walls. The mine is reported to have been a good producer of mica.

RUBY CITY MINE

The Ruby City mine is on the ridge a quarter of a mile west of the Sugarloaf Mountain garnet mill, or "ruby corundum" plant, as it is called. The workings consist of a 20-foot shaft and two prospect pits. The country rock is mica gneiss, which strikes N. 40° E. and dips vertically. The pegmatite is irregularly conformable with the gneiss and is not more than 4 feet thick in any part exposed. Crystals of mica weighing 3 to 5 pounds were seen, but many of them were marked with the A structure or were ruled. The mica has a clear light rum color and is of good quality.

SUGARLOAF MOUNTAIN PROSPECT.

A small prospect was opened on the south side of Sugarloaf Mountain about 200 feet vertically below its summit. The pegmatite is inclosed in the very hard garnet gneiss that composes the mountain.

Only a few blasts had been made, but mica crystals of clear rum color and good quality were found. Most of these crystals were less than 4 inches across.

OCHER HILL MINE.

The Ocher Hill mine is 1¾ miles east of Beta on Ocher Creek. None of the workings were open at the time of the examination in 1906, and all appear to be very old. It is reported that the deposit was worked by aborigines but has never been worked by white people.

About half a mile up Ocher Creek from the Ocher Hill mine, on the west side of the creek, a few hundred feet above the creek level, a small mica prospect is exposed along a little branch on the mountain side. The country rock is mica gneiss and is cut unconformably by the pegmatite. The "vein," where exposed, ranges in thickness from 18 to 24 inches. Small crystals of mica of good quality have been found.

A deposit of mica has been opened on the north side of the State road about 1½ miles east of Beta by a tunnel, an incline, and a small open cut. The pegmatite strikes west by north and the dip on its west wall is 70° E. The "vein" is composed of large masses of semi-decomposed feldspar containing segregations of quartz and having "mica capping." The mica has a light color and is of good quality, though much of it is ruled or has the A structure.

PAINTER MINE.

The Painter mine is 2½ miles S. 65° E. of Sylva, on the northwest slope of a small mountain. The deposit of mica here was opened many years ago by two shafts, with drifts, and a tunnel run at a

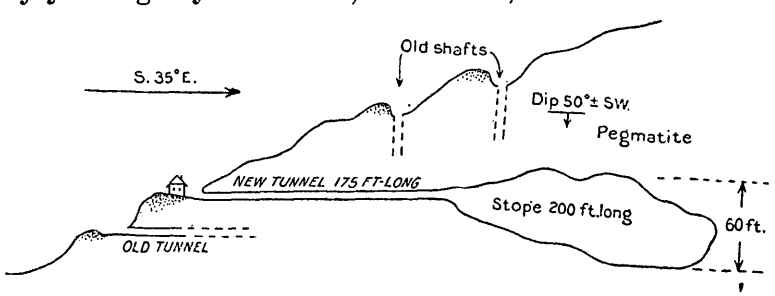


FIGURE 52.—Section in plane of "vein" at Painter mica mine, Jackson County, N. C.

lower level not connected with the shafts. Later work consisted of a tunnel 175 feet long and a stope nearly 200 feet long. The stope, which is very irregular, was carried to a depth of 40 feet below the level of the tunnel and some 20 feet above. A longitudinal section through the "vein," showing the shape of the workings when examined in 1905, is given in figure 52.

The country rock is garnetiferous mica gneiss, which has a strike of N. 35° W. and a high dip to the southwest. The pegmatite is nearly conformable with the inclosing gneiss. The "vein" ranges in thickness from 2 to more than 15 feet. A large streak of quartz in the middle of the pegmatite in this stope is left as a footwall for the workings. The streak of mica lies between this and the hanging wall. More mica might possibly be found by prospecting still further the streak of feldspar between the quartz and the footwall. Several large blocks of mica were exposed in the face of the stope at the time of examination. Most of the mica is clear and of good quality, though a small quantity of specked material was seen on the dumps. A strip of ruled mica of fine clear rum color, saved as a specimen at the mine, measured 2 by 15 inches. It exhibited A structure slightly at each end but was perfectly sound in the middle. The mine was being worked by a Mr. Tustin at the time it was visited by the writer, when it was equipped with a hoisting engine and pump at the mouth of the tunnel and a track in the tunnel and stope. Since then it has been worked on a larger scale with good equipment by R. U. Garrett, whose work during several years has been rewarded by a large production of mica.

TUSTIN KAOLIN AND MICA MINES.

The Tustin mines are on Tustin Mountain, about 2 miles east of Sylva, the kaolin mine on the eastern end and the mica mine on the southwestern end, the two being nearly a mile apart. The kaolin deposit was worked at two levels, one near the top of the mountain and the other on a terrace about 300 feet lower. Large open cuts were made at each place, and circular shafts with cribbing walls were sunk from the lower one. The cribbing was removed and the shafts were filled up after the kaolin had been mined. An incline track connected the two workings. All the kaolin was sluiced down from the lower deposit to a mill in the valley below. This mine produced a quantity of good kaolin when in operation but had been idle for several years when examined in 1905.

The mica mine has been worked from northwest to southeast on each side of and on top of the ridge in which it is located. The workings extend through a vertical height of 150 feet on the northwest side and 140 feet on the southeast side of the ridge. They consist principally of ground-hog tunnels, shafts, and pits. The country rock is mica gneiss, which strikes N. 10°–35° E. and dips 50° or more to the northwest. The pegmatite cuts across the gneiss with a strike of N. 50° W. and a high dip to the northwest. Sheetlike masses of quartz occur in the "vein" parallel with its walls. At the summit of the ridge one of these masses of quartz has a thickness of 3 to 4 feet and is broken into slabs or blocks by

a series of joints perpendicular to its walls. A dike of gray porphyritic granite several feet thick cuts into the "vein" on the northwest side of the hill. Little mica was left around the dumps, except at one or two places on the southeast side of the hill, where a large quantity of small crystals had been found. Only part of these had been saved.

A second and nearly parallel "vein" of mica and kaolin was opened about 150 feet northeast of this deposit from the summit down the southeast side of the ridge through a vertical distance of 150 feet. Most of the mica obtained was taken from the upper openings. A promising body of kaolin was opened by three tunnels in the lower part. The kaolin includes masses and small sheets of quartz.

On the south side of Carver Mountain, 1¾ miles S. 35° E. of Beta, several small prospects have been opened on a deposit of kaolin and mica. In the most northerly pit a small, hard body of pegmatite was encountered. This body had a strike of N. 10° E. and a high dip to the west. In two openings to the south masses of kaolin containing a little mica were found.

E. D. DAVIS PROSPECT.

The Davis prospect is close to the road along Tuckasegee River, at the mouth of Locust Creek, 1½ miles east by south of Webster. It was opened by a small shaft. The mica gneiss country rock strikes N. 75° E. and dips 80° SE. The pegmatite cuts across the gneiss with a strike of N. 10° W. and a dip of 70° W. It is only about 2 feet thick and has a streak of quartz in the middle as much as 10 inches thick. Only two small sheets of mica were seen.

On the south side of Locust Creek a mile above its mouth a crosscut trench was made on a mica "vein." The country rock is mica gneiss, and the pegmatite is apparently conformable with it.

GEORGE WHITE PROSPECT.

The George White prospect is on the ridge southeast of Cane Creek, 2 miles above its mouth and about 4 miles east of Webster. The pegmatite cuts across the mica gneiss country rock with a northwesterly strike. Only "mica capping" and small crystals of mica were seen around the mine. The quality of the small sheets is very good.

ADAMS MINE.

The conditions at the Adams mine, 1½ miles southeast of Webster, in Jackson County, are unique. A granite dike 4½ to 8 feet thick cuts sharply across the country rock, which is mica gneiss. The dike strikes N. 25°–30° W. and dips 55°–70° NE.; the mica gneiss

strikes about northeast and dips from nearly vertical to 70° SE. This granite is light gray to nearly white and is rather fine grained. It has an even texture and shows no banding. The dike has been traced more than 100 yards along the strike by prospects, openings, and tunnels. On each side of the granite throughout its exposure there is a streak of pegmatite from 1 foot to 2 feet thick. (See fig. 53.) At some places this pegmatite consists chiefly of mica, at others of feldspar and some quartz. The contact between the pegmatite and the granite is irregular and is not sharply defined. Many of the crystals of mica, especially those near the contact of the pegmatite with the mica gneiss, have cleavage planes normal to the walls of the pegmatite, but they show no other definite orientation. The feldspar near the surface has been to some extent kaolinized. Most of the blocks of mica are less than 5 inches in diameter. The blocks have a clear rum color, but many of them are damaged by clay stains between the laminae. They are plentiful, however, and yield much punch and scrap material.

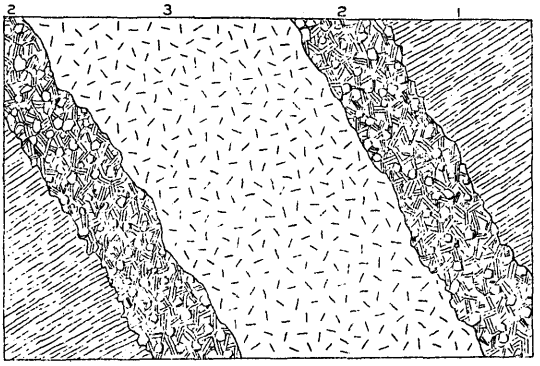


FIGURE 53.—Section of pegmatite at Adams mica mine, 1½ miles southeast of Webster, Jackson County, N. C. 1, Wall rock (mica gneiss); 2, pegmatite, mostly mica; 3, granite, rather fine grained. Distance from wall to wall, 7 feet.

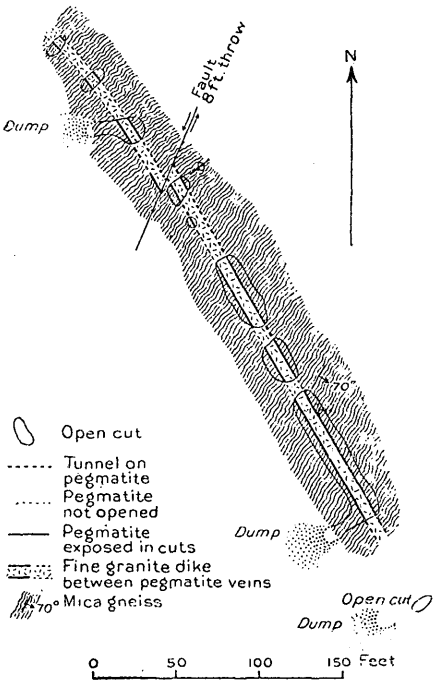


FIGURE 54.—Plan of Adams mica mine, near Webster, Jackson County, N. C., showing the geology.

The streak of mica on the southwest side of the granite has been brought nearly opposite that on the northeast side by a fault having a throw of 8 feet. This fault strikes north by east and is nearly vertical. The formations on the east side of it have slipped to the north a few feet, or those on the west side have slipped to the south.

A plan showing the workings and the geology of the deposit is given in figure 54.

BOB ASHE MINE.

The Bob Ashe mine is 2¼ miles S. 35° E. of Webster. The work done consists of two tunnels 40 to 50 feet long, one about 18 feet above the other. The country rock is mica gneiss containing beds of hornblende gneiss. The body of pegmatite is very irregular, and the strike of its main part ranges from northeast to north by west and the dip from 30° W. to nearly vertical. It cuts the schistosity of the gneiss at many places and follows it for short distances at others. At one place the pegmatite forks, one arm standing nearly vertical and striking northeast and the other striking northeast and dipping about 45° SW. The pegmatite ranges from a thin film to a mass 5 feet thick. In some places it contains streaks of quartz 12 inches thick or more. The mica is of good quality and has a fine rum color.

COX & DAVIES MINE.

The Cox & Davies mine is about three-quarters of a mile south of Cullowhee, Jackson County, on the point of a ridge, 200 or 300 feet above the road. The developments consist of open cuts, shafts, and tunnels, most of them in bad repair. There are two parallel "veins" about 70 feet apart, and both have been worked for about 100 yards across the top of the ridge. The mica gneiss country rock strikes about N. 80° E. and dips south, and the masses of pegmatite conform in a general way, though in places they cut the gneiss.

A tunnel run into the hillside on the north "vein" was examined for about 150 feet. The "vein" was generally from 2 to 4 feet thick, but in places it swelled to a thickness of 6 or 8 feet. At one point the pegmatite was warped, the strike shifting from N. 70° E. to S. 80° E. and back again, with a varying southerly dip. It cut across the mica gneiss, which at this point had a strike of N. 45° E. and a vertical dip. Quartz was exposed only in small masses and ledges in this tunnel. The feldspar was partly kaolinized and was easily removed in mining. Quartz was more plentiful in the south "vein." In one of the tunnels still open a streak of quartz nearly 2 feet thick was exposed in the roof and extended some distance back. Both veins have been more or less "ground-hogged" through their whole length by petty leasers, who did not care what happened to the mine after their leases expired. Mica of excellent quality and in large quantity has been removed from each vein. The mica is of a fine clear light-rum or wine color and is said to have brought the highest prices.

GREGORY MINE.

The Gregory mine is 1 mile S. 20° W. of Panther Knob, near the top of the ridge running south from that mountain to the Cullowhee

Mountain divide. It was worked by an open cut about 50 feet back into the mountain side. On one side of the cut a deeper cut and room had been stoped out. The deepest part was probably not more than 25 feet deep. The country rock is mica gneiss, which strikes N. 30° E. and dips vertically. The pegmatite cuts across the gneiss with a strike of about N. 50° W. and a vertical or high southerly dip. It is at some places at least 10 feet thick and contained large streaks and masses of quartz, one 4 feet through. The contact of the pegmatite with the mica gneiss is not sharp and at one exposure along the southwest wall was jagged, as shown in figure 55. Small mica is plentiful in parts of the "vein" and some rather larger crystals were left in a pillar over the stope. The mica is rum-colored and is of good quality.

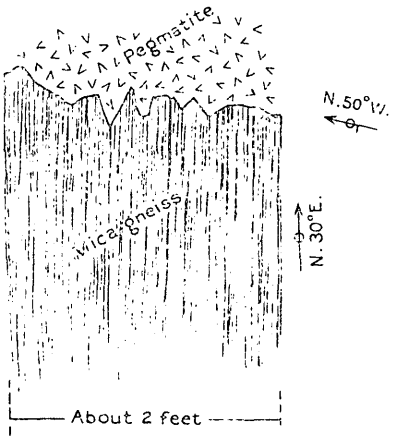


FIGURE 55.—Uneven contact of pegmatite and mica gneiss at the Gregory mica mine, Jackson County, N. C.

BOWERS MINE.

The Bowers mine is 1 mile S. 30° E. of Panther Knob. The mine is in the east face of a steep mountain side, almost a cliff. It was worked by an open cut not so wide as the pegmatite, run 40 feet into the mountain side to a maximum depth of 35 feet. A shaft was sunk from the inner end of this cut. The country rock is hard mica gneiss, which strikes N. 55° E. and dips 70° NW. The pegmatite carries much quartz and is very hard. Near the top of the cut the pegmatite forks, one streak, which has been worked out for several feet, running westward and the other streak, which is larger, running northwestward. The mica is of excellent quality and has a fine rum color.

L. C. PRESLEY MINE.

The Presley mine is three-quarters of a mile S. 55° E. of Panther Knob, about 2¼ miles S. 30° W. of Cullowhee. The workings consist chiefly of tunnels and an open cut. The tunnels are run northeastward into a hillside and the open cut runs northwestward along a small branch. The country rock is mica gneiss, which strikes about N. 25° E. and has a vertical or high southeasterly dip. The workings are evidently on different bodies or branches of the pegmatite. The open cut, which runs N. 25° W., follows the vertical contact between mica gneiss on the southwest and a large body of pegmatite on the northeast. The pegmatite cuts across the gneiss. The tunnels are about 75 yards northeast of the open cut and have been

run on at least three different streaks of pegmatite, which are nearly conformable with the inclosing gneiss. The probable relations of the pegmatite to the workings and to the country rock are shown in figure 56. The pegmatite near and in the open cut has a slightly schistose structure, corresponding to that of the mica gneiss, and is cut by ramifying streaks of quartz. The pegmatite that crops out in the branch is hard and, with the mica gneiss, forms a cliff just below the mine. The mica obtained is of good quality and in parts of the pegmatite that were not removed in mining small crystals from 1 inch to 3 inches in diameter are plentiful.

Another prospect, called the Spence prospect, has been opened about 300 yards southwest of the Presley mine, but it was reported that work was carried on there for only a month and a half.

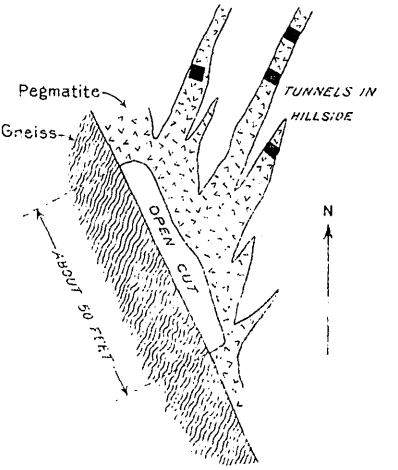


FIGURE 56.—Plan of Presley mica mine, Jackson County, N. C.

MRS. KELLER'S MINE.

Mrs. Keller's mine is 1 mile S. 85° E. of Panther Knob. The work done consists of open cuts, the deepest only about 15 feet. The country rock is mica gneiss, which strikes N. 30° E. and dips vertically. The pegmatite is 2 to 4 feet thick and is conformable with the inclosing gneiss.

Openings had been made on another deposit of mica about 300 yards to the northeast.

JUDGE FERGUSON MINE.

The Judge Ferguson mine is about 5¾ miles S. 55° W. of Webster. It is one of the older mines and was reopened in 1906 by Mark Bryson. At the time the mine was visited the workings consisted of an old open cut, two old shafts run from the surface, an interior shaft 55 feet deep at the end of the crosscut tunnel, and drifts and stopes. The new work consisted of a tunnel 180 feet long, run irregularly toward the old workings at a level 65 feet lower than the old tunnel. The new tunnel was driven for about 25 feet to cut the pegmatite.

The pegmatite strikes about east and has a vertical dip, cutting across the country rock, which is mica gneiss, at a small angle. The mica gneiss strikes east by north and has a nearly vertical dip. The pegmatite is about 12 feet thick in the old workings and in a part of its course contains a large streak of quartz. The mica occurs in the streaks of feldspar between the quartz and the wall rock. It has a

clear light color and much of it is of good quality, though a part of it has A structure.

JOHN LONG MINE NO. 1.

The John Long mine No. 1 is a quarter of a mile northeast of the mouth of Wayehutta Creek, 4 miles southeast of Webster. It has been worked by a tunnel that was carried for 90 feet nearly on the strike of the country rock, which is mica gneiss, and was there divided into two branches, which were joined about 45 feet farther on, encircling a large pillar. An incline was sunk under the large pillar. Some work was done on the outcrop—a shaft that passed to one side of the underground workings and an old tunnel, now caved in. A plan of the workings is shown in figure 57. The pegmatite is so soft that the tunnels require careful timbering. Nearly all the rock in the large pillar except a horse of mica gneiss several feet thick is pegmatite, and the body contains streaks or ledges of quartz that lie parallel to its general course. Several large blocks of mica and many small ones were seen in the kaolinized feldspar. The mica was more or less fractured and some of it contained clay stains between the laminae. The mica that has not been clay stained has a clear rum color.

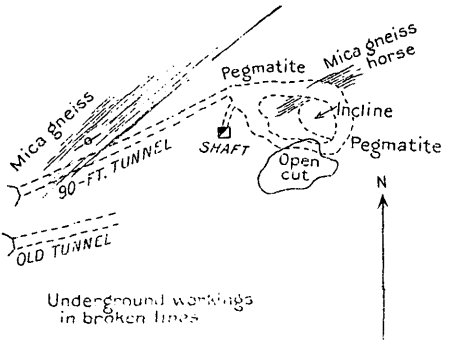


FIGURE 57.—Plan of John Long mica mine No. 1, Jackson County, N. C.

JOHN LONG MINE NO. 2.

The John Long mine No. 2 is close to the mouth of Wayehutta Creek, about a quarter of a mile southwest of mine No. 1. The workings consist of a crosscut tunnel 60 feet long, driven from a point slightly above the creek level, and a 40-foot drift on the "vein." The vein has been stoped out to the surface for 20 feet and has been removed to a depth of 10 feet below the level of the tunnel. A plan of the workings is given in figure 58.

The country rock is biotite gneiss striking about N. 25° E., and dipping nearly vertically. The pegmatite is 10 to 12 feet thick and includes a number of streaks of gneiss. The mica is more plentiful along the east wall of the pegmatite, where the rock is removed to a width of 5 to 8 feet in mining. The streaks of included gneiss split the pegmatite into lenses and bands from a few inches to a foot or two thick. The formation is fresh and hard from the surface down and requires much blasting. The mica is of fine clear rum

color. It is reported that during three months of 1906 rough mica worth $400 was obtained.

A prospect has been opened a little more than a mile east of Painter on the ridge above the John Long mines. The work consists of an open cut and a short tunnel. The pegmatite, which is about 3 feet thick, is conformable with the mica gneiss, strikes N. 50° E., and has a vertical dip. Sheets of quartz are inclosed in the pegmatite parallel with its walls, and the country rock, which is mica gneiss, incloses small stringers of pegmatite, which lie parallel with its schistosity. Little mica had been left around the workings.

A mine has been opened on the summit of the knob 2 miles east of Painter by four pits or shafts. The country rock is mica gneiss, which strikes N. 50° E. and dips high to the northwest. The pegmatite is conformable or nearly conformable with the inclosing gneiss. Streaks of mica schist are inclosed in the "vein" parallel with its strike. The mica from this mine is of good quality and has a fine rum color.

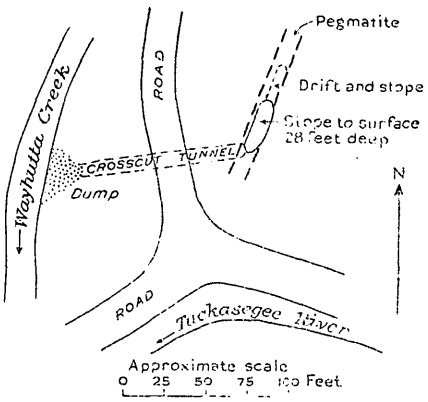


FIGURE 58.—Plan of John Long mica mine No. 2, Jackson County, N. C.

C. D. BRYSON MINE.

The C. D. Bryson mine is on the northwest side of Wayehutta Creek, about 2 miles from its mouth. It has been worked by several small ground-hog pits and tunnels. The country rock is mica gneiss which strikes northeast and dips northwest. An intrusion of fine to medium grained porphyritic granite cuts the pegmatite and the inclosing gneiss. In one of the openings a streak of pegmatite was observed along a contact between mica gneiss and granite. The pegmatite is marked by large segregations of quartz, which crop out prominently on the surface and were encountered in nearly every opening. The mica is of good quality, but few of the larger sheets measure more than 4 by 5 inches.

Another "vein" of mica was opened by a small pit about 40 yards lower down the hillside. The mica was more or less surface or clay stained from exposure to the weather.

WAYEHUTTA KAOLIN AND MICA MINE.

The Wayehutta kaolin and mica mine is on the west side of Black Mountain, near the head of Wayehutta Creek, 3 miles due south of Willetts. The mine is 300 or 400 feet above the valley, high on the side and on the top of a steep ridge. The developments consist of

an 80-foot tunnel, 45 feet of crosscutting, and two interior shafts on the pegmatite, and several trial tunnels and openings that do not expose the main body of the pegmatite. Figure 59 shows the position of the openings and the formations encountered in each. The country rock is mica gneiss, which strikes N. 60° to 70° E. and has a southeasterly to vertical dip. The pegmatite contains in places streaks or horses of mica gneiss, and its contact with the gneiss is highly irregular. A massive vein of quartz 2 feet thick was encountered near the southeast side of the pegmatite. Another vein 3 feet thick crops out on the top and on the opposite side of the ridge, 40 yards southeast of the kaolin deposit. Workings on this quartz ledge show that it is not directly connected with the main body of the pegmatite. The feldspar of the pegmatite is thoroughly decomposed, and in places large masses have been altered to pure kaolin. The upper 12 feet of the 30-foot interior shaft and 9 feet of the 10-foot shaft were cut through kaolin. A small quantity of clear rum-colored mica was found in parts of the workings.

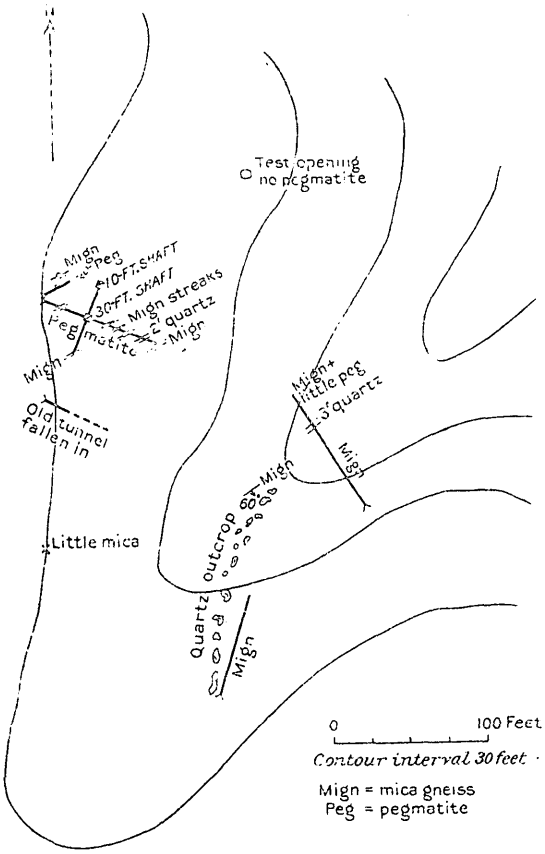


FIGURE 59.—Plan of Wayehutta kaolin and mica mine, Jackson County, N. C.

ROCK MINE.

The Rock mine is three-quarters of a mile south of Sugarloaf Mountain, on the headwaters of Wayehutta Creek. It has been worked by an open cut in the mountain side. The country rock is mica gneiss, which strikes northeast and dips vertically. The pegmatite exposed in the face of the cut is nearly 20 feet across and is conformable or nearly conformable with the inclosing gneiss. The pegmatite is highly acidic, containing large quantities of quartz and only a little

feldspar. A hard, fine-grained, slightly garnetiferous porphyritic granite dike several feet thick cuts the pegmatite and has been left standing in part of the open cut. This dike cuts across the formation with a strike of N. 50° W. and a vertical to high southwest dip. The mine is said to have been a good producer, but as very little sheet mica had been left around the workings the quality of the output could not be determined.

A mica prospect was opened on the knob southwest of the deep gap of Black Mountain. The location is marked by large blocks of massive white quartz.

SHEEP MOUNTAIN MINE.

The Sheep Mountain mine is on a spur or ridge of that name on the southeast side of Black Mountain, about two-thirds of a mile west of Moses Creek. Several tunnels have been driven northeastward into the ridge, but they have caved in so badly that the pegmatite was exposed in only one opening at the time the mine was visited in 1905. The country rock is biotite gneiss, which is very schistose near its contact with the pegmatite. It is reported that good "vein" matter was found in only two of the tunnels but that the yield from one of these was very large. Another mass of pegmatite, 3 to 4 feet thick, was opened by a tunnel a few hundred yards southeast. This "vein" has a northeasterly strike and is conformable with the inclosing mica gneiss. The mica from the Sheep Mountain mine is clear and of fairly good quality. Some biotite is associated with it.

WOLF PEN GAP TRAIL PROSPECT.

The Wolf Pen Gap Trail prospect is about 150 yards west of the point where the trail to Wolf Pen Gap of Black Mountain leaves Moses Creek. The country rock is mica gneiss, which strikes N. 35° E. and dips 75° NW. The body of pegmatite is conformable with the gneiss, is nearly 2 feet thick, and contains several small streaks of quartz, which are parallel with the course of the body of pegmatite.

LEON HOOPER MINE.

The Hooper mine is on the road along Moses Creek, a little more than a mile above its mouth. It was worked by an open cut 60 feet long and 10 to 18 feet deep, run along the "vein" close to the roadside, and a crosscut tunnel was run under the road to remove the waste. The country rock is mica gneiss, which strikes N. 50° E. and dips 75° SE. The mass of pegmatite is conformable with the inclosing gneiss and is 5 to 12 feet thick. All the pegmatite was not

removed from the thicker parts of the mass, only that containing a "lead" of pockets being mined. The mica gneiss is very schistose near its contact with the pegmatite, which contains a few streaks of quartz that lie parallel with its walls. One of these streaks near the northeast end of the cut was 18 inches thick but pinched out within a few feet. The mica at this mine has a dark-brown color in sheets a sixteenth of an inch or more thick but is clear when split into thin sheets. Part of it is a little specked.

CEDAR CLIFF MINE.

The Cedar Cliff mine is a quarter of a mile east of the Deep Gap of Black Mountain, in the face of a cliff of hard rock. It has been operated by an open cut that is nearly 60 feet high and that extends 5 to 25 feet back from the face of the cliff. The country rock is garnetiferous mica gneiss, which strikes N. 45° E. and dips northwest. The pegmatite cuts across the gneiss with a strike of N. 10° E. and a nearly vertical dip. The "vein" ranges from 1 foot to 3 feet in thickness and contains streaks of quartz parallel with its walls. Other masses of pegmatite crop out in the cliff, and some of them appear to contain mica in commercial sizes. The mica is clear and of good quality.

HAMP WOODS PROSPECT.

The Hamp Woods prospect is on the southeast end of Sheep Mountain, about 200 feet above the road along Moses Creek, where a few blasts have been made in hard rock that outcrops on the steep hillside. The country rock is biotite gneiss, which strikes N. 50° E. and dips almost vertically. The "vein" consists of lenticular streaks and masses of pegmatite and quartz, which are nearly conformable with the associated gneiss. These segregations range in thickness from a few inches to a foot or more and are several feet long. They occur in a belt of gneiss about 10 feet thick. The crystals of mica are scattered through this belt but occur more plentifully around the lenses of quartz. A block of mica 6 by 10 inches across and 3 inches thick was blasted out at the time the place was visited. It was not a perfect piece, however, and would yield only small sheets, for it was badly fractured and contained inclusions of quartz.

COWARD MOUNTAIN MINE.

The Coward Mountain mine is near the top of the south end of Coward Mountain, on the north side of the valley of Cany Fork. The country rock is hard garnetiferous mica gneiss, somewhat schistose near its contact with the pegmatite. The notable features are

the occurrence of sheetlike horses of wall rock and streaks of quartz parallel to the walls of the pegmatite. The body of pegmatite is about 10 feet thick, strikes about N. 45° E., and dips 75° NW., and, where seen near the surface, is nearly or quite conformable with the inclosing rock. Quartz is the predominant mineral and occurs in veins and streaks 1 inch to 2 feet thick parallel to the wall rock. Feldspar is nowhere very abundant in the pegmatite and is confined chiefly to a streak 2 or 3 feet thick near the hanging wall, where, with quartz and mica, it forms the "vein." Horses or sheets of schistose wall rock, some of them several inches thick, are included in the pegmatite at several places. These horses and the bands of quartz and streaks of mica, all parallel to the walls, give the rock a banded appearance. Such inclusions of sheetlike horses of wall rock and veins of quartz in parallel position are common in this region.

This mine has not been worked in recent years. The developments consist of a shaft on the "vein," reported to be 30 feet deep, and sufficient open-cut work at the surface to give working room on the mountain side. The mica is of a clear rum color, and, to judge from pieces seen, is of good quality. Biotite is found with the clear mica. A little pyrrhotite is scattered through the "vein" and wall rock.

BROWN'S COWARD MOUNTAIN PROSPECT.

A small opening for mica has been made on the land of Albert Brown, on Coward Mountain, about a mile north by east of Cowarts. The deposit is marked by a large outcrop of massive white quartz which trends east by north.

ANDY NICHOLSON MINE.

The Nicholson mine is a few hundred yards south of Johns Creek, nearly a mile above its junction with Cany Fork. The workings consist of two tunnels, a shaft, and small open cuts. The country rock is mica gneiss, which strikes N. 20° E. and dips 65° SE. The pegmatite is conformable or nearly conformable with the gneiss, which is streaked with small bands of pegmatite near the contact. Quartz is segregated here and there in the "vein," and blocks of it 2 or 3 feet thick were left around the workings. Some of these blocks bear "mica capping." Only small-sheet or scrap mica was left on the dumps, but the large size of the workings indicates that valuable mica was found.

J. B. PRICE MINE.

The J. B. Price mine is on the south side of Johns Creek, about 1¼ miles above its junction with Cany Fork, about 75 feet above the

road that runs along the creek. The workings consist of a large open cut, a shaft 35 feet deep run from the bottom of the cut, a crosscut tunnel and stopes connected with the shaft, and two prospect trenches. The country rock is mica gneiss, which strikes N. 25° E. and dips 65° SE. The pegmatite is nearly conformable with the inclosing gneiss and ranges in thickness from about 2 feet in the prospect trenches to 20 feet in the open cut. Sheetlike inclusions of mica schist or gneiss and of quartz, some as much as 4 feet thick, lie parallel with the strike. A large streak of quartz forms the northwest wall of the "vein" in the open cut and is represented by another streak in the same position in the tunnel below. Considerable mica lies near or in contact with this streak of quartz, and a little is included in the quartz. Some rather large crystals of mica were obtained from this mine, but much of it was specked and showed A structure.

A. L. LOVEDAHL PROSPECT.

The Lovedahl prospect is on the north side of Johns Creek, about 1¼ miles above its junction with Cany Fork, close to the creek level. The openings consist of two pits and a small tunnel. The country rock is schistose mica gneiss, which strikes N. 15° E. and dips vertically in the upper workings and strikes N. 30° E. 25 feet below, at creek level. The pegmatite is conformable with the inclosing gneiss and contains sheets of quartz which lie parallel with its strike. The upper workings are probably not on the same band of pegmatite that is exposed in the lower workings.

LEWIS QUEEN MINE.

The Queen mine is 3 miles east of Cowart, on the Rich Mountain Divide. It was opened by a tunnel on mountain side driven S. 20° W. on the "vein." Considerable masses of kaolin and large segregations of quartz were encountered in the workings. Only badly weathered mica was seen around the dumps.

FRADY CREEK MINE.

The Frady Creek or Chastine Creek mine is on Frady Creek a quarter of a mile above the point where it empties into Chastine Creek, more than 2 miles northeast of the Rich Mountain post office. The workings consist of an open cut, pits, and a tunnel. The country rock is mica gneiss, which strikes N. 40° E. and dips 40° SE. The "vein" is approximately conformable with the gneiss and contains sheetlike horses of wall rock from 1 inch to 2 feet thick. The pegmatite is at least 15 feet thick and contains streaks of quartz from a few inches to 4 feet thick. The mica was most abundant near these

streaks. It is clear and has a dark color when in sheets one-sixteenth of an inch or more in thickness.

ABBS CREEK MINE.

The Abbs Creek mine is in a steep hillside 450 feet above the level of Abbs Creek on its east side, 1¾ miles north of Rich Mountain post office. The pegmatite is 20 feet or more thick and has a northeasterly strike. Both biotite and muscovite occur in the "vein." Part of the mica has the A structure, though sheets of good quality could be obtained between the A lines.

BEARWALLOW FORK MINE.

The Bearwallow Fork mine is on the branch of that name 2¼ miles above its junction with Cany Fork. It is an old mine and the workings have caved in badly. Three open cuts were carried N. 50° E. from points near the stream level up a steep hillside. Several blocks of massive quartz were seen on the dumps. Horses of mica schist inclosed in the pegmatite are exposed in one of the pits. The mica has a clear rum color and is of good quality. A little biotite is associated with it.

EAST LAPORT MINE.

The East Laport mine is on a main road, a quarter of a mile northwest of the mouth of Cany Fork. The workings consist of several shafts, tunnels, and pits. The country rock is mica gneiss, which strikes N. 45°–65° E. and has a vertical to high northwest dip. The body of pegmatite is large and includes tongues of mica gneiss. The outcrop is marked by large blocks of massive quartz. The feldspar has largely decomposed to kaolin, but in places the decomposition has been only partial so that crustlike shreds of feldspar remain in the kaolin. The mica has a clear rum color and is of good quality.

RODA KAOLIN AND MICA MINE.

The Roda mine is on the south side of Tuckasegee River opposite the mouth of Cany Fork. The deposit lies in the summit of a low rounded hill and has been proved on three sides by tunnels and pits. The relative position of these workings is shown in figure 60, A. The deposit is covered by massive, coarse sugary quartz, which was also encountered in the workings. The first work done here was undertaken in search of mica. It consisted of an opening on the south side of the hill and in this a large mass of kaolin was exposed. The principal development is a crosscut tunnel on the west side. This

cuts masses of both gritty and very good kaolin and sugar quartz. A 40-foot shaft was sunk from the interior of this tunnel and encountered kaolin through its whole depth. A diagram of this tunnel is shown in figure 60, B. The tunnel on the east side of the deposit was

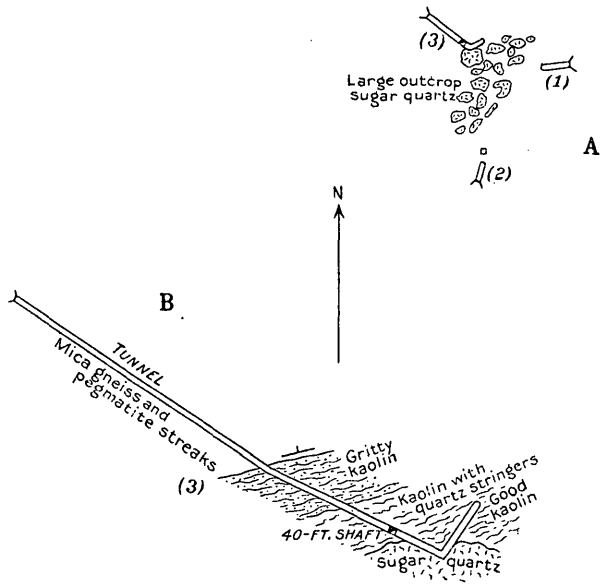


FIGURE 60.—Roda kaolin and mica mine, Jackson County, N. C. A, Plan; B, details of tunnel 3, shown in (A).

driven 18 feet in a mass of fairly pure kaolin after passing through a number of feet of soil.

ISLAND FORD MINE.

The Island Ford mine is in the loop of Tuckasegee River, one-third of a mile below the mouth of Sol Creek. The deposit here has been worked for 150 feet along the strike by open cuts and stopes. The country rock is mica gneiss, which strikes east and dips 35° N. The pegmatite is irregularly conformable with the gneiss and is 3 to 7 feet thick. The mica is dark and is partly specked. Much of it has the A structure, which, however, is not sufficiently developed to spoil the whole crystal.

RICE MICA AND BERYL MINE.

The Rice mica and beryl mine is on a spur of Sassafras Mountain, about half a mile N. 10° E. of the top and 2 miles S. 30° W. of Sapphire. It now belongs to Dr. Robert Grimshawe. The work consists of an open cut along the "vein" and some tunnels, now caved in. The country rock is hornblende gneiss, which strikes N. 30° E. and

dips east about 50°. The pegmatite cuts across the gneiss with a north strike and a vertical dip. Two forks of pegmatite were exposed in the face of the cut, one going off in irregular conformity with the inclosing hornblende gneiss, as shown in figure 61. Much of the mica seen was of the A variety and of dark color. Beryl crystals of good size and green color were found, and a few were reported to have been of gem quality.

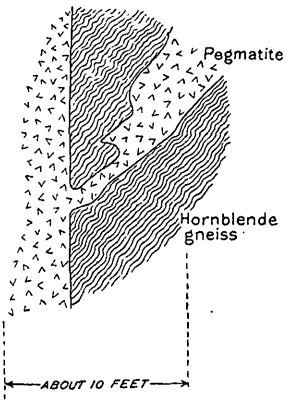


FIGURE 61. — Section showing fork of pegmatite in Rice mica and beryl mine, Jackson County, N. C.

JAKE RICE MINE.

The Jake Rice mine is 1¾ miles N. 45° E. of Ocala and 1¼ miles S. 75° E. of Terrapin Mountain. It has been worked by "ground hogging" for a width of about 100 feet in places and for about 200 feet up and down the hillside. The mine was operated for a few months during 1906. The country rock at the deposit is highly schistose mica gneiss, near which there is some diorite. The gneiss strikes N. 35° E. and dips 40° to 60° E. The mica occurs in several streaks of pegmatite that cut the gneiss at different angles. Small-sheet mica is plentiful. Its color is dark brown and part of it is specked. Some of the sheets do not split well but tear across the laminae.

A mica prospect was opened on the land of P. N. Bryson, 3 miles S. 20° E. of Whiteside Mountain and a quarter of a mile east of Chattooga River. Another strong lead of pegmatite with indications of mica crosses the road 200 or 300 yards north of the Bryson prospect.

D. L. WATSON MINE.

The Watson mine is 1½ miles N. 40° W. of Ocala. There are two sets of openings, which are about 200 yards apart and lie nearly along the strike of the formation. The one to the southwest consists of an open cut about 70 feet long and 6 to 15 feet deep. The country rock is biotite gneiss, which contains numerous streaks and lenses of pegmatite. The "vein" is 2 to 4 feet thick and is approximately conformable with the inclosing gneiss, which strikes N. 45° E. and dips 30° NW. The whole formation is fresh and very hard. The mica has a clear apple-green color.

The openings to the northeast consist of two short inclines sunk on the dip of the "vein." The relations between the pegmatite and the

gneiss are very similar to those at the open cut, and the dip and strike are the same. The mica, however, has a dark-brown rum color.

THOMAS GRIMSHAWE MINE.

The Thomas Grimshawe mica mine is 1¾ miles due east of the top of Whiteside Mountain, half a mile northeast of Whiteside Cove. It has been idle since about 1880 and the workings had caved in badly when they were examined in 1906. It was closed down because of the small demand for specked mica at that time. The country rock is fine-grained gray granite. The remains of the pegmatite on the dumps consist of coarsely jointed or sheared blocks of quartz as much as 2 feet thick and blocks of orthoclase 8 or 10 inches thick, some with graphic intergrowths of quartz. The masses of quartz were sheared and broken into subrectangular glassy clear fragments, the largest half an inch in diameter. The mica is dark and specked. Some rather large blocks were obtained, and Mr. Grimshawe has preserved a sheet measuring about 20 inches across. Pratt notes that the accessory minerals from the Grimshawe mine are samarskite, large crystals of beryl (some of gem quality), garnet, and black and pink tourmaline.

J. H. ROCHESTER MINE.

The Rochester mine is one-third of a mile southeast of Ocala post office. It comprises two openings on different bodies of pegmatite. The one to the northwest is an incline run down on the "vein." The country and wall rock is pegmatized mica gneiss striking N. 30° E. and dipping 50° SE. The pegmatite is conformable with the inclosing gneiss and is about 3½ feet thick. About four-fifths of it, as exposed, consists of quartz. The mica is more plentiful near the walls of the pegmatite.

The other opening, 75 yards to the southeast, is the principal one and consists of an open cut 10 to 20 feet deep and 50 feet long on the outcrop, a crosscut tunnel, and drifts, about 100 feet in all, at a lower level and under the open cut. The pegmatite is from 1 foot to 5 feet thick, and is conformable with the inclosing gneiss. Massive quartz is more or less prominent in different parts of the pegmatite. The mica is clear and has a dark-brown color tinged with green.

CHINK KNOB PROSPECT.

South of Chink Knob, near the main road through Canada Township, Jackson County, there is a small opening, several feet deep, which is described here only because of the peculiar type of pegmatite exposed. The country rock is mostly mica gneiss but includes small masses of granite, which are doubtless outliers of the larger intrusive masses in the neighborhood. Some of them in places as-

sume a coarse, pegmatitic texture. The prospect reveals a vein of pegmatite 3½ to 4 feet wide, which strikes about N. 5° W. and dips 75° to 80° E., cutting one of the masses of coarse granite just mentioned. (See fig. 62.) The mica gneiss country rock, a few rods from the prospect, strikes N. 55° E. and dips 50° NW.

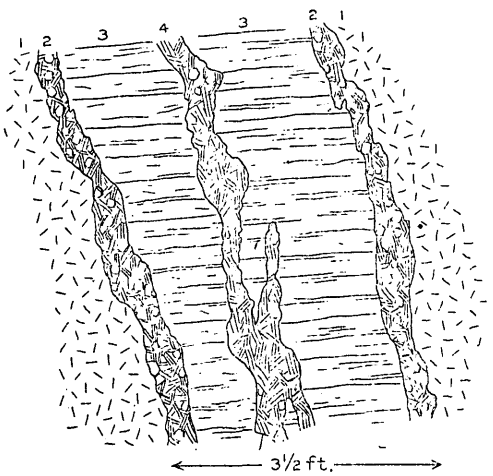


FIGURE 62.—Section of pegmatite at mica prospect near Chink Knob, Jackson County, N. C. 1, Coarse granite; 2, mica and feldspar; 3, quartz, jointed; 4, feldspar with little mica.

The vein consists largely of quartz. On each side and down through the interior of this quartz there is a streak or band of feldspar and mica. The interior band consists of feldspar and a small quantity of mica, but the bands between the walls and the quartz probably contain more mica than feldspar. The quartz is massive and of a dark smoky color. It has a sheety columnar jointing about normal to its walls, probably caused by rock movements. Most of the mica is wedge shaped and of the A variety. It is of a dark, smoky color and partly specked. Blocks from 3 to 5 inches across were probably the largest found during the prospecting.

JIM WOOD MINE.

The Jim Wood mine is on the west side of Wolf Creek, about a quarter of a mile above the Wolf Mountain road. The workings

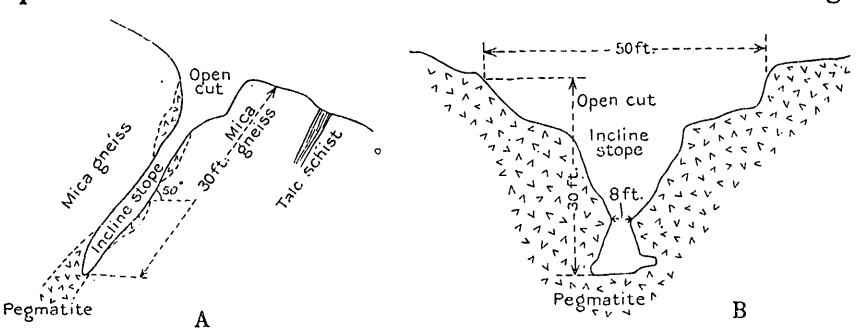


FIGURE 63.—Sections at Jim Wood mica mine, Jackson County, N. C. A, Cross section; B, section in plane of the "vein."

consist of an open cut about 50 feet long and an open incline run 20 feet deeper from the bottom of the cut. The country rock is mica gneiss and contains a layer of gritty talc schist a few feet

southeast of the "vein" of pegmatite. The "vein" is conformable with the inclosing gneiss, which strikes N. 70° E. and dips 50° N. The "vein" was rich in mica near the surface for the whole length opened, but at a point near the bottom of the incline was rich enough to work for a width of only 8 feet, though at the bottom of the incline the "pay streak" became wider again. The pegmatite was not all removed, only that part of it which carried the streak of mica having been mined. The workings and the geologic relations are shown in cross and longitudinal section in figure 63, A and B. The mica has a dark-brown color in sheets of sufficient thickness, and part of it is specked. Some of the crystals are well developed; others are wedge shaped.

PINHOOK GAP MINE.

The Pinhook Gap mine is on the southwest side of Pinhook Gap, in Tennessee Ridge. The deposit here has been worked extensively at different times. In 1905 a new deposit was opened about 250 yards southwest of the old workings. C. H. Wolford operated the Pinhook Gap mine during parts of 1905 and 1906 and reported a production of about 600 pounds a week of merchantable sheet mica for a part of this time.

The older workings consist of a large open cut from the southwest corner of which a crosscut tunnel was driven a short distance into the pegmatite and thence turned along the strike of that rock. This tunnel connects with another driven in at a lower level. Other short tunnels were driven from the open cut in different directions. Numerous pits and crosscut trenches were made a short distance to the northeast. The body of pegmatite is irregular, swelling from a thickness of a few feet on its southwest side to a thickness of 30 feet in the open cut and to nearly 50 feet at a point northeast of it. Segregations and streaks of quartz are scattered through it. On the east side of the open cut a mass or boss of garnet-mica rock or "mica capping" several feet across was encountered. It was composed of bunches of wedge-shaped mica crystals showing A structure, and coarse garnet crystals were scattered thickly through it. The crystals of mica ranged from a fraction of an inch to 3 inches across, and the larger ones of garnet were nearly 2 inches in diameter. The garnet crystals constitute at least 25 per cent of the whole mass and are found to be fresh and firm on crushing, even if apparently badly weathered on the surface.

The later workings consist of a shaft 30 feet deep, a drift from it on the vein, and a crosscut tunnel run from the hillside below. The country rock is mica gneiss, which strikes N. 40° E. and dips 40° NW. The pegmatite is conformable or nearly conformable with the strike of the gneiss. The outcrop of the "vein" is marked by

large irregular-shaped masses of quartz, some of which pinch out at slight depth. The masses of feldspar in the pegmatite are also irregular in shape. The feldspar is 6 feet thick at the surface in the shaft.

The mica from the Pinhook Gap mine is brownish and is partly specked. Large sheets are sometimes obtained, however, from which the specks can be eliminated by splitting.

FREEMAN BAIRD MINE.

The Freeman Baird mine is on the west side of Neddie Knob, nearly 500 feet above Sols Creek, in Canada Township. It is an old mine and was worked by two tunnels, now badly caved in. The pegmatite and the inclosing mica gneiss strike northeastward into the mountain side. In one of the openings a ledge of nearly solid "mica capping" 3½ feet thick was encountered. The feldspar formation is large and is associated with massive quartz. Large boulders of quartz are scattered over the surface southwest of the mine. A crystal of mica several inches across was seen, but like the smaller mica in the "capping" it was partly wedge-shaped and fractured.

MRS. SUSAN BROWN'S PROSPECT.

A small open cut was made for mica in pegmatite on the land of Mrs. Susan Brown, on the south side of Neddie Knob. The pegmatite strikes northeast almost conformably with the inclosing mica gneiss. Large segregations of quartz were encountered in the workings. The mica has a dark-brown color and part is specked.

JAMES REECE MINE.

The James Reece mine is on the Cathay Gap-Pinhook Gap road, between Charley and Wolf creeks. It was opened by a tunnel about 40 feet long. Large boulders of quartz are scattered over the surface above the outcrop of the pegmatite and a vein of massive quartz was encountered in the tunnel. The feldspar formation that incloses the quartz and carries the mica is also large. About $500 worth of rough split mica is said to have been removed from the mine.

ALBERT BROWN PROSPECT.

A small prospect was opened near Brown's camp, a mile east of the James Reece mine, along the Cathay Gap-Pinhook Gap road, in Canada Township. A large vein of quartz and a little feldspathic matter was encountered. "Mica capping" was associated with this quartz and a few good blocks of mica are said to have been found.

Some work was done on a mica-bearing pegmatite "vein" about half a mile below the Cathay Gap-Pinhook Gap road, on the west

bank of Wolf Creek, a short distance below the Upper Falls, in Canada Township. This "vein" cuts irregularly across the mica gneiss country rock, which strikes N. 50° E. and dips 45° NW. The pegmatite cuts the country rock with a northwest strike and a southwest dip. The mica is dark green and clear.

A. E. GALLOWAY MINE.

The Galloway mine is on Wolf Mountain near the Wolf Mountain post office. It has been opened by a crosscut trench, a small incline run from the trench along the "vein," and an open cut, also on the "vein" but not connected with the crosscut. The "vein" consists of several small bands of pegmatite inclosed by or inclosing streaks of mica schist. These bands of pegmatite probably were larger or came together in the parts of the mass that were mined for mica, for a good yield was reported, and very little mica was seen in the small streaks of pegmatite left in the face of the workings.

A small mica prospect has been opened on the Wolf Mountain ridge about 1½ miles south of Black Mountain, in Canada Township. The country rock is garnetiferous mica gneiss, which strikes N. 65° E. and dips 60° NW. The pegmatite is conformable or nearly conformable with the inclosing gneiss. The "vein" contains much quartz in the form of streaks parallel with the walls. The crystals of mica lie near the walls. A few crystals measuring 3 by 4 or 3 by 5 inches were seen.

CAMP MOUNTAIN MICA AND KAOLIN MINE.

The Camp Mountain mine is a mile west of Pinhook Gap, on the trail to Cathay Gap, a few hundred yards east of Tennessee Creek. The workings consisted of two tunnels and two pits dug around a large outcrop of quartz, but they have fallen in so badly that little could be seen. It is said that good kaolin was found in the search for mica. Large blocks of sugar quartz similar to those found around other deposits of kaolin in this part of North Carolina lie on the ground here.

LINCOLN COUNTY.

THOMAS BAXTER MINE.

The Thomas Baxter mine is a little more than half a mile N. 62° E. of the southwest corner of Lincoln County, on the south side of the main road. The mine is probably the oldest one in this region, having been worked, it is said, before 1870. The workings, which consisted of several shafts, cuts, and tunnels, have caved in so badly that little of the formation is exposed. It is reported that one shaft was 65 feet deep and that good mica was found at its bottom. The ground-water level in a well near the mine was about 35 feet below

the surface. The workings fall within an area that is about 40 yards wide and that extends east by north for about 75 yards. The country rock is much-folded mica gneiss, into which Whiteside granite is intruded a few yards west of the mine. The outcrop of a large "vein" or ledge of quartz extends N. 70° E. through the workings. The mica is of the best quality, splits well, and has a clear rum color. A large quantity of weathered mica in sheets 2 or 3 inches in diameter lies scattered around the mine. It is said that the mine produced a great quantity of mica, some of it in sheets measuring as much as 10 by 12 inches.

FRANK BAXTER MINE.

The Frank Baxter mine is three-quarters of a mile northwest of the southwest corner of Lincoln County. The openings consisted of two shafts, which are about 30 feet apart from east to west and are connected by a tunnel. The country rock is the highly contorted, probably kyanitic mica schist gneiss that is characteristic of much of the Piedmont region. In places the gneiss is garnetiferous, bearing on its surface rough, rusted crystals of garnet more than an inch in diameter. Some of the mica left on the dump was rum-colored and of good quality, but the remainder was a little specked and of the A variety.

I. K. WILSON PROSPECT.

The Wilson prospect is 1¼ miles north of the southwest corner of Lincoln County. Two pits have been opened here about 25 feet apart from north to south. Large streaks of quartz were found in each. The quartz in the northern pit is 8 feet thick and bears on each side a streak of mica that contains many small crystals. The wall rock is granite gneiss.

Large quantities of mica are reported to have been mined on the old David Lackaye farm, which adjoins the land of I. K. Wilson. Prospecting has disclosed deposits of mica on the land of C. D. Dillinger, on the old Lincolnton-Rutherfordton road, about one-third of a mile east of the Cleveland County line.

W. A. THOMPSON MINES.

The mines and prospects now owned by the W. A. Thompson heirs are about 4¾ miles northeast of Fallston. There are five or six mines and prospects within an area measuring half a mile from east to west and a quarter of a mile from north to south. The deposits are in an area of garnetiferous kyanitic mica gneiss of the Carolina gneiss, which is here strongly folded, strikes prevailingly east to northeast, and dips low south to southeast. A few of the bodies of

pegmatite are conformable with the bedding of the gneiss through a part of their course at least, but most of them are unconformable.

The principal mine is about 200 yards northwest of the house, on the west side of the road. A prospect was opened 200 yards north of this one, and the other mines are farther east. The main deposit was opened many years ago and the workings have caved in badly. Several pits, shafts, and tunnels were run N. 80° E. for about 75 yards along the outcrop of the pegmatite. The country rock strikes N. 80° E. and dips 20° S. and the pegmatite cuts it with similar strike but nearly vertical dip. The mica from this mine has a good clear rum color and flat cleavage. Sheets of fairly large size are said to have been found.

The other mines and prospects have been worked more recently, one being in operation in 1912. The workings consist of pits and shafts and of irregular tunnels run from them. The irregularities of the workings are due largely to irregularities in the mass of pegmatite. In two of the prospects examined the mass of the pegmatite cuts across the bedding of the gneiss in various directions and with varying thickness, and at some places small beds branch out from it. The yield of mica from one of these prospects seemed fairly large, but as the workings were not deep much of the mica was stained with clay. Part of it, however, was of good quality and had a clear rum color.

Another mica prospect, called the Parker mine, has been opened on land that adjoins the Thompson place on the north, and much work is reported to have been done at a mica mine of C. Blanton, half a mile north of the Thompson mine.

JOE STAMEY MINES.

Two prospects have been opened on the Joe Stamey place, one-third of a mile west of the W. A. Thompson mine and close to the Cleveland County line. At one of these prospects an irregular mass of pegmatite strikes about N. 70° E., in conformity with the strike of the kyanitic mica gneiss that forms the country rock, but cuts it with a vertical dip, whereas the gneiss dips 20° S. The mass of pegmatite is probably not more than 2½ feet across. The mica is badly ruled but is of good rum color.

PLATO HOUSER MINES.

The Houser mine is about a quarter of a mile north of the old Lincolnton-Rutherfordton road and one-third of a mile east of the Cleveland County line. This mine was last operated in 1903 by the Empire Mica Co. A 30-foot shaft had been sunk on the "vein," and short drifts had been run from it. In a small pit about 100 feet from the shaft the "vein" appeared to have pinched out. The

country rock is much-folded kyanitic mica gneiss. The pegmatite has an easterly strike and a vertical to northerly dip. It ranges in thickness from a few inches to 4 or 5 feet. The mica has a clear light rum color and is of fine quality, though much of that which lies near the surface is partly broken and clay stained. There are several prospects and another old mine on the Houser place.

BESS MINE.

A mica mine was worked on the Bess Farm, which adjoins the Houser place on the northeast. The openings consisted of a shaft, pits, and tunnels. The wall rock is kyanitic mica gneiss, which strikes due east and dips 30° N. The pegmatite appears to be conformable or nearly conformable with the walls. The "vein" has been opened for about 100 feet. The mica has a clear rum color and is of fine quality.

M. M. HULL MINE.

The Hull mine or Rock Cut mine is about 2½ miles northeast of Hull Roads. The work at this mine, which was started about 1891, consists of a cut 40 feet long, 20 feet deep, and 5 feet wide. The mass of pegmatite strikes N. 70° E. and stands nearly vertical. It cuts across the kyanitic mica gneiss country rock, which strikes N. 10° E. and dips 50° SE. Small bunches of mica are still left in the walls. The mica is of good color and quality, and some sheets that measured 10 by 14 inches are said to have been found.

JOHN DILLINGER MINES.

The Dillinger mine No. 1 is 2 miles south of Henry, on the roadside, and No. 2 is on a branch a quarter of a mile west of the road. Both were worked in 1905 and 1906 by the Cawood Mica Co. The country rock is much-folded kyanitic mica gneiss. The streak of pegmatite is irregular and has an easterly strike. Each mine was opened by a cut 18 to 20 feet deep. In mine No. 1 much of the output was A mica, which, however, was of good color and included some clear parts. The pegmatite in mine No. 2 contained ledges of quartz and most of the mica was found near these ledges. It is said that beryl also was found in this mine.

D. C. HEAVNER MINE.

The Heavner mine is 5 miles southwest of Reepsville. It was being worked by the Cawood Mica Co. when examined in 1906. The workings consisted of an open cut and a shaft. The country rock is kyanitic mica gneiss, which strikes north and dips 20° E. The body of pegmatite is irregular and is not wholly conformable with the

gneiss. The mica obtained was of very good quality. Another prospect has been opened on the Heavner place about 150 yards north of the house.

M'DOWELL COUNTY.

SOURWOOD GAP PROSPECT.

A deposit of mica near the top of the Blue Ridge, below Sourwood Gap, about 2 miles northeast of Montreat, was tested by Mr. Queen, of Black Mountain. Only about ten days' work was done.

A deposit about 3 miles northwest of Woodlawn or 10 miles north by west of Marion, was worked on a fairly large scale. This deposit was not visited by the writer.

MACON COUNTY.

SMITH OR BAIRD MINE.

The deposit at the Smith or Baird mine, which is about a mile west of Franklin, was worked on a large scale by the aborigines. The mine was operated in the early days by C. D. Smith, and last in 1905 and 1906 by Mr. Eldridge, of Franklin. None of the operators except C. D. Smith found large bodies of mica. Some of the later workings cut through layers of scrap mica in old dumps and openings, finding scrap mica suitable for electric use. Several shafts were sunk near the old openings on the top of the ridge, but none of them struck the "vein." One of the later tunnels carried from stream level encountered material from ancient workings and could not be driven farther because the ground caved badly. About 75 yards northwest of the shaft, across a small branch, some work was done along a quartz ledge striking N. 60° W. The country rock at this mine is mica gneiss, which contains biotite and garnet and inclusions of diorite. The mica has a clear rum color and is of good quality. Considerable biotite is associated with the muscovite. A large sheet of mica measuring 16 by 18 inches is still kept in the Baird house near the mine as a specimen of the material obtained by C. D. Smith. The early operations at this mine have been well described by Mr. Smith,[68] whose description is quoted below:

> The ancient works on my own farm are the most extensive I have yet seen and are therefore worthy of description. The vein, as I have proved by my drifting upon it, has a general strike of N. 73° W.–S. 73° E. So far, however, as I have drifted upon it, it runs in a zigzag along this general strike. The old excavation commences at a small branch and runs at a right angle from it into a ridge that juts down with a gentle slope. The dump material has been

[68] Smith, C. D., Ancient mica mine in North Carolina: Smithsonian Inst. Rept., 1876, pp. 441–443.

thrown right and left for the first hundred feet. I tunneled in diagonally and struck the vein 60 feet from the branch, and have drifted along it 40 feet. Here we reach an immense dump rim, 65 feet higher than the level of the branch, which seems to have been thrown back upon their works. It forms at this end a circular rim to the continued excavations higher up the ridge. The whole length of the excavation from the branch to the upper end of the cut is about 320 feet. The material removed from the upper part of the cut was carried up the hill as well as down it. The dump on the upper side of this upper part of the cut, and at the widest point, is about 25 feet above the bottom of the excavation, and at this point dump and excavation measure about 150 feet across. At the upper end of my tunnel the old digging has been carried down about 30 feet below the surface. If the excavation at the point just mentioned was carried as deep as the work at the upper end of the tunnel, it would make the dump heap on the upper side 55 feet higher than the bottom of the old works. I have been thus particular in order to show that with mere stone implements it must have required a series of years and a large force to have accomplished such results.

KASSON OR HOLBROOK MINE.

The Kasson Mining Co.'s mine, operated by C. T. Holbrook, is 2 miles N. 55° E. of Franklin. The deposit here has been opened at three places within a distance of about 100 yards. The principal workings are near the summit of a hill and consist of an old shaft and irregular drifts, now badly caved in, a new shaft 72 feet deep, and workings on the "vein." The new shaft is 10 feet from the "vein," to which crosscuts were run at depths of 52 and 72 feet. At the time the mine was examined (in October, 1910) drifts had been run about 80 feet west and 35 feet east from both levels. An air shaft was made from the drifts to the surface west of the main shaft. A prospect pit or shaft sunk about 30 yards east by north of the main shaft exposed a ledge of pegmatite. About 100 yards east by north of the main workings a shaft 35 feet deep was sunk in the hillside some years ago, and recently a tunnel has been started at the foot of the hill about 80 feet farther east to cut the "vein" in the old shaft.

The country rock of the region is hornblende gneiss and mica gneiss, which strike north by west. The "vein" of pegmatite strikes about N. 70° E., dips high to the south near the surface, and is about vertical in the lower workings of the mine. It is 3 to 8 feet thick and contains in the middle a prominent streak of quartz, which is exposed in most of the workings. This streak ranges in thickness from a few inches to 2 feet. At the east end of the drift on the 52-foot level the streak fails, the quartz occurring only in small lenses and masses. The mica is in the feldspathic streaks on both sides of the quartz streak and is more plentiful nearer the quartz. Where the quartz streak fails the pegmatite contains little mica.

MOORE OR CABE MINE.

The Moore or Cabe mine is close to the east bank of Little Tennessee River, 1½ miles north of Franklin. It was idle at the time it was examined in 1906, but has since been operated on a rather large scale by the Carolina Mica & Manufacturing Co. In 1906 the workings consisted of an open cut, pits, and tunnels badly caved in. The open cut was run westward and the pits and tunnels were turned nearly north and south from the west end of the cut. The country rock is mica gneiss, which is folded in a curve that is followed by the workings and has a high northeast dip. Massive quartz occurs in the pegmatite, and in one opening a "vein" of pegmatite 2½ feet thick was exposed. Mica of good quality is reported to have been obtained.

JOHNSTON MINE.

The Johnston mine is about a mile northwest of Franklin. The deposit was opened first by pits and shafts from which tunnels were run N. 70° E. for more than 100 yards. Some prospecting was done later still farther to the east. It is reported that the "vein" became poor at very shallow depths. Of the mica left around the old workings only small sheets, considerably ruled but of good quality, were seen. Some biotite was found with the muscovite.

C. T. BLAINE MINE.

The C. T. Blaine mine, 1½ miles northwest of Franklin, was operated by several openings. The "vein" was traced more than 100 yards and considerable massive quartz was encountered in the openings.

JACOB W. HENRY MINE.

The Jacob W. Henry mine is 2 miles S. 80° E. of Higdonville, on a steep mountain slope. Two deposits have been opened. The main working consists of a pit 20 feet across and 15 to 20 feet deep. At this place there is a large outcropping mass of pegmatite, from which a streak of pegmatite 3 feet thick, inclosed in the mica schist-gneiss country rock, extends to the northeast. The hanging wall of the pegmatite exposed in the cut strikes east and dips 25° S. The footwall was not exposed. Mica-bearing sheets or beds that strike north and have a nearly vertical dip, occur in the pegmatite. These beds are generally about 6 inches thick, but in places they bulge out to a thickness of 2 feet. The cleavage of the mica crystals is nearly parallel with these sheets. One streak of mica crystals is said to have been followed northeastward across the cut. The pegmatite appears to form a large irregular body in the gneiss. The mica is partly specked.

CORUNDUM HILL MICA MINE.

The mica mine at Corundum Hill is about half a mile southwest of the corundum mine at that place. It has been opened by several pits, shafts, and tunnels. One of the tunnels, which was driven in northwestward for about 150 feet, cut a 4-foot pegmatite "vein," not rich in mica. The "vein," which was exposed in different workings, had a strike of N. 40° E. and a vertical dip. The mica has a dark smoky-brown color in sheets over one-sixteenth of an inch thick. Much of it is specked.

MINES ALONG COWEE MOUNTAINS.

Several deposits of mica have been worked along the Cowee Mountains within a few miles of Cullowhee Gap. Three of these were visited in 1906. The Haskett mine, a mile south of Cullowhee Gap, has not been worked since the eighties and the tunnels have now caved in badly. An opening was made on a deposit on the Haskett land on the summit of Kirby Knob. Both rum and greenish colored specked mica were seen on the dumps.

The Deerlick Gap mine, north of Onion Mountain, consists of three pits, opened by J. D. Moore. A body of pegmatite 3 feet thick, striking N. 10° W. and dipping 80° W., was exposed in the lowest workings. About 100 yards farther north along the strike, near the top of the ridge, the "vein" of pegmatite exposed in the pits is only about 2 feet thick. This "vein" is conformable with the inclosing mica gneiss. Mica of good quality but principally of small size and a little biotite were found.

LEDFORD MINE.

The Ledford mine is 2½ miles northeast of Franklin, on Rabbit Creek (called Cat Creek on the Cowee topographic map). The "vein" of pegmatite here has been worked in a northeasterly direction for about 100 yards by pits and ground-hog tunnels. Three good shafts have been sunk along the northwest side of the "vein" and tunnels have been run from them. The country rock is mica gneiss. The "vein" strikes about N. 55° E. and has a variable dip, chiefly to the southeast. At one place it is as much as 8 feet thick. At some places it contains large masses of quartz. Much of the feldspar of the pegmatite has been altered to kaolin. The mica has a clear rum color and is of good quality where it is free from clay stains. Biotite is associated with some of the muscovite.

QUIZZENBERRY MINE.

The Quizzenberry mine is about a quarter of a mile northwest of the Ledford mine, a little more than 2½ miles northeast of Franklin.

The work at this mine consists of small shafts and tunnels, now badly caved in. The "vein" of pegmatite strikes about N. 60° W. and has a vertical to high southwest dip. It includes streaks of quartz.

ELMORE MINE.

The Elmore mine is at the head of one of the branches of Rabbit Creek, 3¾ miles N. 45° E. of Franklin. It was worked by an open cut run N. 65° E. and by shafts near the northeast end of the cut. A large quantity of material had been removed from the workings, but these were badly caved in and little could be seen at the time the mine was examined in 1906. The open cut is in decomposed rock, but the shaft encountered hard, unaltered pegmatite. The mica obtained is clear and of good quality.

FOX MINE.

The Fox mine, on Watauga Creek, 4¼ miles N. 35° E. of Franklin, has been operated intermittently by numerous pits, shafts, and tunnels. Apparently a very large body of pegmatite was encountered.

Farther up Watauga Creek, near Eulalie post office, a prospect for mica was opened on the land of Mrs. M. E. Henry in 1906. The work consisted of a pit and a small, crooked tunnel. Mica of fair quality is reported to have been found.

L. J. BAILEY KAOLIN AND MICA MINE.

The Bailey kaolin and mica mine, 4½ miles N. 25° E. of Franklin, is owned by Charles Harris, of Dillsboro, N. C. The operations here have consisted of prospecting and a small amount of mining for mica. The openings consist of two tunnels on the west side of the ridge in which the deposit lies and a 40-foot shaft on the ridge. Several smaller openings have been made, exposing pegmatite containing mica and kaolin. The country rock is mica gneiss which strikes a little north by west and dips vertically. At some places the body of pegmatite is conformable with the inclosing rock, but at other cuts across it. Only small mica was seen around the dumps, though sheets measuring 3 by 6 inches are reported to have been obtained.

About 200 yards east of the Bailey mine, across a small branch, openings have been made for mica around a large outcropping ledge of quartz or a "vein" of pegmatite that strikes a little west of north. Mica is reported to have been found here plentifully, though chiefly in wedge and A shaped crystals.

MILL KNOB MINES.

Several deposits of mica have been mined 3 miles N. 30° E. of Franklin on the summit and around the sides of a hill called Mill

Knob, which rises about 200 feet above the surrounding country. The owners of the mines are Messrs. Grindstaff, Billings, Winecoff, and Zachary. The workings consist of a large open cut, a shaft 95 feet deep on the top of the knob, and more than a dozen smaller shafts, tunnels, and cuts around the sides of the hill. Some of these workings exposed more than one body of mica-bearing pegmatite. A tunnel was started into hard rock on the south side of the knob but was not carried through to the rich deposit of mica reported to have been left in the bottom of the 95-foot shaft. The country rock in Mill Knob is mica gneiss having a strike varying from N. 20° E. to N. 20° W. and an easterly dip. Most of the streaks of pegmatite are conformable with the strike of the inclosing rock. They range in thickness from a few inches to 25 feet. The larger "veins" were encountered in the workings on the summit of the hill and the smaller ones on the northwest side. The smaller "veins" were probably branches of the larger. The pegmatite near the outcrop has in places been softened by weathering, but the deep workings encountered hard, unaltered pegmatite. At the time the place was visited, in 1906, the only operations consisted of a search of the dumps for small-sheet mica. The mica at these mines is of good quality and is reported to have been found abundantly in some of the openings.

SANDERS AND OTHER KAOLIN AND MICA PROSPECTS.

Several prospects have been tested for kaolin and mica 3 or 4 miles north-northeast of Franklin. One of these, the Doc. Sanders kaolin mine, owned by Charles Harris, of Dillsboro, N. C., is 3½ miles N. 20° E. of Franklin. The workings at this mine consist of a cross-cut tunnel, a shaft, and several pits and borings which expose kaolin. The deposit lies in a ridge that trends southeastward, and has been traced by the borings for more than 100 yards up and down the ridge. The mica gneiss country rock strikes northwestward along the ridge. Higher up on the ridge there is an outcrop of massive sugary quartz. Very little mica was found in these prospects.

The Berry mica and kaolin mine is a quarter of a mile northwest of the Sanders mine. The workings consist of a tunnel and a series of pits and shafts that have been carried for 80 yards up a small ridge northeast of the tunnel. The country rock is mica gneiss, which strikes N. 50° E., dips vertically and incloses streaks and disconnected lenses of pegmatite, which conform with it in strike and dip. Streaks of quartz were encountered in several of the openings. Small plates of mica were seen on the dumps around nearly all of the workings.

The kaolin prospect of R. Sanders is a quarter of a mile north of the Berry mica and kaolin mine. A few pits and borings were made here, with uncertain results. The country rock is mica gneiss. In one of the openings a 4-foot streak of pegmatite cuts across the gneiss, striking N. 35° E. and dipping 70° SE. Small plates of mica were obtained from this opening.

LYLE KNOB MINE.

The Lyle Knob mine is 5 miles a little east of north of Franklin, in the southwest side of Lyle Knob. There are two mines here, the Lyle Knob mine proper and the Abernathy mine, which adjoins it on the west. Both mines have been owned for several years by the Detroit Mining Co. (now called the Lyle Knob Mica Mining Co.). Work was first done here on a large scale between 1880 and 1885. The principal "vein" crops out near the summit of a spur ridge leading southwest from Lyle Knob and on its southeast side. Other "veins" lie farther west and northwest. The largest working is on the southeast side of the ridge, but a tunnel has been cut through from the northwest to the southeast side. There is an open cut and a tunnel, stope, and some large rooms cut into the mountain side. An incline with side stopes was sunk on another well-marked bed of pegmatite about 200 yards to the north, on the western slope of a hill.

The country rock is mica gneiss, which incloses beds of hornblende gneiss. The gneisses have irregular strikes and dips, some striking N. 55° E. and dipping 20° NW., others striking east and dipping 75° N., and still others striking N. 60° W. and dipping northeast. The largest deposit of pegmatite is at least 25 feet thick. It strikes about northeast into the ridge and has a high northwest dip. It contains streaks and lenses of quartz and yielded a large output of mica. The other "vein," which was opened by the incline with stopes, is 3 to 6 feet thick, strikes northeast, and dips about 45° SE. Some good mica has been obtained here. Other prospects have been opened around these workings but were not examined.

CAMPBELL OR HIGDON MINE.

The Campbell mine is in a shallow cove or hollow on a steep mountain side about 1½ miles N. 75° W. of the point where the road from Webster to Franklin crosses Cowee Gap. Here more than a dozen tunnels have been run on probably two or more "veins." The soil in places in this cove is deep, especially over the lower part of the mine, and contains fragments of sheet mica derived from disintegrated veins of pegmatite. Mining through this soil is made difficult by landslides. One recent slide carried a large body of the soil down

about 10 feet. At the time the mine was visited, in 1906, two tunnels had been opened in hard rock, an old one in landslide material was being cleaned out, and another one, 250 feet long, was being driven at the base of the old workings in search of "vein" matter. This tunnel was run in a very crooked course to avoid masses of loose slide rock, which were struck at several places. In one of the hard-rock tunnels a good "vein" of pegmatite about 10 feet thick was encountered. It contained a streak of quartz 2 to 5 feet across. The mica was obtained from the streaks of partly kaolinized feldspar that lay between the quartz ledge and mica gneiss walls. The mine has yielded some mica of fine quality and a clear rum color.

BOYD KNOB MICA AND KAOLIN MINE.

The Boyd Knob mine is in a small knob 8 miles east of north of Franklin, about 3 miles N. 65° E. of West Mills. The mine, which is owned by B. C. Grindstaff, has been opened by three tunnels and some pits on the north side of the knob and by several tunnels and openings on the south side. The exposures in the tunnels on the north side indicate that the pegmatite formation strikes northwestward, cutting across the mica gneiss country rock. One of these tunnels, which is about 150 feet below the summit and has been driven in 300 feet, cuts across mica and kaolin bearing formations. Openings at the summit of the knob show similar formations associated with a ledge of coarse sugary quartz, also striking northwestward. This ledge ranges in thickness from 12 feet at the summit to 1 foot in the tunnels below, on the south side. The body of pegmatite is of irregular shape and is probably as much as 100 feet thick. The feldspar of the pegmatite has thoroughly decomposed to kaolin, which occurs in large masses. The mica is both scattered through the kaolin and segregated into richer bodies. Most of that mined is in rather small crystals of fine quality and a clear rum color.

BEASLEY MINE NO. 1.

The Beasley mine No. 1, also called "Bradley butt," is half a mile east of Mica City. It has been operated by a large open cut, a little stoping from the bottom of the cut, and several tunnels at lower levels on the hillside. Some of these openings are on different branches of the main mass of pegmatite worked in the open cut. The open cut is about 200 feet long and has a maximum depth of 30 feet. One of the tunnels below the cut was run in about 75 yards. The pegmatite was as much as 30 feet thick in one part of the open cut and pinched down into two small streaks 1 foot and 2 feet wide, between which, at the east end of the cut, lay 4 feet of mica gneiss. The country rock is biotite gneiss. The pegmatite strikes about east

and dips 85° S. near the outcrop and 30° S. at a depth of 25 feet. It cuts sharply across the gneiss and includes horses of gneiss. The rock formations here are unaltered and very hard, requiring much blasting. Irregular segregations of massive quartz lie here and there in the pegmatite. Some parts of the feldspar have a greenish cast, caused by stains from the partial decomposition of the sulphides that are scattered through it. A large pocket of mica, which yielded some large sheets of high-grade mica, is reported to have been found in the open cut. Much of the mica from the Beasley mine No. 1 is of excellent quality and of a clear rum color, but some greenish mica that had A structure was found in one of the lower openings.

BEASLEY MINE NO. 2.

The Beasley mine No. 2 is about half a mile south of the Beasley mine No. 1, on the south side of a high ridge. The deposit has been opened by prospect pits for about 150 yards along the outcrop and by a tunnel, drifts, large stopes, and an incline which connects with the stopes. The lowest tunnel entering the drifts to the stopes is about 75 feet lower than the mouth of the incline entering the stopes on the hillside above. The drift from the end of the tunnel is about 150 feet long, and the farther half of it opens up into the stope above. The country rock is mica gneiss, which strikes east and dips 65° S. at the mouth of the tunnel. The pegmatite strikes about N. 70° W. and dips 40° SW. The pegmatite is in places more than 15 feet thick, but the entire thickness was not removed in mining. The mica evidently occurred more plentifully within the mass than along the walls. In 1906 these old works were being cleared out preparatory to developing new ground. The mica from this mine is of fine quality. Some biotite is associated with it.

BRYSON MICA AND KAOLIN MINE.

The mica mine of James Bryson is 6½ miles west of north from Franklin, near Wests Mill. A series of ground-hog tunnels, pits, and shafts has been made continuously for 150 yards N. 25° E. and about 75 yards farther toward the east, across a small cove. Other workings show the same or a similar formation. The country rock is mica gneiss carrying a little diorite. Irregular masses of quartz several feet thick crop out at several places along the body of pegmatite. The mica, most of it in small sheets, is found in streaks and pockets in the pegmatite. The feldspar of the pegmatite has been thoroughly altered to kaolin through the greater part of the mass, though a few isolated bodies where mica is abundant have not been completed altered. The kaolin and mica are of good quality, but they have not been developed below a depth of 40 feet.

WEST BROTHERS MINE.

The kaolin and mica mine of J. L. & W. J. West adjoins the Bryson mine on the east. The body of pegmatite has been traced for more than 200 yards across the West property, chiefly by small pits and ground-hog workings for mica. Here, as in the James Bryson mine, masses of quartz occur through the pegmatite and in some of the openings bodies of good kaolin were exposed.

NEAL BRYSON MINE.

The Neal Bryson mine is a mile south of Wests Mill, on the east side of Little Tennessee River, in a small depression in a steep hillside. The deep soil that has accumulated in this depression carries mica derived from broken-down bodies of pegmatite. Some ground-hog mining for mica has been done in this soil. The principal workings consist of an old shaft, drifts and stopes on the vein, a new 180-foot crosscut tunnel, and a new shaft and other drifts. The mouths of the shafts are about 60 feet above that of the crosscut tunnel. The stopes from the old shaft extend down to the level of the new tunnel. A drift run from this tunnel to the east connects with the new shaft on this level and on a small level 15 feet above.

The pegmatite has an irregular easterly strike and a varying dip that shows considerable warping. The dip ranges from vertical to 70° N. at one place to 30° S. at the west end of the workings. The "vein" ranges in thickness from 1 foot in one part of the workings to 12 feet in others. A quartz streak that varies in thickness as the thickness of the pegmatite varies is included in the pegmatite near its middle part, where it is more than 3 feet thick. The mica occurs in the feldspar between this quartz streak and the mica gneiss walls. At the east end of the tunnel the "vein" is richest next to the south wall. The quality of the mica from this mine is excellent.

HALL AND WELCH MINES.

The Hall and Welch mines are on opposite sides of the same ridge, 5 miles N. 60° W. of Franklin, and may well be described together. A plan of the workings is shown in figure 64. A shaft was sunk to a depth of 80 feet at the Hall mine northeast of the summit of the hill, and tunnels were started nearly at stream level and carried in as crosscuts and drifts on the "vein" to its bottom. From a higher level in this shaft a crosscut was carried northward to extensive workings. These workings and the shaft have partly fallen in. A line of pits and shafts run farther up the hill shows the position of another "vein." Farther south along the summit of the ridge, in the Welch property, there is a line of workings on the outcrop, at the east end of which there is a shaft 40 feet deep. Openings have been made for

nearly 250 yards along this lead and carried southwestward farther west along the ridge. More than 120 yards to the south and 115 feet lower down the hill a new crosscut tunnel has been driven in, cutting the "vein" that forms the crest of the ridge and another "vein" about 60 feet south of it. The lower "vein" is 2 to 8 feet thick and has also been prospected along the outcrop. Drifts have been run both east and west along this body of pegmatite, and a 50-foot raise and a stope have been made on the east side of the crosscut tunnel. The pegmatite that forms the crest of the ridge is about 14 feet thick where it is cut by the tunnel. Two streaks of quartz, 1 foot to 3 feet thick, are inclosed in the body of pegmatite parallel with its direction. This body of pegmatite cuts across the mica gneiss country

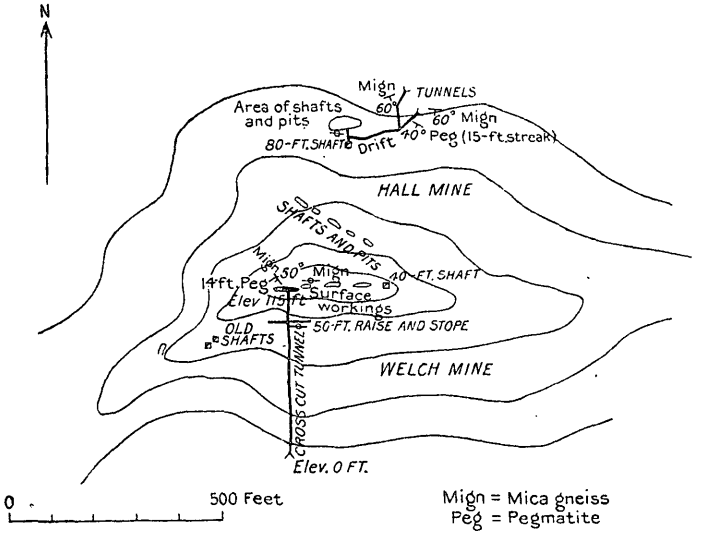


FIGURE 64.—Plan of Hall and Welch mica mines, Macon County, N. C. Contour interval is 25 feet.

rock in parts of its course and has a varying easterly strike and a nearly vertical dip. Most of the mica mined has been obtained from the two outside streaks of feldspar, which lie between quartz and mica gneiss walls, but some has been obtained between the two streaks of quartz. The mica obtained from these mines is of fine quality and has a clear rum color.

IOTLA BRIDGE KAOLIN AND MICA MINE.

The Iotla Bridge mine, 4 miles N. 10° W. of Franklin, has been worked for both kaolin and mica. At the time it was examined in 1907 the deposit was being worked by the Franklin Kaolin & Mica Co., and the following description and diagram were prepared at that time. Since then most of the kaolin has been worked out and the mine is now idle.

The deposit lies in the hill along the west bank of Little Tennessee River, near the mouth of Iotla Creek. The developments consist of eight or ten tunnels, about the same number of shafts and pits, and two rather large open cuts. The deepest shaft, which is 65 feet deep, was sunk from the summit of the hill at a point 120 feet higher than the lowest opening. Two other shafts were sunk to depths of 40 and 45 feet and connected with underground workings. The workings extend for 550 feet, starting northwestward at the south end, swinging northward along the hilltop, and ending with a northeasterly trend at the north end. The body of kaolin and the country rock have the same sweeping curved trend. The position of the workings is shown in the sketch map forming figure 65.

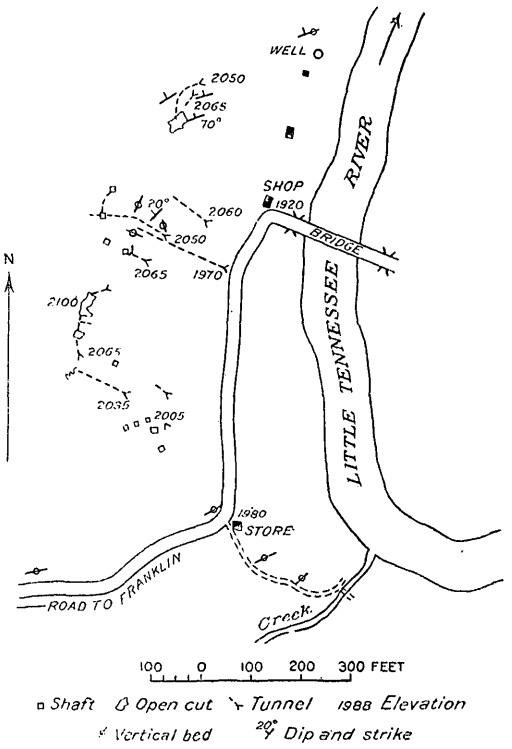


FIGURE 65.—Plan of Iotla Bridge kaolin and mica mine, Macon County, N. C.

The country rock is mica gneiss containing streaks of hornblende gneiss. The pegmatite is irregularly conformable with the inclosing gneiss and may not be one continuous body. The thickness of the pegmatite body varies from a few feet to nearly 100 feet. At some places the feldspar was massive and has decomposed to large bodies of pure kaolin. At others it includes considerable mica and quartz, which remain in the kaolin. Large bodies of sugar quartz were encountered in the workings, and a large mass crops out on the hilltop west of the shafts. Boulders of quartz are scattered over the hillside below part of the pegmatite outcrop and lie in the river, along the west bank, at the north end of the deposit. The greater part of the mica obtained from this mine has consisted of small sizes. In 1907, however, one crystal that weighed more than 4,000 pounds was found in a small tunnel connecting with the 65-foot shaft. This crystal, though somewhat irregular in shape, had a rough rhombic outline. It measured about 29 by 36 inches and was

about 4 feet thick. It was not sufficiently solid to yield sheets of this size, but it did yield some that were 12 to 18 inches square. It was sold in the rough for $1,500. The quality of the mica from this mine is excellent and the color is a rich rum.

WINECOFF MINE.

The Winecoff or old Jacobs mine is 2½ miles northwest of Franklin. It has been opened for about 300 yards, in a northwesterly direction, by numerous shafts, pits, cuts, and tunnels. A plan of the workings is given in figure 66. At 1 remains of ancient workings were found, and later four shafts with ground-hog tunnels were made. The pegmatite has a width of about 25 feet where exposed in these openings and is badly decomposed. The principal developments to the northwest were made by the last owner, Mr. Winecoff, before 1907. At 2 an open cut exposed a ledge of pegmatite rang-

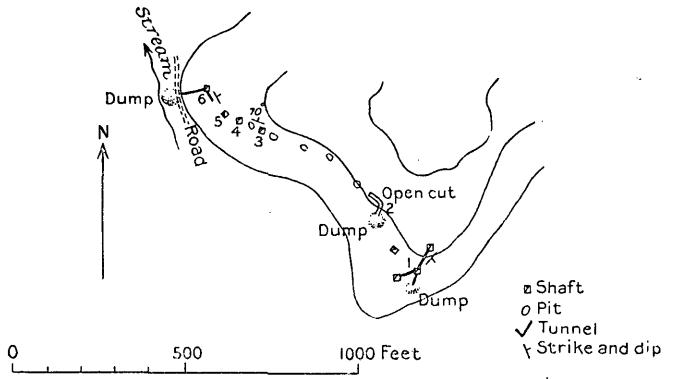


FIGURE 66.—Plan of Winecoff mica mine, Macon County, N. C.

ing in thickness from 5 feet at the surface to 8 feet in the bottom of the cut. At 3 a shaft 35 feet deep encountered a ledge of pegmatite inclosing bands of quartz. At 4 and 5 two shafts, reported to be 65 feet deep, exposed a ledge of pegmatite ranging in thickness from 6 to 8 feet and containing bands of quartz. At 6 a shaft about 40 feet deep, connecting with a crosscut tunnel and drifts, encountered a 6-foot streak of quartz, along the sides of which were small streaks of feldspar.

The workings at 1 are probably on a different body of pegmatite from that found to the northwest, though a swing in the strike (northwest) at 1 might bring the same ledge of pegmatite to 2 and other points. The strike and dip of the pegmatite are shown at 1, 3, and 6. The banded appearance of the "vein" is marked in openings 3 to 6 by streaks of quartz and mica schist in the pegmatite and parallel with its walls. Most of the mica obtained has been taken from the workings at 1, 4, 5, and 6. Possibly the same body of peg-

matite was opened at the old Harris or Raby mine, about 75 yards northwest of the Winecoff mine, across a branch. The mica from these mines has a clear rum color and is of fine quality.

RABY-SWEET MINE.

The Raby-Sweet mine is 2½ miles northwest of Franklin, about a third of a mile southwest of the Winecoff mine. It was worked by several shafts and tunnels, the last work being a tunnel more than 400 feet long, built for drainage. This tunnel connected with two of the shafts at depths of 60 and 75 feet, respectively. The country rock is mica gneiss. The pegmatite contains masses and streaks of quartz and in places was very rich in mica. The mica has a clear light run color.

IOTLA MINE.

The Iotla mine, an old mine, 3 miles northwest of Franklin, is on the steep mountain side along the north bank of Iotla Creek. The workings consist of three or more tunnels and a shaft. The size of the dumps at these old workings show that the underground operations were extensive. In an open cut among the upper workings the pegmatite is at least 20 feet thick and includes horses of mica schist. The strike of the mica schist country rock is N. 45° E. and the dip is 35° SE. The contact of the pegmatite along one of its walls, at least, cuts across the schist with a strike of N. 70° W. and a dip of 80° S. The schist next to the pegmatite also strikes N. 70° W. The pegmatite exposed in this opening contains an irregular mass of quartz 12 feet thick. Massive quartz was also encountered in the underground workings. It is reported that more than 200 feet of incline and tunnels was driven from the bottom of the open cut and that this work was not connected with the tunnels driven into the "vein" from lower down the mountain side. The dumps of this mine were being reworked for small sheet mica when visited in 1906. The mica has a clear rum color and is of the finest quality.

A deposit of fine rum-colored mica has been tested on the land of Samuel Valentine, adjoining the Iotla mine property on the west.

N. L. BARNARD MINES.

Two "veins" of mica were opened on the N. L. Barnard place, 3¼ miles N. 60° W. of Franklin, during 1905 and 1906. The most northern of these "veins" was tested by two shafts, one near the old Iotla mine, and by pits for 150 yards N. 70° W. The country rock is mica gneiss. The pegmatite is 4 to 6 feet thick, strikes N. 70° W., and dips vertically. Indications of ancient workings were found in one of the shafts. This deposit has since been worked for kaolin.

The other mica "vein" on the Barnard property lies nearly a quarter of a mile south of the north "vein" and is called the "ribbon-mica lead." It has been opened by tunnels, shafts, and pits for 60 yards to the top of a ridge. A few hundred yards farther on in the same line another opening exposes a "vein" with the same strike. The mica gneiss country rock strikes N. 70° W. and dips 60° S., and the pegmatite cuts obliquely across it with a strike of N. 55° W. The pegmatite ranges in thickness from 10 to 15 feet and includes horses of mica gneiss. Large masses of quartz crop out along the "vein" and were encountered in the workings. The mica from the Barnard mine is of good quality and has a clear rum color. Large sheets have been obtained from each "vein," though much of the mica from the ribbon-mica lead has been ruled into strips.

CHALK HILL MINE.

The Chalk Hill mine is 1½ miles east of Burningtown. The operations here have extended for more than 200 yards up the west side of a ridge to its top and for 150 yards down its east side. The principal workings and the deepest shafts are on the west side of the ridge, considerably below the top. The country rock is interbedded hornblende and mica gneiss, which strikes N. 80° E. and dips 75° N. The main lead of the mica deposits is parallel with the schistosity of the country rock, though small streaks of pegmatite cut the strike of the gneiss. Outcrops of massive sugary quartz occur along the whole line of openings, and large bodies of it were cut in some of the workings. Two or more streaks or "veins" of pegmatite have been developed by the main lead of workings. Thirty yards south of the point where the main lead crossed the ridge another streak of pegmatite carrying mica was exposed in a cut. The mica from this mine is clear and has a beautiful rum color. A little biotite is associated with it, and in some places the two are intergrown.

BURNINGTOWN OR POLL MILLER MINE.

The deposit of mica at the Burningtown mine, 3 miles S. 55° E. of Burningtown Bald, was opened before 1880. It was worked intermittently until 1903 and from then until early in 1906 on a larger scale by the Flint Mica Co., of Flint, Mich. This company equipped the mine with electric-power drills, hoisting machinery, and lights. The power drills were discarded during the last year of operation and hand drills only employed. Electricity was generated by a dynamo and turbine using the fall of a neighboring stream. The workings consist of a large open cut, a crosscut tunnel, drifts and stopes, and a small prospect tunnel and short drifts on the level of the open cut. The drifts from the main crosscut tunnel

are about 45 feet lower than the open cut. The "vein" has been removed above the drift by a large stope extending to the bottom of the open cut. An incline stope was also driven from the drift to a depth of 45 feet. A plan of the workings is shown in figure 67. A hoist was located in the drift at the end of the crosscut tunnel.

The country rock is mica gneiss, which strikes N. 70° W. to west and dips of 80° N. The pegmatite cuts across the country rock with a strike of N. 10° E. and a dip of 55° E. It ranges in thickness from 6 to 12 feet and carries streaks of quartz. One of these streaks has a maximum thickness of 4 feet and is near the middle of the pegmatite. The mica is obtained from the feldspar streaks between the quartz and the mica gneiss walls. The quality of the mica from the Burningtown mine is excellent, and the color is a clear rum. The output is said to have been large.

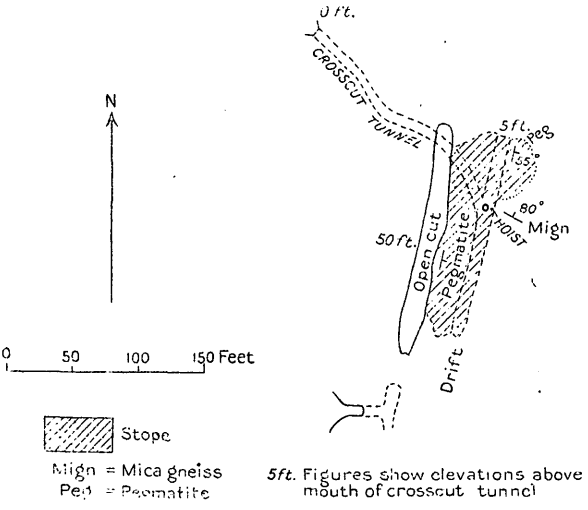


FIGURE 67.—Plan of Burningtown or Poll Miller mica mine, Macon County, N. C.

RUTH STALCUP MINE.

The Ruth Stalcup mine is 3 miles S. 40° E. of Burningtown Bald. It has been opened along the outcrop for 50 feet by two small cuts and a crosscut tunnel driven to the "vein." The country rock is mica gneiss. It is cut unconformably by the pegmatite, which strikes about N. 70° E. and dips variably to the south. The pegmatite is 6 feet thick and is made up in part of streaks of quartz which lie parallel with its course. The mica is of good quality and has a clear rum color. Good-sized blocks were reported to have been found.

Bear Pen mine.—The Bear Pen mine is about 300 yards southwest of the Ruth Stalcup. The deposit here has been worked about as much as that at the Stalcup mine.

WAYAH BALD MINE.

The Wayah Bald mine is on the east side of Wayah Bald Mountain, at an elevation of about 5,000 feet above sea level. The work consists of a tunnel that extends nearly 40 feet into the mountain side and a small amount of overhead stoping. The country rock is

mica gneiss, which strikes N. 70° E. and dips 60° NW. The "vein" cuts across the gneiss with a strike of N. 45° W. and a dip of 35° SW. The "vein" of pegmatite ranges in thickness from 2½ to 4 feet where exposed in the workings and incloses a streak of quartz in its middle. At one place in the pegmatite the streak of quartz forks, nearly inclosing a small mass of feldspar (fig. 68), and in another it completely envelops a mass of feldspar 3 or 4 inches thick. The mica occurs in the feldspathic streak between the quartz and the walls of the pegmatite. The feldspar is partly kaolinized and is therefore easy to mine. The mica has a clear rum color and is of good quality.

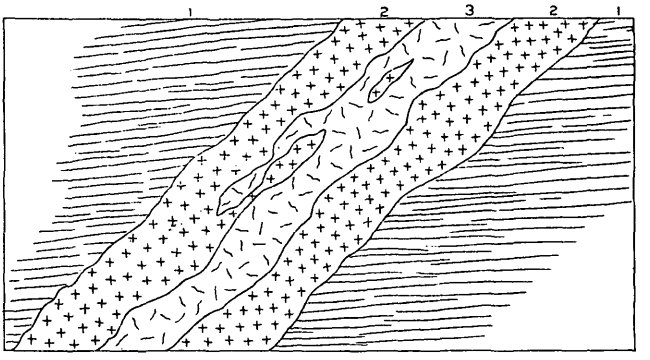


FIGURE 68.—Cross section of pegmatite 2½ feet thick at Wayah Bald mica mine, Macon County, N. C. 1, Wall rock (mica gneiss); 2, pegmatite, mostly feldspar, quartz, and mica; 3, massive quartz.

LYLE CUT OR EVANS MINE.

The Lyle Cut or Evans mine is on the steep side of the ridge that extends eastward from Wayah Bald Mountain, about three-quarters of a mile northeast of its summit, at an elevation of about 4,300 feet above sea level. The working consists of an open cut of the width of the pegmatite run about 40 yards back into the mountain side. The depth is nowhere more than 35 feet.

The country rock is mica gneiss, which strikes N. 80° E. and dips 60° NW. The pegmatite cuts across the gneiss with a strike of N. 40° E. and a dip of about 70° SE. It is 7 feet wide in places, but pinches down to about 3 feet at the entrance to the cut. These variations in thickness are rather gradual, and the deposit appears to be very regular. The strike and dip remain uniform as far as the rock is exposed in the cut. A persistent streak of quartz of variable thickness and continuity lies within the pegmatite near its middle. It ranges in thickness from 10 inches to 2 feet and extends to the full height of the pegmatite exposed in the face of the cut. It has a peculiar banding parallel to its direction and to the walls of the pegmatite. In hand specimens the texture of the rock is granu-

lar and the banding appears as alternating parts of more or less translucent and white quartz. Small plates of mica lie in certain streaks or seams parallel to this banding. Under the microscope a thin section proved to be composed almost entirely of rather fine grained quartz. The grains are angular and fit somewhat closely together. Some of them show evidence of moderate strain. Between crossed nicols a slight banding is apparent in certain directions by the extinction of the quartz grains. Parallel to this banding there are two streaks of minute black particles, probably magnetite. These lie chiefly between separate grains of quartz, though some are included in the grains. The quartz contains many inclusions. Some of them seem to be irregular cavities with or without gas; others have a reddish color and may be iron oxide that has worked its way from the pores between the grain into the cavities in the quartz.

The mica was reported to be plentiful in the feldspar-quartz streak between the quartz band and the wall rock. The color is a beautiful rum and the quality is excellent.

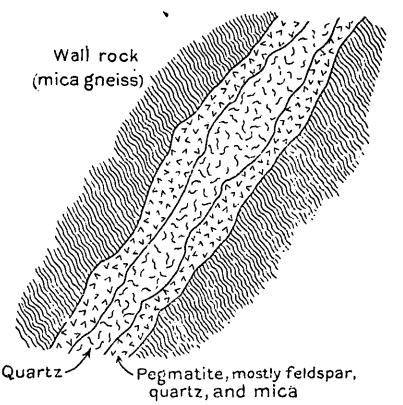


FIGURE 69.—Cross section of pegmatite 8 to 10 feet thick at Turkey's Nest mica mine, on Wayah Bald Mountain, Macon County, N. C.

TURKEY'S NEST MINE.

The Turkey's Nest mine is on the north side of the ridge that extends eastward from Wayah Bald Mountain about a mile from its summit, at an elevation of about 4,800 feet above sea level. The "vein" has been worked for about 50 yards by an open cut in the mountain side and by some incline work from the bottom to a depth of about 35 feet. The country and wall rock is hard mica gneiss, which strikes N. 60° E. and dips 60° NW. The pegmatite was 8 to 10 feet thick where it was worked in the cut but pinched down to small streaks in the end of the cut. It cuts across the gneiss with a strike of N. 60° E. and an irregular dip of 45° to 70° SE. A prominent streak of quartz is inclosed in the middle of the vein (fig. 69) and in places composes half the thickness of the pegmatite. The mica occurs in the streaks of feldspar and quartz on either side of the streak of quartz. The quality of the mica is good and the color is clear rum.

THORN MOUNTAIN MINES.

The Thorn Mountain mines are on the south side of Thorn Mountain, about 3 miles south of Wayah Gap, in the Nantahala Moun-

tains, in Macon County. There are two mines about a quarter of a mile apart on this mountain. Mine No. 1 was worked by an open cut 30 feet deep and a tunnel along the strike of the vein from the mountain side into the cut. The country rock is biotite gneiss, which has a north strike and a high easterly dip. The pegmatite is, in part at least, conformable with the inclosing gneiss. The "vein" ranged in thickness from 6 feet at the surface to 18 feet in the cut. Nearly the whole thickness of the thicker part was removed in mining. At mine No. 2 the work consists of a large open cut, which was carried back about 40 feet on the strike of the pegmatite and is about 25 feet deep at the farther end. The country rock is pegmatized mica gneiss, which strikes about N. 50° E. and has a high northwest to vertical dip. The pegmatite is from 10 to 15 feet thick

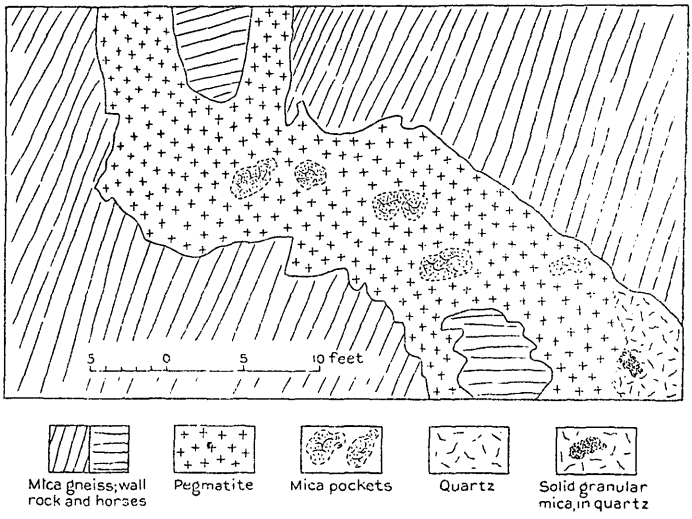


FIGURE 70.—Cross section of pegmatite at Thorn Mountain mica mine No. 2, Macon County, N. C.

and cuts the gneissic country rock with a strike of about N. 25° E. and a dip of 50° SE. (See fig. 70.) At least one horse of mica gneiss is included in it and exposed near the bottom of the cut. This horse is a large one, and its schistosity forms an angle to that of the wall rock. In the face of the cut just below the top the pegmatite either forks or, more probably, includes another horse of wall rock. The schistosity of this inclusion is also not parallel with that of the walls. These horses are even more highly pegmatized than the country rock, and the lower one has a very irregular outline.

The pegmatite has the texture of very coarse granite. The mica does not seem to be confined to any one part of it, but is found in bunches or pockets in the mass. It is said that in mining often several feet of barren "vein" would have to be removed before one

of these pockets was encountered. They generally yielded a large quantity of mica, however. In the bottom of the cut on the southeast side a mass of quartz had been laid bare, but it was not sufficiently exposed to disclose its relation to the rest of the pegmatite. An irregular band of solid mica, composed of an aggregate of small crystals one-eighth to one-half inch or more in diameter, was included in this quartz. It was 6 to 10 inches thick and 8 feet long. A little biotite is found with the muscovite at this mine. The two minerals are in places intergrown, and in one specimen seen a sheet of biotite inclosed a rhombic plate of muscovite, which had very much the appearance of a fancy window in a dark wall. A small quantity of pyrrhotite carrying a little chalcopyrite is scattered through this quartz in lumps of different sizes, some of which weighed as much as half a pound.

This mine has not been worked for several years. The "vein" material removed was exceedingly hard. The distance of the mine from any settlement made it difficult to obtain labor. The mica was reported to be fairly plentiful, however, and this fact, combined with its light color and excellent quality, ought to equalize any disadvantage due to location.

ROARING FORK MINE.

The Roaring Fork mine is about 2½ miles S. 35° W. of Wayah Gap and a few hundred yards south of Roaring Fork Creek. Two "veins" have been worked at this mine by open cuts on the outcrop and a tunnel run from one of these. The veins are about 40 feet apart and strike N. 10° E. and N. 20° E., respectively, converging toward the south. Massive quartz was encountered in each deposit.

WINDING STAIR MINE.

The Winding Stair mine, half a mile northeast of Winding Stair Gap, in the Nantahala Mountains, at the head of Cartoogechaye Creek, has not been worked for many years. The operations here seem to have been confined to an open cut and a tunnel, both now badly caved in. The country rock is mica gneiss. Clear rum-colored mica was found.

One mile east of the Winding Stair mine mica prospects have been opened on the land of J. W. Greenwood. Half a mile farther east other prospects for mica have been opened on the land of W. B. Williamson.

DOBSON MINE.

The Dobson mine is 5 miles southwest of Franklin, on Cartoogechaye Creek. The workings extend for about 75 yards N. 35° E. There are two tunnels, 15 feet apart, just above stream level, and

numerous pits and prospects along the outcrop. The workings are old and have caved in badly. Large masses of quartz crop out along the line of openings.

A mica and kaolin deposit on the north side of Cartoogechaye Creek, about 2½ miles S. 75° W. of Franklin, on a hillside facing east, has been opened about 200 feet by three tunnels. The formations encountered were decomposed and the workings have caved in badly. The country rock is diorite and badly weathered hornblende gneiss. The pegmatite also is decomposed and the feldspar has changed to kaolin of apparently good quality but undetermined quantity. The pegmatite contains horses of diorite and inclusions of quartz. The mica has a clear rum color.

I. A. DEAL PROSPECT.

The Deal prospect is 1½ miles S. 60° W. of Franklin. Here a partly decomposed pegmatite formation, which has a regular strike of N. 25° E. and a dip of 70° SE., was encountered. The mica obtained was clear, though in part clay stained by surface weathering.

BASCOM MINE.

The Bascom mine is a little more than a mile S. 20° W. of Highlands. The deposit was opened by a small cut, 15 to 20 feet across, near the point of the ridge formed by the outcrop of the pegmatite. The rock shows indications of mica for some distance up and down the ridge in a northwesterly direction. The mica obtained at this mine has a dark color and part of it is specked.

A. W. YOUNG MINE.

The Young mine is on the Blue Ridge, 1½ miles S. 15° W. of Scaley Mountain, about 6 miles southwest of Highlands. It was worked by an open cut about 70 feet long and 10 to 18 feet deep. The country rock is mica gneiss, into which is injected many streaks of granite, and has a strike about north and south and a dip of 80° E. The pegmatite cuts across the country rock with an east strike and a dip of 80° N. The "vein" ranges in thickness from 6 to 12 feet and contains a streak of quartz 2½ to 3 feet thick. The pegmatite pinches and swells and extends out in small branches that are conformable with the schistosity of the mica gneiss. Orthoclase feldspar blocks weighing 15 pounds were seen. The mica has a smoky brown to green color and part of it is specked. Much of it shows wedge and **A** structure, though good sheets can be cut from between the **A** lines.

A small prospect 75 yards north yields mica that is of the same colors but that shows very little wedge or **A** structure.

MITCHELL COUNTY.

HAWK MINE.

The Hawk mine is a little more than 4 miles east of Bakersville, near the headwaters of Cave Creek. It was not visited by the writer. The brief description given here is taken from notes made by J. A. Holmes in 1896. The mine was first opened by Buchanan & Buchanan in 1870 and was later taken over by Heap & Clapp and other parties. It was worked on a large scale at intervals by different parties until 1893, but since that time operations have been confined to working over the old dumps. The Hawk mine is classed among the best of the old Heap & Clapp properties. It has been a large producer and is credited with a yield of mica worth at least $75,000. This mica was of fine quality, and some of it was cut into sheets 18 by 20 inches across.

Several shafts with drifts and stopes have been made in different parts of the property and long tunnels have been run in from the mountain side on the vein. Two shafts, the Tom Green shaft and the main shaft, were sunk to a depth of about 250 feet. Most of the others were less than 100 feet deep. In places the "vein" has been largely stoped out, but in other places work was stopped before the stoping was completed because the conditions for mining were unfavorable. More than one "vein" was encountered in the workings, but the best one was generally about 8 feet thick, though it showed local variations in thickness. Most of the country rock is hornblende gneiss of the Roan gneiss formation which incloses a few beds of mica gneiss.

CLARISSA MINE.

The Clarissa mine is 2½ miles due east of Bakersville, on the west side of a small cove about 200 yards north of Cane Creek. It was first worked by Joseph Buchanan and Neal Leatherman about 1870 but was later purchased by Heap & Clapp, who considered it the best of their properties. It has been reputed to be the best mica mine in the State. Some question has arisen as to the ownership of the property, but the greater part of the deposit appears to be owned by Mrs. Ella Clapp Thompson, of Washington, D. C. (a daughter of E. B. Clapp), and Mrs. V. P. Cibotti, of Philadelphia, Pa., and part of the east end of the workings is held by Vance Brown, of Asheville, N. C. Col. J. K. Irby estimates that up to 1896 the mine had yielded mica worth about $175,000.

The workings extend from the bed of the stream in the cove about 150 yards S. 60° W. up to and across the summit of a small ridge that stands about 75 feet higher than the stream. Practically nothing

can be seen of the workings except a depression about 75 yards long, 20 to 30 feet wide, and 5 to 15 feet deep, formed by old surface workings and by the caving of underground workings. A few pits were opened between the end of this depression and the summit of the hill. Dumps were cast up along the workings, but the principal one was at the foot of the hill. Here, at the bottom of the cove, an immense pile of waste was accumulated, but by being worked over for scrap and by washing down in floods it has now been spread out over a large area.

Information regarding the early workings was given to J. A. Holmes in 1892 by Thomas Grindstaff, Col. J. K. Irby, and a Mr. Buchanan, and all this information, supplemented by measurements made by J. A. Holmes, has been abstracted below. The later work at the mine is described by B. B. Westphalen, the mine superintendent, in a report prepared for Mrs. Thompson. Westphalen's report is also abstracted below. J. A. Holmes's notes follow:

Remains of prehistoric workings were found around the Clarissa mine. These workings consisted of a large amphitheatral cut in the northeast side of the ridge. Large trees were found in this cut and in the dumps. In 1896 a chestnut tree that measured 12 feet in circumference 3 feet above the ground was still standing in the dump.

On the west slope of the ridge at the southwest end of the works there is a shaft about 15 feet deep, and there is another of the same depth 23 feet to the northeast. Mica was found in both shafts, but the ground between them was not worked out. A 40-foot shaft was sunk 71 feet northeast of the shaft last mentioned, but it did not find much mica. A shaft was sunk to a depth of more than 60 feet on the summit of the ridge. About 72 feet northeast of the shaft on the summit of the ridge, in an open cut, is the Gooseneck shaft, sunk by Colonel Irby to a depth of about 100 feet. About 50 feet farther northeast another shaft, called the Gooseneck No. 2, also about 100 feet deep, was carried from the bottom of the amphitheatral cut. The vein was not thoroughly worked out southwest of the Gooseneck shaft, but between this and Gooseneck No. 2 most of the mica was stoped out. The Clarissa or Engine shaft is 133 feet northeast of the Gooseneck shaft No. 2. It was worked to a depth of 312 feet. From the bottom of this shaft the work slopes up toward the Gooseneck No. 2 on the southwest and to the pump shaft in the Spread Eagle mine on the northeast. This was the limit of the Clarissa mine, the property adjoining it on the northeast being known as the Spread Eagle mine.

The Spread Eagle shaft is 35 feet east of the pump shaft. It was nearly as deep as the Clarissa shaft, and was used as the engine shaft for the Spread Eagle mine. Another shaft (Spread Eagle

No. 2) was sunk 23 feet northeast of shaft No. 1, but not as deep. Still another shaft, 20 feet deep, was used to pump the surface water from the Spread Eagle mine. The ground was largely worked out between the Spread Eagle No. 2, the Spread Eagle No. 1, and the Clarissa shafts. The workings sloped southwest from the bottom of the Spread Eagle No. 2 to the bottom of the Clarissa shaft.

The abstract from Westphalen's report follows:

Three shoots or chimneys of mica were worked within a space of 150 feet northeast and southwest. These were called the Spread Eagle, Briny Deep, and Gooseneck. All were sunk to considerable depths by different persons, the Briny Deep being carried down 175 feet by Mr. Westphalen and opened by drifts and stopes. In this working the stopes were worked out by 3-foot benches, and in some of the larger stopes there were as many as 10 of these benches, one above the other. A large force of men worked at the mine during the day and a small force at night. Blasting was done twice a day. Water was hoisted in 50-gallon oil barrels at the rate of one barrel every 15 minutes. Other parties carried on mining by less systematic methods. Waste rock was allowed to accumulate or was dumped into older workings, which made them difficult to reopen.

The vein was inclosed in hard, firm walls below the zone of surface weathering and had a high to vertical dip. Its thickness was variable, ranging from a few feet to 10 feet, but as the vein bulged or pinched in places it averaged nearly 8 feet. The bulges were so rich in fine crystals of mica that it was difficult to drill without injuring the crystals.

A study of the present surface indications shows that the country rock is hornblende gneiss interbedded with muscovite-biotite schist and gneiss. The mica schist and gneiss form the wall rock of the pegmatite. The pegmatite strikes about northeast and is approximately conformable with the gneiss. Potash feldspar, quartz, small mica, and opaque red garnets were observed in the dump. The mica has a fine clear rum color and good flat cleavage.

CLOUDLAND MINE.

The Cloudland mine is 3½ miles S. 70° E. of Bakersville, in a mountain spur in a cove on the south side of a small tributary of Cane Creek. It received the name "Cloudland" because the Cloudland Hotel on the summit of Roan Mountain could be clearly seen from the mine and because the large white dump of the mine was so plainly visible from the hotel.

According to information given to J. A. Holmes by Thomas Green in 1896, the deposit was discovered by Thomas Green about 1870 while digging ginseng. Mica was found in a large rock, which was

either a block fallen from the "vein" or one still attached to the "vein." The surface of this rock contained many crystals of mica, one of which, 8 by 24 inches across, was sold for $67. It would have brought $250 if it had not been exposed to the weather. This deposit paid a few men $4,000 in two months, after which it was worked by Abernathey & Rorison and later by Heap & Clapp. Colonel Irby estimates that the mine yielded mica worth about $100,000 up to 1896. It is now owned by Mrs. Ella Clapp Thompson, of Washington, D. C., and Mrs. V. P. Cibotti, of Philadelphia, Pa.

The mine is in a steep mountain side at an elevation of nearly 4,000 feet above sea level or 1,000 feet above the valley two-thirds of a mile to the north. The entrance to the mine consists of a large open cut, which extends more than 100 feet back into the mountain side in a S. 70° W. direction. The cut, which is about 75 feet deep at its southwest end, passes into a stope (open to the surface through part of its course) and extends back into the mountain side in a sinuous course extending about S. 35° W. The open cut is 20 to 35 feet wide but has been partly filled by the blasting down and caving of the side along the hanging-wall. A large dump that stands about 100 feet high and is probably 50 feet thick near the top has been built out on the mountain side. The stopes were closed by fallen rock when the mine was examined, and the notes on the underground workings are taken from a report by B. B. Westphalen, the former mine superintendent. The open cut is filled to a depth of 10 to 15 feet with large blocks of wall rock and pegmatite. The stope was carried back for some distance to the southwest and was worked to a depth of 200 feet.

The country rock is muscovite-biotite schist and gneiss, which strikes northeast and has a variable southeast dip. The pegmatite is approximately conformable with the inclosing schist. The hanging wall in the open cut has a rolling dip, which ranges from 75° to 25° SE. and averages about 60°. The pegmatite cuts the schist where the wall has a low dip and is conformable where it has a high dip. Westphalen states that the dip in the deep stope was about 75°. The pegmatite was about 40 feet thick in the deep stope, 20 feet thick in the open cut, and pinched to 6 feet at the surface above the stope, at the southwest end of the open cut. Little pegmatite was exposed in place at the time of the examination. The material seen on the dumps contains quartz, mica, small quantities of bluish-green apatite and pinkish-red garnets, and a plagioclase feldspar that is nearly albite. The mica has a clear rum color and flat cleavage. The mine yielded a large output of mica of fine quality, which was taken from both the open cut and the deep stope. The "vein" for about 20 feet between these two workings contained little mica.

RANDALL MINE.

The Randall mine is about 3 miles south of Bakersville. It was not visited by the writer. The information given below is taken from notes made by J. A. Holmes in 1896. The mine was opened by Peter Grindstaff and Dave Glenn about 1875 and worked successfully for about three years. It then changed hands, but the operations since 1878 have not been profitable. Four shafts were sunk to depths of 20 to 100 feet within a distance of about 160 feet in a line running northeastward. The "vein" between three of these shafts is said to be largely stoped out for a distance of about 75 feet to a depth of nearly 50 feet. The "vein" could be reached by a tunnel from the hillside at a level to permit drainage and mining. A good deposit of mica about 6 feet thick is reported to have been left in the bottom of the mine.

BUCHANNAN MINE.

The Buchannan mine is on the south slope of a small mountain 1½ miles N. 25° W. of Ledger. According to information furnished to J. A. Holmes by Bailey Bros. and Arthur Thompson it was opened about 1875 by William Buchannan, who removed mica worth about $1,500 in two months. Later the mine was operated by Colonel Irby and Jim Davis, and again by Arthur Thompson and West Bailey. There are two or more "veins" and on one of them pits were made by aborigines. At one place a tunnel was cut in the altered feldspar of the pegmatite for 15 feet alongside a quartz vein. Stone implements used by the prehistoric miners have been found around these old works, and fragments of them were still to be seen at the mine when it was visited in 1904. The work by white men has been done principally on "veins" east of that worked by the aborigines. One of these deposits, probably another "vein," was worked intermittently by a tunnel in 1904, but the tunnel was locked and the mine was idle at the time of the visit. Another ledge of pegmatite crops out farther east and has been opened by several pits, an open cut, and a small tunnel.

The country rock is mica gneiss, which strikes about N. 25° E. and dips about 70° E. The bodies of pegmatite appear to be conformable with the inclosing gneiss. They contain streaks or ledges of massive quartz parallel with their walls. The mica is of good quality and is reported to be plentiful in places. Large crystals of green beryl are found occasionally, though none are of gem quality. Uranium minerals, pitchblende and its alteration products, are reported to have been found in some of the openings. Apatite and monazite are also reported to be associated minerals.

SINK HOLE MINE.

The Sink Hole mine is near Bandana. It is one of the old mines of Mitchell County and was first worked by the aborigines. According to information given to J. A. Holmes in 1896 by Thomas Grindstaff and William Roberson the nature of these ancient workings was mistaken by General Clingman and a shaft was sunk near them in search of silver in 1868. Good mica was encountered but thrown on the dump, where it was seen later by E. B. Clapp. Clapp recognized its value and soon commenced to work for mica in partnership with J. G. Heap.

A dozen or more shafts, some of them 150 feet deep, have been sunk by the persons working this mine, who have also done considerable drifting and stoping. Among the veins encountered were the Sink Hole "vein," the Silvers "vein," and the Rorison "vein." The underground work on these veins is said to amount to 2,000 to 3,000 feet. The ancient workings are said to have been extensive and to have included small tunnels and shafts where the formations were soft. Large dumps were thrown out on the surface. When visited by the writer in 1906 the mine was being tested by William A. Robinson. It was opened in three places, one of which was an ancient stope about 18 inches wide and was in places filled with rubbish. Decomposed pegmatite, poor in mica, had been left as one wall of the stope by the aborigines and mica gneiss as the other. The other prospect work was so directed as to get to places where it was thought the whole "vein" had not been removed.

The country rock is mica gneiss, but the relations between the gneiss and the pegmatite were not well exposed. At one place a wall of one of the bodies of pegmatite cuts across the bedding of the gneiss. Much of the feldspar of the pegmatite in the upper workings is kaolinized. Mica of good quality was obtained in large quantities.

GIBBS GREEN MINE.

The Gibbs M. Green mine is three-quarters of a mile northeast of Boonford. In 1906 it was opened by three pits, a tunnel 50 feet long, a shaft 45 feet deep, and other test pits. The tunnel connects with one of the pits at a depth of about 18 feet. The country rock is mica gneiss that strikes N. 20° E. and dips 75° E. The pegmatite is conformable with the inclosing gneiss. The mica has a dark-brown to green color and part is specked. Mica is said to be plentiful in places and blocks a foot in diameter have been found.

FLAT ROCK MINE.

The Flat Rock mine is 1 mile N. 30° E. of Penland. According to information given to J. A. Holmes by Col. Irby the mine was

opened by John Wilson and Moses Young in 1872. It was operated later at different times by J. W. Gudger, Col. Irby, Green & Baker, J. E. Burleson, and Baker & Rorison. The workings extended to a depth of 150 feet. The mine was abandoned when the timbering was knocked out by blasting and it caved in. About $15,000 worth of mica is reported to have been obtained.

The Flat Rock mine has been idle for many years, but the dumps have been turned over for small sheet and punch mica and for uranium minerals. When the mine was visited, in 1904, the workings appeared about as shown in figure 71. They consist of four shafts and a tunnel, from which large quantities of "vein" matter were removed. When the workings caved in a pit about 75 feet long, 50 feet wide, and 10 to 18 feet deep was formed around three of the shafts, as shown in the sketch. The country rock exposed in the east and south walls of the pit is coarse granite or fine pegmatite.

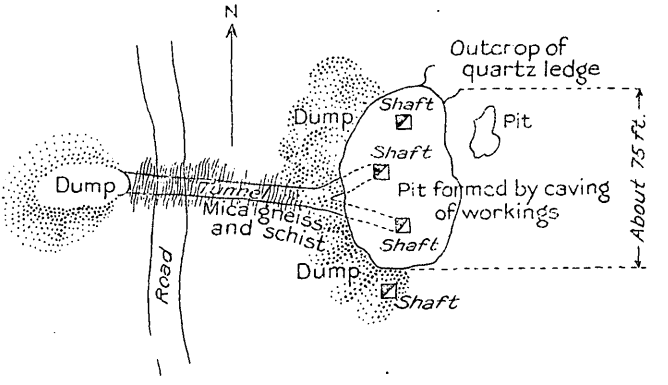


FIGURE 71.—Plan of Flat Rock mica mine, 1 mile northeast of Penland, Mitchell County, N. C.

At the north end of the pit there is an outcrop of a part of a quartz ledge, about 4 feet thick. Quartz is said to have been found in large streaks through the pegmatite in the mine and to have overlain the richest deposit of mica. Among the minerals associated with the mica at this mine were pitchblende and its alteration products, cyrtolite, thulite (pink zoisite) in white feldspar, and garnet. The mica is of excellent quality and is said to have been found in sheets of large size.

During 1905 and 1906 J. E. Burleson sank a new shaft on a mica "vein" about 100 yards north of the old mine. This shaft was said to be nearly 100 feet deep, and drifts were run to the northeast and southwest from its bottom. According to Mr. Burleson two streaks of mica were encountered. The mica of the upper one had a greenish cast and A structure; that of the lower one contained flat, colorless mica.

MINES OF CAROLINA MINERAL CO.

Some of the old mica deposits near Penland have been worked during the last few years for feldspar and mica by the Carolina Mineral Co. One of these is the old Deer Park mine No. 3, about one-third of a mile northeast of Penland, in a horseshoe bend of North Toe River. Another is on the opposite side of the river, west of Deer Park mine No. 3. The company has a water-power plant at Penland that furnishes power for punching and trimming machines, for running an air compressor to supply compressed air for drills in the mine workings, and for operating hoisting engines for derricks. Nearly a mile of piping has been used to carry compressed air to the openings. Several hundred yards of mine track and a spur that bridges the river connect the workings with the Carolina, Clinchfield & Ohio Railway. A platform and chute at the end of the spur are used to load the feldspar directly into freight cars on a siding. Plate XXII is a south of west view of the mine, showing the railroad siding across the river. A large open cut is shown at 4 in the sketch forming figure 72.

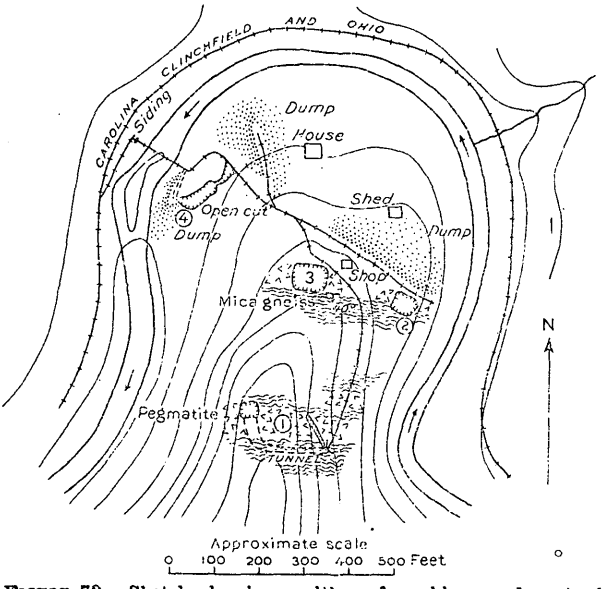


FIGURE 72.—Sketch showing position of workings and part of geology at feldspar-mica mine of Carolina Mineral Co., Penland, Mitchell County, N. C. For explanation of the numbers see text.

The country rock at these mines is highly schistose mica gneiss belonging to the Carolina gneiss, into which has been intruded many bodies of pegmatite, the largest more than 50 feet thick. Streaks and horses of the gneiss are included in the pegmatite and in some places are so large that they form the wall rock in the mine openings. The general strike of the gneiss in this region is east of north, but great variations occur in the neighborhood of the mine, where the strike is nearly east and west. The rock formations have decayed deeply on remnants of old peneplains that stand from 200 to 250 feet above the river, as shown in the kaolin workings of the Harris Clay Co., one-third of a mile north of the mines. Erosion

along the river has removed most of this mantle of decomposed pegmatite and gneiss in the feldspar-mica mines 100 to 200 feet lower, and fairly fresh rock is encountered near the surface.

The rough sketch map forming figure 72 shows the location of the different workings on the south side of North Toe River, which are described below. The workings described are numbered to correspond with the numbers used in the sketch map.

1. An open cut passing into a stope nearly 100 feet deep at an inclination of 40° S. and a tunnel run from the hillside 125 feet to the east. The open cut is about 25 feet square but becomes smaller in the stope below. A long trench-like cut was made up the hillside north of the mouth of the tunnel on a small, rich streak of mica. These workings are in a large deposit of pegmatite, as shown in figure 72. The pegmatite is mostly conformable with the schistosity of the gneiss, but at some places cuts across it. A few streaks of mica schist are included in the pegmatite, about parallel with the walls.

The pegmatite is coarse grained and contains potash feldspar crystals 1 foot to 2 feet thick, masses of granular smoky quartz, and mica in crystals of different sizes. A little uranium mineral was found in this working, and a few stains of autunite or similar alteration products of pitchblende were seen on the dump. The mica was irregularly distributed through the mass of the pegmatite in the main workings and in a streak or vein 1 foot to 2 feet thick that cut across the mass of the pegmatite with a vertical dip in the long trench.

2. A large open stope more than 50 feet deep on an incline of about 40° S. The pegmatite is coarse-grained and thick, about 30 feet being worked under the hanging wall. Potash feldspar occurs in large, pure crystals and smoky quartz in granular masses a foot or two thick. Mica occurs in a streak 3 to 4 feet thick inclosed in the feldspar and about parallel with the walls. The crystals are plentiful in parts of the mica streak and some of them measure more than 12 inches across. Good specimens of pitchblende and its associated alteration products were found in this working.

3. An open cut about 75 feet across and 20 to 400 feet deep; a 40-foot tunnel runs from it to the west. Highly schistose mica gneiss, which strikes about east and dips 60° S. forms the south wall. The body of pegmatite is large, and a thickness of more than 30 feet was worked, chiefly for feldspar. A little good mica is scattered irregularly through the rock. The feldspar was partly kaolinized near the surface but was fresh and of good quality below a depth of 15 feet.

4. An open cut about 150 feet long, 10 to 30 feet wide, and 10 to 40 feet deep, opened chiefly for feldspar, which occurred in a rich streak, 10 to 25 feet thick, having a northeast strike and southeast dip. Some sheet mica and masses of solid mica composed of bunches of small crystals were also found. Plate XXIII, *A*, shows working No. 2 in the foreground, No. 3 in the center, and the dump from these and from working No. 4 on the extreme right. This view was taken S. 80° W. from a point across the river.

Other workings have been made for feldspar and mica across North Toe River southwest of the open cut at 4. These consisted of a few hundred feet of tunnels, some stopes, and a little open-cut work in the bank above the railroad. The feldspar was loaded by a chute into freight cars on a side track below. These workings were not in operation at the time the mine was visited in November, 1914. The

workings were in a large deposit of pegmatite, which was partly decomposed near the surface. Streaks of mica schist or gneiss were inclosed in the pegmatite, but the true walls were not exposed.

The mica from all the workings is similar. Some of the crystals are more than a foot in diameter. A rather large proportion of it is wedge-shaped or A mica, but some good sheet mica is also obtained. The mica is clear and has a rather dark smoky greenish-brown color in sheets one-sixteenth of an inch thick. Where free of A lines it splits smooth and flat. Pretty flattened clear cherry-red garnets have been found in some of the sheets of mica, chiefly those that have the A structure somewhat developed. These garnets range from the thickness of paper to more than one-sixteenth of an inch and reach a quarter of an inch in diameter. The angles between the crystal faces around the edges are plainly evident.

The feldspar forms the most valuable product of these mines, but in places the deposits of mica have also been valuable. The feldspar is a light-gray potash variety, chiefly microline, and occurs in fairly large pure masses that can be cobbed over easily. It is shipped to Trenton, N. J., and East Liverpool, Ohio, for use in making pottery.

MINES OF HARRIS CLAY CO.

The Harris Clay Co. was operating two mines in the Spruce Pine region at the time the place was visited in 1914. One of these was on the east side of Beaver Creek valley, 1½ miles N. 30° E. of Spruce Pine, and the other was one-third to one-half a mile northeast of Penland. Both of these deposits have proved large and have been worked over areas of several acres. Similar modes of operation have been employed in both mines. First the overburden of discolored surface clays is removed by scraping, digging, and carting, and the underlying kaolin is removed in open cuts and circular shafts lined with wooden blocks. The kaolin as excavated is thrown into sluices and carried down to cleaning mills, where it is washed, floated, settled, molded, dried and otherwise prepared for shipment to pottery manufacturers. The circular shafts are carried to depths of 50 to 90 feet, according to the depths at which the feldspar of the original pegmatite has been altered to kaolin. The shafts are sunk from the bottom of the cuts where open work is no longer feasible. The shafts started at higher elevations on the hillsides are in general deeper than those started at lower levels.

The deposit on Beaver Creek lies between 2,700 and 2,800 feet above sea level, and that near Penland between 2,600 and 2,700 feet, extending from the remnants of bench lands at a distance from the creek and river down the hillslopes. At each deposit both the original pegmatite and the inclosing mica gneiss country rock have been

deeply weathered, probably during a long period in which there was relatively little uplift and but slight erosion. During this time broad, flat valleys were developed and the products of weathering remained in place in them. A later uplift of the region gave the streams new cutting power, and the present valleys were cut below the bottoms of the original broad valleys, scattered remnants of which have been left along the sides of the present valleys.

The Beaver Creek and Penland kaolin deposits are the remnants of large deposits of pegmatite that were extensively decomposed during a period of slow erosion. The feldspar was altered to kaolin by the dissolving out of the alkalies and hydration. The less easily altered minerals, quartz and mica, remained as they were, being now embedded in a kaolin matrix instead of feldspar. The original pegmatite occurred in large beds or irregular deposits, which were separated by or included streaks of mica gneiss that now form barren places in the kaolin deposits.

The effects of the long and steady weathering on the pegmatite are shown in strong contrast by the large deposits of kaolin in the Penland mine and the hard, fresh pegmatite encountered near the surface in the feldspar and mica mines of the Carolina Mineral Co., just across North Toe River to the south and 100 to 200 feet lower. The kaolin workings are seen on the summit of the hill to the right and the dump of the Carolina Mineral Co. mine about 15 feet above the river level to the left in Plate XXIII, in which *A* and *B* form a panoramic view.

At the Beaver Creek workings a large quantity of small mica has been removed during the mining for kaolin and has been separated from the associated quartz and other minerals in a washing plant by the English Mica Co., of Spruce Pine, and then ground as scrap mica. A small quantity of larger crystals of mica, suitable for sheet or punching, has also been found in the mining for kaolin.

EDGAR BROS. KAOLIN AND MICA MINE.

A deposit of kaolin was opened in 1906 by the Edgar Bros., 2½ miles north of Penland, in the forks of Bear Creek. The washing plant was on the railroad along North Toe River, a quarter of a mile above Penland, at the place where the Harris Clay Co.'s washing plant now stands. The mine was operated for kaolin, and considerable small-sheet and scrap mica was obtained as a by-product. Basket pits about 20 feet in diameter, lined with cribwork, were sunk in the usual manner in the body of the kaolin deposit. The material from the pit was dumped into a washing bin and washed over screens with 1-inch openings by a jet of water. The mica and waste were shoveled off the screen at intervals when the kaolin was

washed from it, and the mica was sorted later. The kaolin was carried through about 800 feet of wooden trough to a revolving-cylinder disintegrator and thence to a settling bin, where the grit and coarse material were deposited. The fines were washed a second time and sent through another 800 feet of board sluice, which had a more gentle slope than the first 800 feet. The settlings were shoveled out of this as needed. From the sluice the fine kaolin was carried suspended in water through 3 miles of 5-inch pipe to the drying plant, where it was run into settling vats. The water is decanted off and the kaolin mush is pressed into disks in molds and dried.

The body of decomposed pegmatite that is suitable for kaolin is large and is reported to have been proved by boring 200 yards northeast of the place first opened. It is in hornblende gneiss country rock, also much decomposed. The pegmatite is, in part at least, the typical variety, and has quartz and mica scattered through it.

DEAKE MINE

The Deake mine is about a mile northwest of Spruce Pine, on the south side of North Toe River, about 100 feet above the river. The workings are not now open for examination, and all that can be seen are the remains of old cuts, tunnels, and a large dump. According to information furnished by Colonel Irby, the mine was discovered by Lewis Cook and developed by J. C. Deake. It was afterwards operated at different times by different persons and is estimated to have yielded mica worth from $60,000 to $75,000. The "vein," which is reported to be nearly flat, crops out on the river bank. It has been worked both by tunnels from the hillside and by shafts from the surface. Mica of fine quality was obtained as well as good specimens of uranium minerals.

BILL WILLIS MINE.

The Bill Willis mine is about a mile northwest of Spruce Pine, on the south side of North Toe River, about 200 yards west of the Deake mine. It was reopened in 1906 after remaining idle for a number of years. A new crosscut tunnel was driven in to cut a 25-foot incline from an old open cut. The pegmatite has been opened by a cut run eastward for about 60 feet along the hillside. The mica from the east end of the workings has a dark-green color and is partly A and partly hair-lined. Near the west end of the workings the mica has a rum color and is of good quality. The pegmatite is well exposed at the west end and is massive. The crystallization is very coarse, and rough crystals of orthoclase feldspar 2 feet thick were seen in the walls. A large streak of quartz of smoky-blue color is exposed in the pegmatite, and the greater part of the mica is found near this.

Some of the sheets of mica have flattened garnets between the laminae.

WESTALL MINE.

The old Westall mine, owned at the time it was examined, in 1914, by Mrs. T. C. Turbyfill and Mrs. S. A. Dorsett, of Spruce Pine, is 1¼ miles N. 70° W. of Spruce Pine. It was discovered by W. B. Westall and was opened in 1876 by Col. J. K. Irby, and it has been operated intermittently since by different persons. The workings consist of an open cut and a shaft run from its bottom to connect with stopes below. The stopes also connect with a tunnel run from the foot of the hill at a level about 60 feet lower. The full size of the stope could not be determined because the roof had caved in. The mine was being worked in a small way in 1914 for both mica and feldspar.

The country rock is coarse mica gneiss and incloses beds of hornblende gneiss east of the mine. Near the mouth of the tunnel the gneiss is cut by coarse granite, which strikes east and dips 45° S. The body of pegmatite is large, at least 15 feet thick, and has been opened by a stope run N. 60° W. on a slope of 45° SW. The pegmatite occurs in crystals more than 2 feet thick, and a massive segregation of quartz encountered in the east side of the open cut is about 10 feet thick. Part of the pegmatite is decomposed near the surface, but good fresh feldspar is obtained in the lower part of the mine. Some of the crystals of mica are more than a foot across, and one block is reported to have weighed 150 pounds. The mica is dark greenish brown. Many of the crystals have A lines but yield good sheet mica between these structures.

F. M. TOLLEY MINE.

The F. M. Tolley mine is about a mile west of Spruce Pine. It was worked by a tunnel from the hillside and by shafts run on the vein. The country rock is partly decomposed mica gneiss. The body of pegmatite is large and the rock grades from coarse grained in the mica-bearing part to fine grained where it is exposed near one of the walls. It has been partly decomposed and crumbles away after mining. The mine is reported to have yielded considerable mica of good quality.

CHALK MOUNTAIN MINE.

The Chalk Mountain mine is about 2 miles southwest of Spruce Pine, on the west side of Chalk Mountain, near its summit. It has been opened by a tunnel run in along the strike of the pegmatite, two shafts, and several prospect pits and trenches. These openings fall within a space that extends about 100 yards N. 70° E., a direction which represents the strike of the pegmatite. The pegmatite

is inclosed in mica gneiss in approximate conformity with its bedding and dips about 45° N. The workings are in such bad repair that little could be seen of the "vein." The dumps show that the formations encountered are fresh and little decomposed. Dark-green octohedrons of gahnite spinel were found in blocks of feldspar thrown on the dumps.

Z. T. McCHONE MINES.

The McChone mines are 1 mile S. 30° W. of Spruce Pine, nearly a mile east of Chalk Mountain on the same ridge. They include a mica mine, two aquamarine prospects, and a prospect yielding crystals of spodumene and amazon stone. The mica deposit has been worked intermittently; the other deposits have been opened only in a small way. From two of them crystals of beryl were obtained that would yield very small gems of aquamarine. Amazon stone or green microcline feldspar was found in these deposits and also in the deposit yielding spodumene. The amazon stone is semidecomposed at the surface, though it still retains its green color when partly kaolinized. Fragments of badly decomposed crystals of spodumene, 1 inch to 3 inches across, were seen on the dump of one of the prospects. A small part of the interior of these crystals was still unaltered. This fresh spodumene was transparent yellowish green, resembling in color the poorer grades of beryl. Chips as large as $2\frac{1}{2}$ by 5 by 7 millimeters were seen, perfectly transparent and free from flaws.

BLALOCK MINE.

The Blalock mine is about half a mile northwest of Spruce Pine, on the north side of Toe River valley. It was opened about 1873 by McKazier & Campbell and worked for three years. Since 1876 a small amount of exploring work has been done at different times, but no regular operations have been undertaken. The workings have fallen in so badly that little could be seen of the formations. A quantity of decomposed fine pegmatite had been thrown on the dumps along with the kaolinized feldspar of the mica-bearing part of the "vein."

W. W. WISEMAN MINE.

The W. W. Wiseman mine is 2 miles N. 25° E. of Spruce Pine, on the east side of Beaver Creek valley. According to Mr. Mart Wiseman it was opened by James Wiseman and John Pendley in 1875. These men removed mica worth from $2,000 to $3,000 in one year's work. Later the mine was operated by Lum Blalock and Luke Lewis, and still later by other parties. About 1890 the mine was again operated, this time by the Southern Mica Co., and con-

siderable work was done. After a number of years of idleness it was reopened by the Carolina Mineral Co., and has been worked for feldspar and mica for several years.

The mine is in a steep ridge or spur that pitches westward into the valley of Beaver Creek. The old workings consisted of a shaft 30 feet deep, a tunnel 40 feet long run from the shaft, and another tunnel about 100 feet to the north, now caved in. The 30-foot shaft and 40-foot tunnel have been mined away in the later workings. When the mine was first examined, in 1904, the workings of the Southern Mica Co. were still open. They consisted of a crosscut tunnel more than 200 feet long driven into the "vein" and extensive stopes that reached 40 or 50 feet above it. In 1914 the workings had been greatly enlarged. The upstope on the "vein" had been raised to the surface, nearly 100 feet above, and extended farther east, forming a deep open cut or a large open stope more than 100 feet long and 10 to 30 feet wide. Plate XXIV, *A*, is a view eastward across the deep stope from the bottom of the small open cut at the west end of the workings.

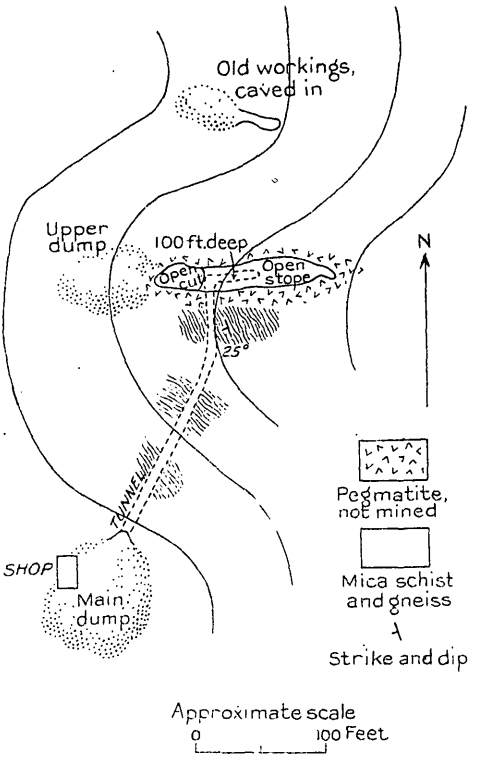


FIGURE 73.—Plan of W. W. Wiseman mine, on Beaver Creek, Mitchell County, N. C.

The country rock is highly schistose mica gneiss, which varies in dip and strike where it is cut by the tunnel. The body of pegmatite is at least 30 feet thick, and cuts across the gneiss and schist with an easterly strike and about a vertical dip. Several feet before the tunnel reached the "vein" it encountered coarse granite or fine-grained pegmatite, which grades into coarse pegmatite nearer the "vein." The coarse granite cuts the schistosity of the gneiss, which trends N. 15° W. and has a 25° W. dip along the contact. Figure 73 shows the position of the workings and the relations of the rock formations. Before the stope was opened to the surface the coarse crystallization of the pegmatite was clearly exhibited by the candle light reflected from the cleavage faces of the crystals of potash feld-

spar exposed. Crystals 2 and 3 feet square had been cut through. This coarse crystallization occurs in a streak in the interior of the pegmatite. The large crystals of feldspar were most plentiful near the middle of the pegmatite, and the mica lay in a shoot on the north side of it, pitching west. Practically all of the shoot has been mined out, but some mica is still found in other places. In the early days of mining one crystal of mica weighing about 2,000 pounds is reported to have been obtained from this mine. It is said six men were able to dance on this crystal at one time. The mica has a dark bottle-green color and good flat cleavage. Some is partly specked.

The feldspar is chiefly of the pinkish potash variety but includes some white plagioclase. When the mine was last visited, in 1914, about 40 tons of feldspar was being shipped each week. Fine specimens of the uranium minerals (pitchblende, gummite, and uranophane), and of allanite, cyrtolite, and other rare-earth minerals have been found. Masses of samarskite weighing many pounds were mined during the early days, but they were broken up and lost before their nature was known.

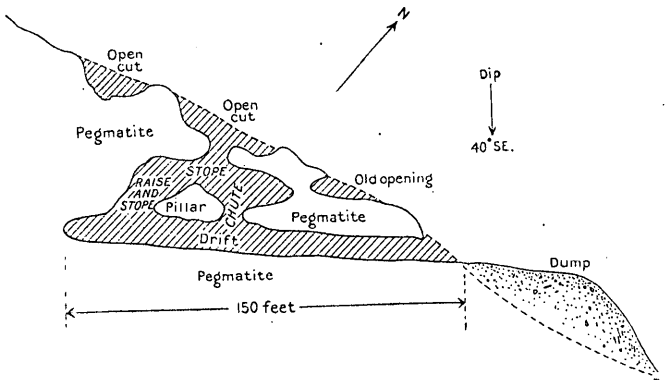
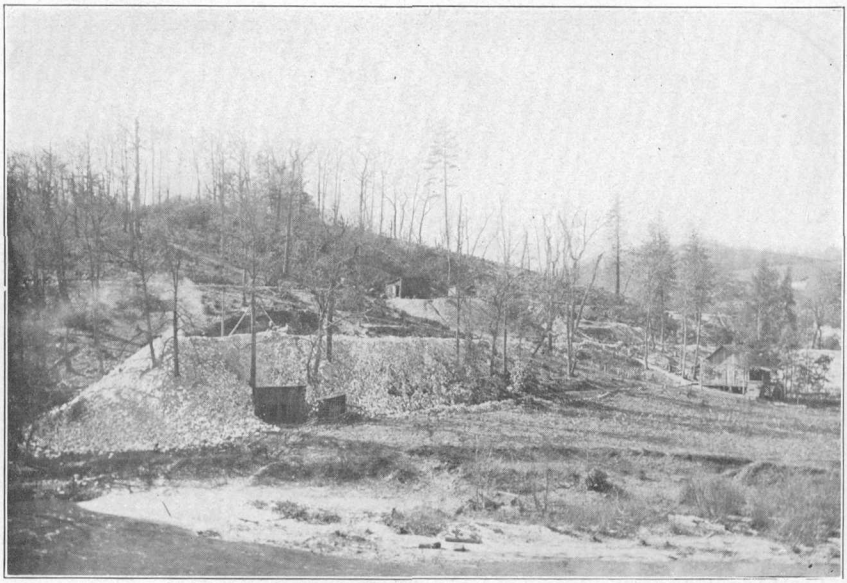


FIGURE 74.—Section in plane of pegmatite at Knob mica mine, Mitchell County, N. C.

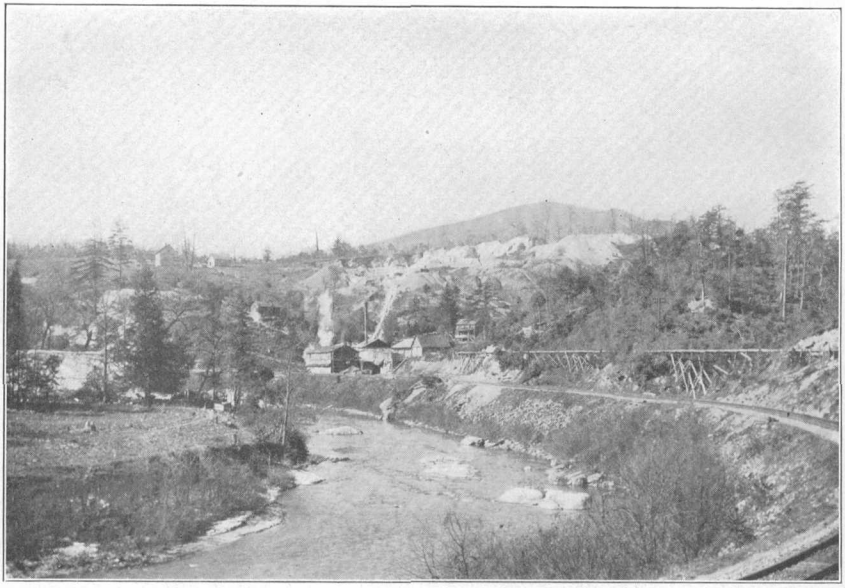
KNOB MINE.

The Knob mica mine is a little more than 2 miles northeast of Spruce Pine. The pegmatite is inclosed in biotite gneiss or schist, with which it is roughly conformable. It strikes about N. 45° E. and dips about 40° SE. The pegmatite is coarsely crystallized next to the hanging wall and grades into fine-grained pegmatite or coarse granite on the lower side. The coarse pegmatite, called the "vein," which is the only part of the deposit mined, pinches and swells, ranging in thickness from 1 to 4 feet. The mine was first worked by open cuts on the outcrop and by shallow inclines. Later a drift was run about 150 feet from the outcrop lower down on the hillside, and parts of the "vein" were stoped out to the open cut above.

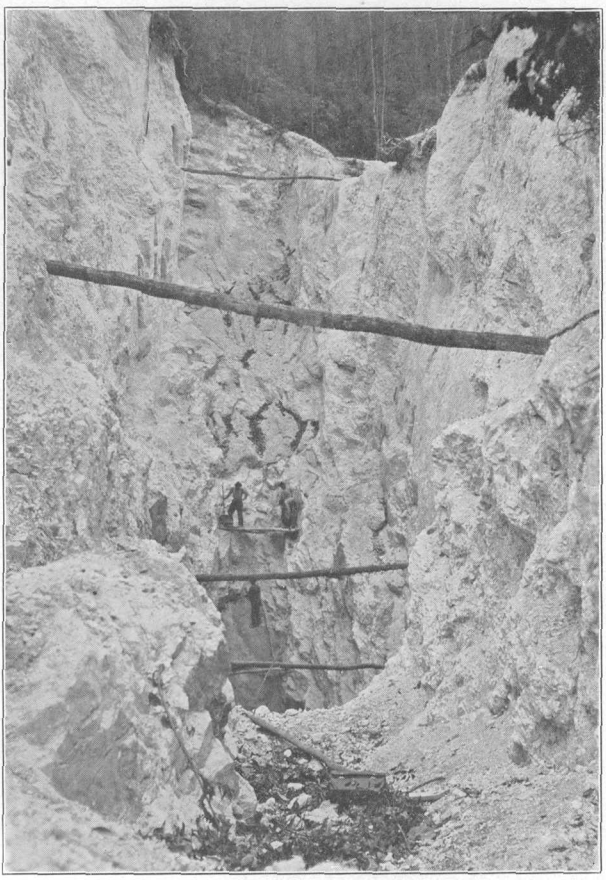
VIEW EASTWARD TOWARD WORKINGS OF CAROLINA MINERAL CO.'S MICA-FELDSPAR MINE, NEAR PENLAND, MITCHELL COUNTY, N. C.



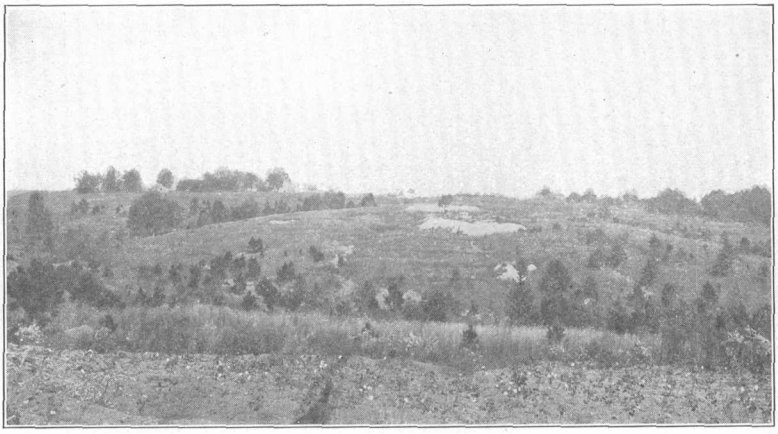
A. VIEW WESTWARD TOWARD WORKINGS OF CAROLINA MINERAL CO.'S MICA-FELDSPAR MINE, NEAR PENLAND, MITCHELL COUNTY, N. C.



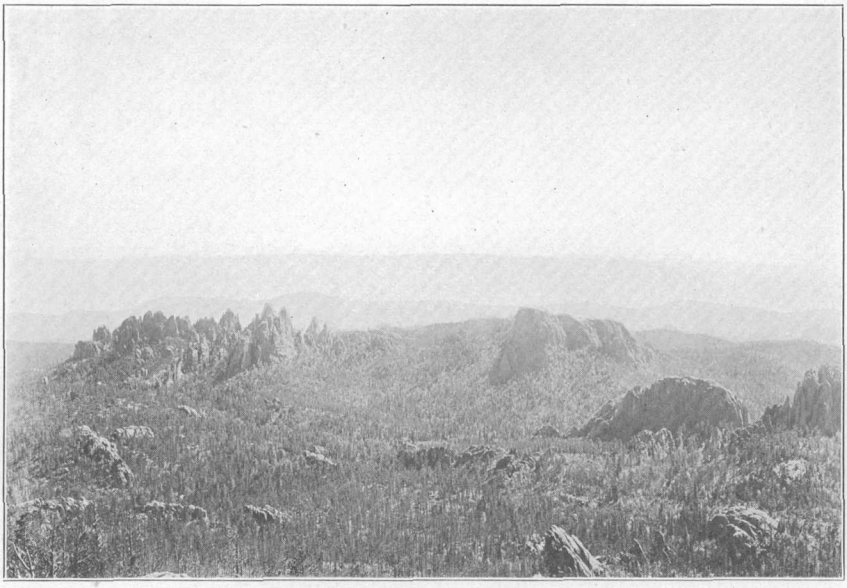
B. VIEW NORTHWESTWARD TOWARD HARRIS WORKINGS OF HARRIS CLAY CO.'S KAOLIN MINE, NEAR PENLAND, MITCHELL COUNTY, N. C.



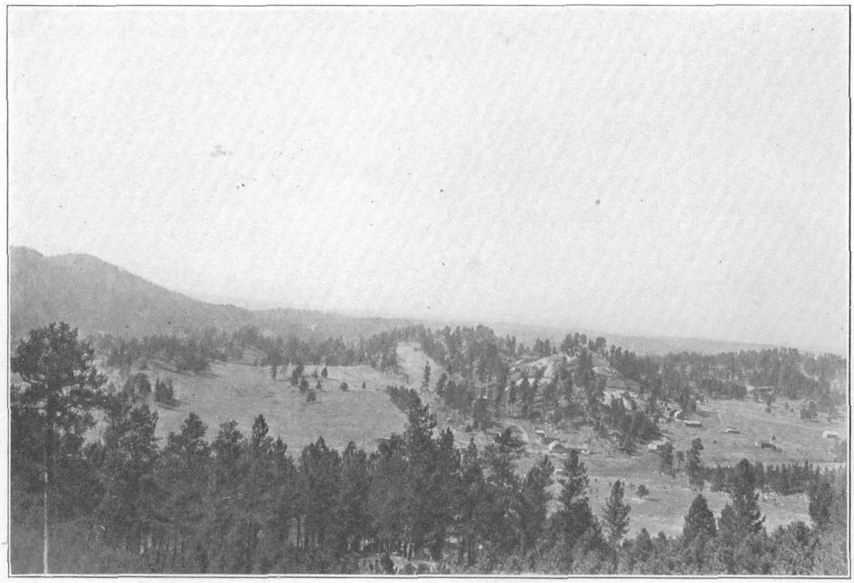
A. VIEW EASTWARD ACROSS DEEP OPEN STOPE OF THE WISEMAN MICA MINE, CAROLINA MINERAL CO., ON BEAVER CREEK, MITCHELL COUNTY, N. C.



B. VIEW NORTHWARD TOWARD WORKINGS OF WILLIMON MICA MINE, GREENVILLE COUNTY, S. C.



A. VIEW SOUTHWARD FROM HARNEY PEAK, BLACK HILLS, S. DAK., SHOWING OUTCROPS OF PEGMATITIC GRANITE.



B. VIEW NORTHWARD TOWARD NEW YORK MICA MINE, NEAR CUSTER, S. DAK.

Figure 74, which is a section in the plane of the "vein," shows the nature of the work done at the time the mine was visited. The mica is dark green, and some of it is abundantly specked with dendritic spots of magnetite. Large crystals are found. One weighing 165 pounds and measuring roughly 12 by 20 by 30 inches was obtained in 1904. The mica was split and graded at the mine and shipped to manufacturers of electrical apparatus. Both men and women were employed in this work.

SURVEY PROSPECT.

The Survey prospect, owned by Capt. Isaac English, is about 100 yards southeast of the Knob mica mine and a little more than 2 miles northeast of Spruce Pine. It consists of a pit about 10 feet deep, in which uranium minerals were reported to have been found, especially gummite, which was said to have occurred in balls at the end of black streaks through the "vein" rock. In 1904 two employees of the North Carolina Geological and Economic Survey spent two days on this prospect in search of uranium minerals.

The country rock is mica gneiss, and the "vein" consists of coarse pegmatite and the hanging wall of fine pegmatite or coarse granite, into which it grades. The vein strikes about northeast and dips 25° southeast. The feldspar of the pegmatite is orthoclase or microcline and occurs in fairly large, rough crystals. The quartz is nearly clear and has a smoky color. The greater part of the mica is A and wedge shaped, though mica suitable for punching was seen. Flattened crystals of garnet are numerous between the laminae of the crystals of mica and some have a beautiful color. Thulite, the pink variety of zoisite, is found in places in feldspar. Several slender black crystals of the thickness of a match and 6 to 10 inches long, probably allanite, penetrated the quartz and feldspar. At the ends of these there were bunches or balls of slightly yellow clay, which gave a test for uranium with the salt of phosphorus bead. No other uranium minerals were found. A small quantity of punch and sheet mica were obtained during this work.

RUTHERFORD COUNTY.

ISINGLASS HILL MINE.

The Isinglass Hill mine is on the Southern Railway about 3½ miles north of Rutherfordton. Here a mass of pegmatite more than 30 yards thick carries mica. The country rock is hornblende gneiss, much folded and contorted, and the pegmatite is roughly conformable with it. The strike is east of north, and the dip in general is nearly vertical. The pegmatite near the mica workings is several yards

thick, but in a railroad cut 200 yards to the north it shows only as small streaks, probably stringers from the main mass. The pegmatite has been traced southward for more than 200 yards by prospect shafts, but its thickness at these shafts is not known. Mica was found most plentifully where the open cuts are shown in figure 75. At these places most of it is associated with a streak of massive quartz. The depth to which the workings had been carried could not be ascertained, for they had caved in badly, as the rock was soft. The mica is in large part badly specked with magnetic iron. The large quantity of sheets 2 to 5 inches in diameter left on the dump indicates that the mica must have been plentiful, though much of this waste was either A or wedge mica.

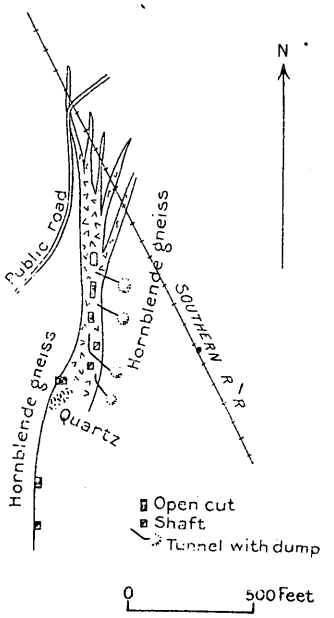


FIGURE 75.—Plan of Isinglass Hill mica mine, Rutherford County, N. C., showing probable shape of the pegmatite.

Since the operations for mica were suspended the deposit has been examined to determine its value as a kaolin mine, and in this examination some of the tunnels on the east and shafts to the south were made. Good kaolin was found in some of the openings, but its extent had not been adequately proved at the time the place was visited. The following analysis of the kaolin, made by T. W. Smith, commercial chemist, Indianapolis, Ind., was furnished by Mr. Olive, owner of the mine:

Anlysis of kaolin from Isinglass Hill mine, N. C.

SiO_2	44.12
Al_2O_3	39.50
CaO	.08
MgO	Trace.
FeO	.08
Alkalies	.81
Ignition	14.53
	99.12
Rational analysis:	
Clay substance	95.59
Quartz	3.39
Feldspar	1.02
	100.00

The kaolinized portion of the pegmatite yielded 42 per cent of kaolin having a refractory value of 1,730° C. when sampled and washed by A. S. Watts.[69]

Mica prospects have been opened at several other places in Rutherford County. V. A. Smith, of Golden, N. C., opened one on the top of Cherry Mountain, about 8 miles north of Bostic, and reported that two prospects were being tested near Union Mills in the spring of 1916. Other deposits have been prospected on the Allen and J. Odom properties between Gilkey and Union Mills, on the Joseph Groves property, 1½ miles northeast of Gilkey, on the W. T. Wilkins property, 3½ miles west of Rutherfordton, and on the W. H. Marvill property, 4 miles northeast of Rutherfordton. The Allen mine is an old one and the workings, which consist of several shafts and pits, were badly caved in when seen in 1906. The country rock is mica gneiss, in part granitic. Blocks of massive quartz on the dumps show that one or more streaks of quartz were encountered in the workings.

STOKES COUNTY.

JOE HAWKINS MINE.

The deposit of mica at the Hawkins mine was first worked about 1890 by people living in the county and was again worked in 1903 by the Empire Mica Co., of New York. It is about 2½ miles southwest of Sandy Ridge, in the northeastern part of Stokes County. The mica occurs in an irregular body of massive pegmatite, in which feldspar and quartz form large separate masses. The body exposed in the workings ranges in thickness from 6 to 12 feet and is approximately conformable to the inclosing mica gneiss country rock, which strikes a little north of east and dips about 35° N. Much of the quartz of the pegmatite occurs in bands or sheets, from a few inches to about 2 feet thick, lying parallel with the strike of the pegmatite. But little mica had been left in the "vein" from the last work, and much of that seen was of the wedge and A variety, but included good mica between the A structure lines. Some of this wedge and distorted mica contained rough garnets, either in crystals or flattened between the laminae. The workings consist of two open cuts, an incline run on the pegmatite from one cut, three shafts 20 to 30 feet deep, and connecting tunnels. In all there is nearly 150 feet of tunnels and incline.

HOLE MINE.

The Hole mica mine is on the ridge between Dan River and Big Creek, near the mouth of the creek and near Tulip post office. There

[69] Mining and treatment of feldspar and kaolin: U. S. Bureau of Mines Bull. 53, p. 148, 1913.

are two separate bodies of mica-bearing pegmatite at this mine, which are opened at points about a third of a mile apart in an easterly direction. The principal deposit consists of a large body of pegmatite more than 20 feet thick, which strikes nearly east and dips 30° N. This deposit, as exposed in the open work on the outcrop and small inclines, is composed of three bands or veins of massive quartz, 4 to 6 feet thick, and of two intervening beds of feldspar, 4 to 7 feet thick. It is said that another band of feldspar was found beneath the lower vein of quartz, but this was covered with rubbish and could not be examined. The bands or veins of quartz and feldspar are parallel with the body of pegmatite and dip with it to the north. The feldspar has been considerably kaolinized and has been removed from the two veins exposed in inclines

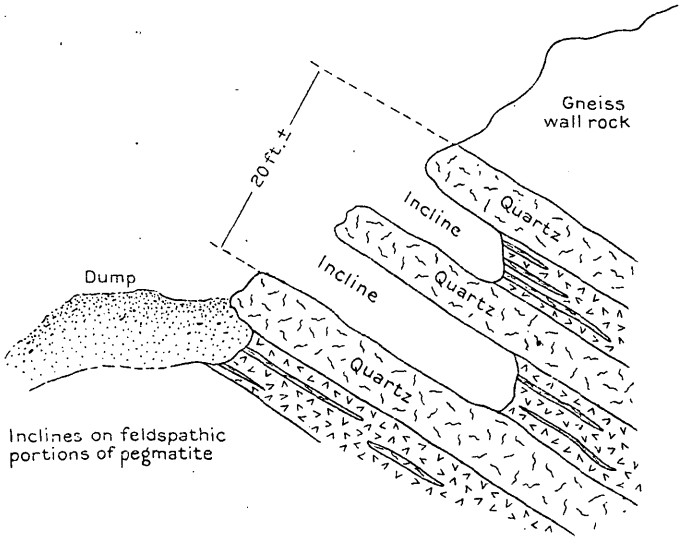


FIGURE 76.—Ideal cross section at Hole mica mine, Stokes County, N. C.

10 and 20 feet deep. The large streaks of feldspar contained small masses and streaks of quartz, 1 inch to 10 inches thick. Figure 76 is an ideal cross section of the pegmatite, which can be traced for several yards along the outcrop by blocks of massive white quartz. Mica occurs through the masses of feldspar and along the contact with the streaks of quartz. The mica is partly of the A variety and has a brownish or smoky color. A 20-pound block of such mica was seen in the face of one of the veins.

At the other outcrop a few small open cuts and an incline 20 feet deep have proved the pegmatite for about 200 feet along a steep hillside. The course of the pegmatite here is conformable with the schistosity of the mica gneiss country rock and is several feet thick. The dip and strike are very much the same as at the deposit first

described. The feldspar of the pegmatite has not been kaolinized, however, and the formation is fairly hard. Only small blocks of mica were seen in the hard rock, and this mica was of clear dark-green color, considerably ruled.

STEELE MICA MINE.

The Steele mica mine is about 2 miles southwest of Sandy Ridge and was operated by the Southern Mica Co. at about the same time as the Hawkins mine. A shop for cutting and trimming mica was set up and preparations were made for extensive operations. The work consisted of three pits, a small shaft, and probably 30 feet of tunnel. It was not possible to determine the relations of the pegmatite to the country rock, which is mica schist or gneiss that strikes about N. 55° E. and dips 45° NW. The body of pegmatite is apparently large, or it consists of more than one mass. Much of the mica seen on the dumps was of the A variety, though some was in sheets 8 to 10 inches across and would yield good mica between the A markings.

RICHARD FOREST PROSPECT.

The Richard Forest prospect is on the north end of Brown Mountain. Here a 15-foot incline was sunk on the dip of the pegmatite. The inclosing rock is mica schist or gneiss, which strikes N. 50° E. and dips 35° NW. The pegmatite contains quartz "veins" parallel with its walls and the mica is found between them and the walls. Part of the mica seen on the dump was of the A sort, though some was of fair quality. Sheets more than one thirty-second of an inch thick had a green color.

A shaft was sunk on a mica "vein" at the north end of the top of Brown Mountain, on the land of William Martin. Much small-sheet mica was seen around the old shaft and there were indications of mica along the surface for some distance. The country rock is garnetiferous mica schist. Mica prospects are also reported to occur on the top of Brown Mountain on the properties of Samuel Simmons, William Hills, Thomas Bundurn, and William Nunn.

TRANSYLVANIA COUNTY.

BEE TREE FORK MINE.

The Bee Tree Fork mine is on a hillside opposite the mouth of Bee Tree Fork, on the headwaters of French Broad River. It was opened years ago by Tarry McCall and after lying idle a long while was reopened in 1905 by C. H. Wolford. The workings consist of an open cut 50 feet long and 35 feet deep at its deeper end, in the hillside. The cut is but little wider than the "vein." The coun-

try rock is mica gneiss, which strikes about northeast and dips 45° NW. The "vein" cuts across the country rock in a sinuous course and has an irregular easterly strike and a dip ranging from 45° to 80° N. The pegmatite ranges in thickness from 2 to 8 feet and is composed principally of quartz, though some feldspar, mica, pyrite, and pyrrhotite are scattered through it. The mica has a clear rum color and is of good quality.

CHESTNUT RIDGE MINE.

The Chestnut Ridge mine is at the headwaters of French Broad River, 2¼ miles S. 55° E. of Tennessee Bald. The work consists of a tunnel run on a small body of pegmatite and two open cuts made on another larger body. The country rock is mica gneiss. The pegmatite exposed in the open cuts is in places as much as 10 feet thick. The mica is of good quality and has a clear rum color, though some of it is ruled into strips. Biotite is associated with the muscovite.

REED MINE.

The Reed mine is 1 mile N. 60° E. of Montvale and 2¼ miles S. 20° E. of Sapphire. It is owned by Dr. Robert Grimshawe, of Montvale. The mine has been worked by several tunnels run at different levels, the greater part of them now fallen in. One 30-foot tunnel was driven in on a 5-foot "vein" which had a north strike and a dip of 30° W. This body of pegmatite is irregularly conformable with the inclosing mica gneiss country rock. It has a 2½-foot quartz streak in the middle and feldspar on each side. About 75 feet to the north, on the opposite side of a small valley, the same "vein" has been worked by two levels, between which the "vein" has been stoped out. One of these levels was driven back about 100 feet. The pegmatite in this tunnel had a strike of about N. 20° E. and a dip of 35° NW. At the end of the tunnel it had pinched down to a thickness of about 18 inches and contained small scattered lenses of quartz. The mica from the Reed mine is dark and is in part specked with magnetite.

BIG JUMBO MINE.

The Big Jumbo mine is in the gap on the south side of Sassafras Mountain, about 1½ miles west by north of Montvale. The mine has not been worked for several years and now belongs to Dr. Robert Grimshawe, of Montvale. Two open cuts have been made, one in the gap and the other about 100 yards N. 25° E. of it, at the foot of the steep grade to the mountain top. The country rock is mica gneiss, which contains a few small streaks of hornblende gneiss in the vicinity of the mine. A ledge of pegmatite about 10 feet thick

was encountered in the cut in the gap. This ledge is apparently conformable with the inclosing mica gneiss, which strikes about N. 20° E. and dips 30° SE. A considerable quantity of mica was found, though only the inferior material had been left on the dump. This mica has a smoky brown color, and some of it contains fine black specks of magnetite between the sheets. Part of it has the A and tangled-sheet structure. Little could be seen of the formation at the other opening.

LITTLE JUMBO MINE.

The Little Jumbo mine is 1¼ miles N. 65° W. of Montvale. The mine was worked along the bank of a branch by three or more tunnels. The country rock is mica gneiss, which strikes N. 15° E. and dips east. The pegmatite is conformable with the strike of the gneiss and possibly with the dip also. It contains streaks and masses of quartz at least 3 feet thick.

MORNING STAR MINE.

The Morning Star mine, owned by Dr. Robert Grimshawe, is three-quarters of a mile west by north of Montvale and 2½ miles S. 20° W. of Sapphire. It was worked by C. Grimshawe between 1880 and 1884, during which time 8,000 pounds of cut mica was mined. The workings consist of several tunnels, now nearly all caved in. The country rock is mica gneiss, more or less crumpled. The pegmatite, which is approximately conformable with the gneiss, strikes from north to N. 25° E. and dips 25° E. It is from 1 foot to 3 feet thick and contains many streaks of quartz. Where seen the quartz streaks were from 1 inch to 12 inches thick and were at least equal in volume to the pegmatite. The mine is reported to have yielded large blocks of dark-brown mica.

TALLOW FACE MINE.

The Tallow Face mine is three-quarters of a mile east of Montvale and 2¾ miles S. 10° E. of Sapphire. It has been opened by a 70-foot tunnel or drift on the "vein" and a 60-foot shaft, sunk to cut the pegmatite on the dip but not connected with the tunnel. The country rock is pegmatized mica gneiss. The pegmatite is about 8 feet thick, strikes N. 25° E., and dips 25° NW. The pegmatite near the mouth of the tunnel carries a 3-foot streak or vein of quartz, which is split by a streak of feldspar. A short distance within the tunnel the streak of quartz is less prominent and the pegmatite has more nearly the texture of typical coarse granite.

W. J. NICKELSON MINE.

The Nickelson mine is three-quarters of a mile north of Montvale. The workings had fallen in badly and little could be seen of the

formations. The body of pegmatite appears to be conformable with the inclosing mica gneiss. The mica was dark, smoky, and in part of the A variety.

J. P. Hinkle has opened a mica prospect about a mile southeast of Montvale. Crystals of mica 2 to 3 inches across were seen here in a 3-foot "vein" of pegmatite. The pegmatite has a N. 30° E. strike and a vertical to high easterly dip. Another prospect was opened about 300 yards east of south from the Hinkle prospect. The mica from these prospects is dark and is in part specked.

WAKE COUNTY.

A prospect was opened for mica about 3 miles southwest of Wake Forest early in 1916 by J. E. Coggins, of Raleigh. When the place was examined in June, 1916, there was a pit about 10 feet across and 5 feet deep. The country rock is granite, slightly gneissic in places. The mass of pegmatite exposed in the walls of the pit is from 1 foot to 3 feet thick, and is very irregular in size and shape. It grades into the surrounding granite by diminishing coarseness of texture.

The pegmatite is composed of partly altered potash feldspar in crystals that reach a thickness of 1 foot, dark, smoky quartz in irregular-shaped masses from less than 1 inch to 18 inches thick, and crystals of mica, some of which are as much as 10 inches across. One crystal of mica taken out is reported to have weighed about 75 pounds. Mica weighing between 400 and 500 pounds was removed from the pit. Part of this is of the A variety, part is tangle sheet, and a little is ruled. Clear sheets 2 by 3 inches, 3 by 3 inches, and probably larger can be cut between A lines from parts of the larger crystals. The mica is clear where free of clay stains and has a smoky, greenish color.

WARREN COUNTY.

A little mica mining was done in the "Forks" region, south of Inez, Warren County, about 1880. A trimming plant was set up and the mica was cut into patterns on the William Connell property, about 2½ miles southeast of Inez. A sufficient number of mica plates of the large sizes then required could not be obtained, and the work was abandoned. Such mica as was found would perhaps now be valuable.

Rocks characteristic of mica regions—that is, mica schists and gneisses—occur in this area, but the predominant rock is granite. Belts of mica gneiss occur between Warrenton and Inez and south of Inez. Small crystals of mica were seen in the outcrops of pegmatite in these formations in this area, and crystals of beryl have been found on the land of Mrs. Jennie Connell, 2 miles southeast of Inez.

WATAUGA COUNTY.

DOBBINS MINE.

The Dobbins mica mine is 2 miles north of west of Elk Cross-roads. It was operated extensively about 1890 and on a smaller scale ten years later by the Blue Ridge Mica Co. There are two sets of workings 250 yards apart, one at the foot of the hill and the other on top of the ridge to the northeast. The work done near the road consists of five tunnels, two shafts, and some ground-hog openings. The tunnels have been run in at different levels on the hillside, in a space about 70 feet wide on a large body of pegmatite. These tunnels, which have been run in directions ranging from N. 25° E. to N. 45° E., show roughly the trend of the body of pegmatite. The country rock is biotite gneiss, which strikes between N. 30° E. and N. 40° E., and has a nearly vertical dip. The body of pegmatite is conformable, or nearly conformable, with the inclosing gneiss. Some parts of the pegmatite that were exposed in the workings were rich in small mica, but others contained little or no mica. The openings on the ridge consisted of three shafts and tunnels on each side of the summit. They were confined to a belt about 100 yards long and about 40 feet wide, extending N. 35° E. One deep shaft had been well timbered and was in a good state of preservation, but the other openings had caved badly. Little mica had been left around these workings. Most of that seen at the openings along the road was dark brown to greenish brown. Part was specked and in wedge-shaped blocks with the A structure. Some clear sheets were seen with good cleavage but of rather dark color.

Charlie Todd owns a mica mine 1¾ miles northwest of Elk Cross-roads. The mine has not been opened for 15 years. The pegmatite is marked by the outcrop of massive quartz. R. H. Clawson prospected for mica about a quarter of a mile northwest of the Todd mine in 1904.

LOCKE GREEN MINE.

Mrs. Locke Green owns a mine on the south end of the knob of Deep Gap of the Blue Ridge Mountains, west of Stony Fork. It is said that a 50-foot incline driven on this vein yielded chiefly specked mica.

ARTHUR WELCH MINE.

The Welch mine is about half a mile west of Stony Fork post office, on the headwaters of Stony Fork Creek. Some prospect pits were dug here about 1895 and two more in 1905. These pits disclosed a deposit of good pegmatite with granitic gneiss wall rocks

in a region of mica gneiss country rock. The pegmatite is probably 5 feet thick and contains streaks of quartz as much as a foot thick. The strike of the inclosing rock is about northwest and the dip is 45° NE. Most of the mica is heavily specked with magnetite and has a dark clear green color. Blocks 5 or 6 inches in diameter, weighing several pounds, were seen.

F. A. LINNEY MINE.

The Linney mine, sometimes called the Rich Mountain mine, is 1½ miles northwest of Boone, on the steep side of a mountain cove. The chief working is an open cut near the top of the hill, but three other pits have been made east of this at a lower level. The country rock is mica gneiss, which strikes from east to N. 75° E. and dips 30° N. Mica of good quality and fine rum color was found. Sheets of mica as much as 6 inches across were seen, though the small sizes predominated. Another prospect was on F. A. Linney's land half a mile north, near the Foster mine. Good mica is reported from this locality and from other places in the same neighborhood.

ARNEY FOSTER MINE.

The Foster mine is on Doe Ridge 2 miles N. 20° W. of Boone. Openings have been made here at three places within a quarter of a mile of one another. In one of these openings, west of the house, a ledge of pegmatite 8 feet thick was exposed. It was inclosed in biotite gneiss striking northeast and dipping 15° SE. Both muscovite and biotite are found and in some places they are intergrown. South of the house an opening exposed streaks of pegmatite inclosed in biotite gneiss striking N. 60° E. and dipping 30° NW. The mica found at these prospects has a clear rum color, but most of it is small. East of the house open cuts had been made and a tunnel run in for a short distance. Part of the mica found here was black specked.

C. C. GREEN PROSPECT.

The Green prospect is 3¾ miles north of Boone, on the road from Norris to Silverstone. The pegmatite has been opened by several small pits. The country rock is biotite gneiss, which strikes north and dips vertically. Bands of hornblende gneiss are included in the country rock, and pegmatite is common in the region. Small sheets seen on the dump indicate that mica of good quality had been found. Sheets of biotite 2 inches in diameter were also seen. Other prospects were opened in this region on the land of Richard Norris, Manly Green, and the Wall brothers.

WILKES COUNTY.

JOEL TRIPLETT MINE.

The Triplett mica mine is on Stony Fork near Hendricks, 16 miles from Wilkesboro. Here there are three mica prospects, one of which was opened several years ago by a tunnel 40 feet long. The workings exposed a body of pegmatite about 8 feet thick that was approximately conformable with the mica gneiss country rock, which strikes N. 30° E. and dips 35° SE. and contains numerous small lenses and masses of quartz and pegmatite. Mica was segregated in small blocks along the walls of the pegmatite. About 50 pounds of sheet and cut mica was seen. The sheets ranged in size from 2 by 2 to 4 by 4 inches. The mica varied from clear sheets with good cleavage to smoky or specked and A mica. The color of the best was rather dark greenish brown in sheets a sixteenth of an inch thick or more.

YADKIN COUNTY.

HAUSER MINE.

A new locality for mica in North Carolina was brought to the attention of the writer in 1913 by Mr. George H. Hauser, of Winston-Salem. It is in Yadkin County, about 6 miles east of Yadkinville, and most of the prospects that have been opened are on land owned by Mr. Hauser. An itinerant miner located the prospects several years ago and after ground-hog mining at a number of them abandoned the work. The country is a rough part of the Piedmont Plateau and much of it is covered with timber. The country rock is diorite, in places strongly schistose.

The best deposit tested is about half a mile south of the main road leading west into Yadkinville. It was worked by numerous pits, trenches, and cuts and one shaft 40 feet deep within an area 250 yards long northwest to southeast and 200 feet wide, as shown in figure 77. Outcrops of pegmatite carrying mica and another pit lie outside of this area. The exposures were not so good as to permit the determination of the relations between the pegmatite and the inclosing schistose diorite. In a pit across a branch on the northeast side of the mine the country rock is cut by a body of pegmatite having a northeast strike and a vertical dip. The country rock strikes northwest and has a vertical to high northeast dip. The position of the workings indicates either an irregular body of pegmatite with arms branching out, several veins, or a large blanket ledge (or ledges) from which there are offshoots of smaller veins. The appearances suggest one or more beds of pegmatite cropping out on the hillside with a low dip to the northeast. If the conditions are those indicated

the deposit could be very effectively mined by open cuts and drifts from this hillside.

Large blocks of white, gray, and smoky quartz, some translucent and some nearly clear, were removed during mining. Some of this quartz shows imprints of numerous mica crystals. Semikaolinized feldspar was encountered in many of the workings, and an outcrop of pegmatite along the branch contains solid crystals of microcline 18 inches across, with small mica. In the principal workings mica seems to have been fairly plentiful. Only small crystals had been left around, but these were mostly of good quality, having a clear brownish-green color and very good cleavage. Some was slightly specked. Some of the blocks have good crystal outline with fairly sharp faces, especially the crystals adjoining massive quartz. A few

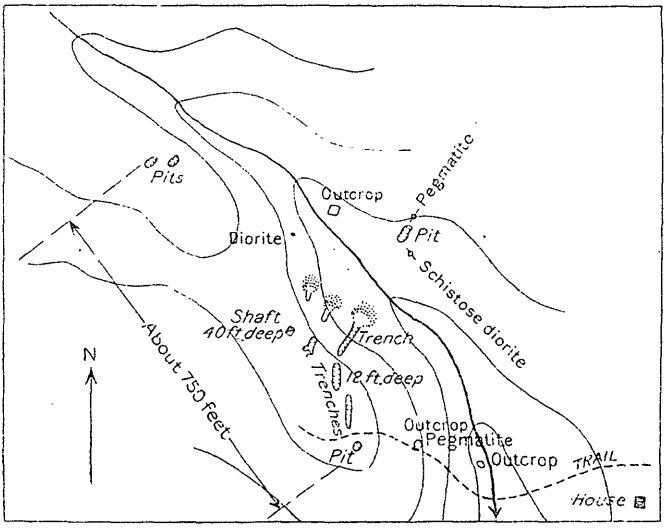


FIGURE 77.—Plan of Hauser mica mine, 6 miles east of Yadkinville, Yadkin County, N. C.

larger crystals of mica, measuring from 4 to 6 inches across, found on the dumps, were badly crushed and had a very imperfect cleavage. Some of these included numerous small crystals of mica penetrating the laminae at various angles. In the two pits at the northwest end of the workings much A, wedge, and fishbone mica was found. Masses of tangled blocks of this mica, measuring several inches across, had been left around the pits, but such material would be suitable only for grinding.

Another prospect was opened near a branch on the point of a low ridge a quarter of a mile southeast of this mine. A cut 6 feet deep and 20 feet long in a N. 70° W. direction was made on the north side of the ridge, exposing a pegmatite dike about 10 feet thick with a strike of N. 70° W. and a high dip to the south cutting

schistose diorite. Most of the mica seen was in bunched masses of wedge and A crystals. Some slightly specked small-sheet mica was also seen. The pegmatite contains feldspar crystals a foot thick, but most of the rock is very uneven grained.

Another mass of pegmatite crops out on the hillside about 100 feet to the north, across the branch. This pegmatite is coarse grained and from it crystals of mica from 2 to 3 inches across have weathered out.

YANCEY COUNTY.

GIBBS MINE.

The Gibbs mica mine is on the west side of South Toe River, 2 miles south by west of Newdale, Yancey County. It was operated on a large scale until 1906 by the J. E. Burleson Mica Co., and was then abandoned for mines where mica could be obtained with less difficulty. The entrance to the mine is on a hillside, about 75 feet above the river. The work consisted of an incline on the dip of the "vein" carried down more than 500 feet. The incline has a grade of about 35° for the first 150 feet from the surface and about 25° below this. For about two-thirds of the length of the incline the "vein" has been removed for a width of 40 feet. Pillars were left, and a few stulls were placed as supports. The workings off to the sides of the incline were irregular, consisting of short tunnels, rooms, or stopes where rich "leads" of mica were found. The "vein" was first removed for a thickness of 7 to 10 feet in the upper part of the mine, and then for the full thickness of 15 feet or more in the lower part. Hoisting was done by a steam engine with a track and skip. The skip was used as a pump also and satisfactorily handled the mine water.

The pegmatite formation is large and is more continuous than at many other mica mines in North Carolina. It is conformable with the bedding of the inclosing mica gneiss, striking about N. 50° W., and dipping 35° SW. at the surface, and less with increase of depth. The feldspar of the pegmatite is a plagioclase carrying soda and some calcium and is probably oligoclase. Most of it is pure white, though part is transparent and has a pale aquamarine-green color. Other minerals of the pegmatite are quartz, muscovite, biotite, and a little garnet and apatite. The texture of the pegmatite is granitic and fairly coarse. Masses of feldspar crystals weighing 200 pounds were seen on the dump, and blocks of mica of similar weight are sometimes obtained. The quality of mica from the Gibbs mine is the finest, and the thick sheets have a rich rum color. The crystals generally run from 3 to 12 inches in diameter. Still larger sheets are sometimes obtained. At the time the mine was examined in 1905, the produc-

tion amounted to about 1,000 pounds of good block mica a week, though at times larger quantities were obtained.

POLL HILL MINE.

The Poll Hill mine is 1¾ miles south by west of Newdale, on the east side of South Toe River, just across the river from the Gibbs mine. This mine consists of two parts, both of which have been operated intermittently and actively since 1906. The part near the bank of the river was worked by the Burleson Mica Co., and that higher up on the hill by Hall Bros. & Burleson. The part near the river was being cleaned out at the time the mine was visited, and was equipped with a steam pump and hoist. The workings consist of an incline about 20 feet deep on the pegmatite and a tunnel northeast of it. The country rock is mica gneiss, which strikes about N. 75° E. and dips 55° S. The pegmatite is only approximately conformable with the gneiss and so far as seen ranges

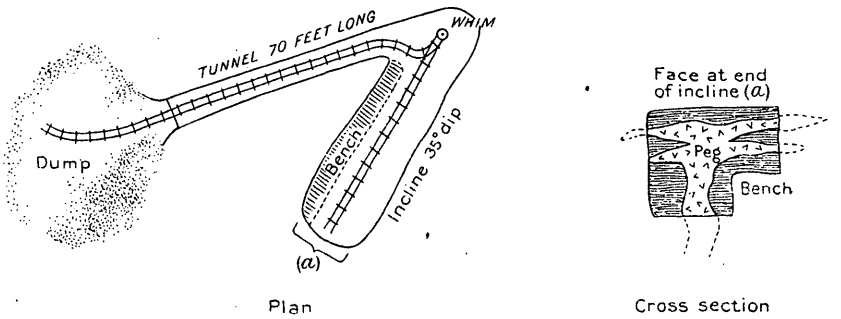


FIGURE 78.—Plan of Poll Hill mica mine, Yancey County, N. C., and cross section of pegmatite at end of incline.

from 10 to 15 feet in thickness. It contains numerous small horses or streaks of mica gneiss or schist, which lie parallel with its walls.

The upper part of the mine has been worked at several places, and in such positions as to show an irregular pegmatite formation or several masses of pegmatite. The last operations had been in progress about one year at the time the mine was visited, and the nature of the work is shown in figure 78. A 70-foot tunnel was driven in a N. 75° E. direction on a "vein" of mica. From this tunnel an incline was run southwestward on a dip of about 35°. The incline was about 70 feet long, 20 feet wide, and 10 feet high. A bench was left on the northwest side in barren rock. The waste and mica were hoisted from the incline by means of a hand whim at the head of the incline.

The wall rock is biotite gneiss, through which the pegmatite cuts and into which it forks out. Figure 78 shows also the vertical

cross section of the pegmatite exposed in the face at the bottom of the incline. The position of the bench in barren gneiss is shown on the side. The incline was driven on the pegmatite where that rock was diverted from its course across the gneiss into lens-shaped masses. These lenses became smaller or pinched out in a short distance on each side.

The quality of the mica from the Poll Hill mine is good and the color a clear rum.

ALEY MINE.

The Aley mine is at the head of Browns Creek, about 3 miles southwest of Micaville. It has been opened by at least three tunnels, one an incline, and by open cuts and a shaft 40 feet deep. The last work was that of the J. E. Burleson Co. in 1904. The "vein" strikes N. 15° E. and has a high easterly dip. It has been opened along its strike for nearly 100 yards up the side of the mountain. The lowest opening is an old tunnel run in on the "vein" for drainage and development. A shaft that was started higher up the hill to meet this old tunnel never was completed. At the time the mine was visited a block of mica weighing nearly 100 pounds was found in the bottom of the shaft and several other fine blocks of mica were found within 3 feet of the surface in a cut east of the shaft. Some of these blocks may have been drift from the outcrop of the "vein" above, though they were probably derived from a second "vein" parallel to the first. A corresponding "vein" has been opened by an incline lower down on the hill, above and east of the drainage tunnel. The mica from this mine has a rich ruby-red to rum-red color and is of excellent quality for use in stove windows.

YOUNG MINE.

The Young mine is about 2 miles west of Boonford and 100 yards west of South Toe River. The mine has been opened for a distance of more than 200 feet by cuts, pits, tunnels, and shafts covering a width of more than 50 feet. The workings extend from the south side of a ridge about 100 feet high over the top to the north side. The mine was operated in 1904–5 by the J. E. Burleson Co. The country rock is hornblende gneiss, biotitic near the contact with the pegmatite. The pegmatite outcrop crossing the creek on the south side of the ridge is about 100 feet wide. The strike of the formations is about N. 35° E. and the dip is 75° SE. Streaks or horses of mica schist are included in the pegmatite and are parallel with it in strike. The mica occurs in streaks parallel with these horses of schist, which are in some places left as walls to the workings. The "veins" have yielded a large quantity of mica in small

sheets and some in large sheets. The mica is of good quality and said to be especially fitted for making electric appliances.

BAILEY MOUNTAIN MINE.

The Bailey Mountain or White mine is about 1¼ miles east of Celo, on the public road close to South Toe River. Here several deposits are grouped together, some of which have been worked. One of these was reopened in 1906 by Bergen, Shuford, Washburn, and Myrtaugh. The old workings consist of numerous tunnels and open cuts carried for 200 yards up and down the hillside, both above and below the public road. A large opening was made on the lower side of the road. The new work consists of a crosscut trench about 30 feet above the river level and an open cut on a "vein" below the old workings. The country rock is biotite-mica gneiss, which strikes N. 15° E. and dips 25° W. The "vein" exposed in the new workings is conformable with the inclosing gneiss and ranges in thickness from 18 inches to 5 feet. This pegmatite is evidently another mass than that opened directly above or it is a fork from the main body of pegmatite. The mica is somewhat evenly distributed through the pegmatite. It is dark brown and some is a little specked. Part is of good quality and part is suitable only for making electric appliances.

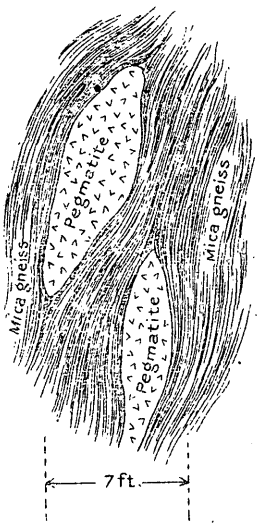


FIGURE 79.—Vertical cross section of pegmatite at Hensley mica mine, Yancey County, N. C.

HENSLEY MINE.

The Hensley mine is on Pigpen Creek, about 2 miles south by west of Green Mountain. It was operated by the Hampton Mining Co. in 1906, when the accompanying notes were taken. It is said that there were ancient workings at this mine, which was also worked before 1906 by white people. The country rock is mica gneiss, which strikes north and has a nearly vertical dip. The pegmatite is conformable or nearly conformable with the schistosity of the inclosing rock. It occurs in lens-shaped masses 3 to 4 feet thick. The mine has been opened by two shafts, 40 and 45 feet deep and 15 feet apart, each having evidently been sunk on a rich lens. In the space between the shafts, partly worked out, the overlapping of two lenses was well shown. (See fig. 79.) The gneiss and schist walls bend around the lenses. Fifty feet south of the shafts an open cut exposed a lens 2½ feet thick and about 15 feet long, lying in the gneiss. Blocks of mica that weighed many pounds have been found. Part of the mica is clay and iron stained near the surface and is used

for electric appliances, and part has a clear amber color and is suitable for stove windows.

CATTAIL BRANCH MINE.

The Cattail Branch mine is near the head of Cattail Branch, nearly a mile southwest of Celo Mountain, at the north end of the Black Mountains, about 5,500 feet above sea level. It was discovered about 1904 by Silvers & Son and B. Rolland, of Yancey County. The mine was examined in 1906, when the following description was prepared. The developments consist of open cuts at three different points on the outcrop. The country rock is biotite gneiss, which strikes northeastward. Near the pegmatite it is much flexed and of an inclined trough having a horseshoe or U-shaped cross section.

The bottom of the trough pitches about 55° SW. and cuts directly across the country rock. The sides are nearly vertical and at a little distance from the bottom of the trough conform in a general way with the strike of the country rock. Figure 80 is an attempt to represent the shape of the pegmatite, A being a plain view and B a perspective view.

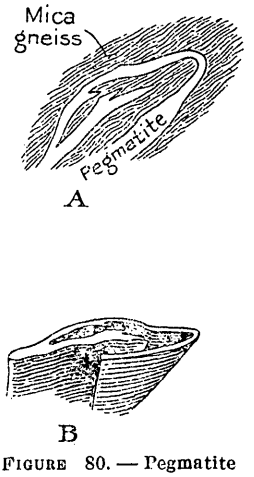


FIGURE 80. — Pegmatite at Cattail Branch mica mine, Yancey County, N. C. A, Plan view; B, perspective view.

The thickness of the pegmatite ranges from 3 feet in the curve of the horseshoe to 20 feet or more some distance out from the curve. This measurement includes horses or tongues of wall rock around which the pegmatite has forked. About 30 feet southwest of the curve the west arm is nearly 25 feet thick, the greatest thickness exposed. The "vein" must have bulged out abruptly to attain so great a thickness at this point. It contains mica gneiss bands or horses from a few inches to several feet in thickness, oriented parallel to the walls. The southeast arm shows a similar bulging, being about 12 feet thick at a distance of 25 feet from the curve.

The texture of the pegmatite is very coarsely granitic. The larger part of the mica is found in the interior of the pegmatite, though some is scattered along the walls. Its quality is excellent and its color is a beautiful rum. The yield in larger sizes is good, and smaller sizes are plentiful.

LETTERMAN MINES.

M. P. Letterman owns two mines about 1¼ miles southwest of Daybook, on the mountain ridge between Pigpen Creek and Mine Fork.

Both these mines were operated during 1905 and 1906. The principal mine, which is on the Pigpen Creek side, was operated by George Bartlett for Berry & Patrick, of Spruce Pine. The workings consist of a tunnel driven 150 feet along the "vein," an old shaft, and a pit. The country rock is biotite gneiss, with which the pegmatite is approximately conformable. The body of pegmatite is about 8 feet thick in the thinnest part opened and swells to 12 feet in the thickest. It crops out on the hillside, in a course about due north, which, however swings to S. 35° E., where it was followed into the hill. It stands nearly vertical. The streak or "vein" of mica is in the middle of the pegmatite and is about 3 feet thick in its thickest part. The pegmatite along the walls is said to be nearly barren of mica. Greenish (copper-stained) feldspar with a streak of garnet and pyrite lies along the east wall. Mica was plentiful along a quartz vein encountered in the pegmatite. It is found in rather thin, flat, fairly large blocks, has a red rum color, and is of good quality.

Another mica deposit has been opened in the past by a shaft and tunnel about 300 yards to the southeast, lower down on the mountain side.

The deposit on the Mine Fork side of the mountain was opened by M. P. Letterman by two small tunnels, run within a short distance of each other, and a prospect pit. One of the tunnels was on a streak of A mica and the other exposed a flat rum-colored variety. The pegmatite, which is conformable with the hornblende gneiss country rock in these openings, strikes N. 30° E. and dips 10° SE. The pit was about 100 yards southwest of the tunnels. Here a streak of pegmatite 18 to 20 inches thick was encountered in biotite gneiss, which strikes N. 45° E. and dips 80° SE. The pegmatite contained considerable quartz, which was in the feldspar, and yielded some beryl and columbite. One fractured crystal of columbite weighing 6 pounds and smaller fragments, weighing in all about 30 pounds, were seen.

A mine was operated in 1906 on the land of Wesley Higgins, on the Mine Fork side of Green Mountain, nearly 1 mile south of the Letterman mines and 2½ miles northeast of Burnsville. The work was done by Grover Huskins and consisted of an open cut nearly 100 feet long and about 20 feet deep in its deepest part. The mica is reported to be of rum color, but only part of it is suitable for electrical use.

An old mine at the head of East Fork of Pigeon Creek was reopened by J. S. Huskins in 1906, and two new tunnels, one 50 feet and the other 100 feet long, were driven on the hillside, across and along the "veins." About 100 yards higher up the hill an incline had been sunk some time before. The mica is rum-colored but is soft, and most of it is used for electric appliances.

RAY MINE.

The Ray mine, a little more than 2 miles S. 35° E. of Burnsville, was opened by Garrett D. Ray in 1869. It was operated until 1885 and was then closed down until 1914, when part of it was reopened by J. E. Burleson. Mr. Ray estimated that about 100,000 pounds of mica of first quality, worth $125,000, was removed from the mine during his operations. The mine has been famous for its large yield of beryl crystals suitable both for cabinet specimens and for cutting into gems. It was worked by several shafts from 50 to 250 feet deep in a distance of about 400 yards along the "vein."

According to D. M. Glenn, of Phenoy, a little work was done in 1905 on his mine on the west side of Crabtree Creek, 3 miles east of Celo. Flat mica with A markings was obtained. It has a dark smoky-brown color with a greenish tint, and part of it is specked. Uranium minerals are also reported to have been found, and their yellowish-green stain was seen on specimens at Mr. Glenn's house.

PENNSYLVANIA.

GENERAL FEATURES.

From time to time small quantities of mica have been mined in Pennsylvania. Deposits occur in Berks, Lehigh, Chester, and Delaware counties. There are early references to mica mining near Reading[70] and on South Mountain near Newmanstown,[71] and a mine was worked many years ago on Blackhead Hill, 7½ miles N. 5° E. of Boyertown, in Berks County. Prospects are reported by E. F. Bliss and A. I. Jonas about 7 miles N. 10° W. of Boyertown, near Landis Store, and 8½ miles N. 75° W. of Quakertown. Prof. B. L. Miller, of Lehigh University, mentions an old mica prospect, opened in 1883, about 1½ miles southwest of Seidersville, in Lehigh County.

Other deposits have been worked in Chester and Delaware counties. A little mica has also been obtained from quarries worked for feldspar in these counties. The feldspar quarries have been described by E. S. Bastin.[72] Two of the deposits in Delaware County were visited by the writer in 1915 and are briefly described below.

DELAWARE COUNTY.

KASSON MICA CO.

Mica was mined by the Kasson Mica Co., of Camden, N. J., 1¼ miles east of Glen Mills, 4 miles west of Media, in 1913. The de-

[70] Eng. and Min. Jour., vol. 40, p. 47, 1885.
[71] Mica: U. S. Geol. Survey Mineral Resources, 1885, pp. 518–520, 1886.
[72] Feldspar deposits of the United States: U. S. Geol. Survey Bull. 420, pp. 63–72, 1910.

posit here was discovered and first worked by John H. Smedley, of Media, sometime prior to 1870. Mr. Smedley says that he shipped about 250 tons of mica. The operations of the Kasson Mica Co. for several months in 1913 resulted in an output of more than 50 tons, most of it scrap mica.

The workings consisted of an open cut 80 feet long driven N. 60° E. into a southwestward-sloping hillside. This cut is 15 to 35 feet wide, and 5 to 20 feet deep to water in a shaft or stope in the bottom. The mine was idle at the time it was examined in 1915 and the possible extent of underground workings could not be ascertained. Old, overgrown dumps have been built out on the bank of a ravine 50 to 75 yards south of the open cut, but the source of this material was not evident.

The country rock is gabbro, which, according to F. Bascom,[78] is of early Cambrian or pre-Cambrian age. The gabbro has a somewhat schistose structure, and incloses interbedded mica gneiss. These rocks have a northeast strike and variable southeast dip. There is one large deposit of pegmatite with smaller parallel beds on either side. These beds cut the gneiss with a strike of about N. 60° E. and a vertical dip. The main pegmatite is at least 12 feet thick and probably thicker near the middle of the open cut. It is coarse grained in places and contains masses of feldspar several feet thick, quartz in segregations and veins from a few inches to 2 feet thick, and mica in crystals some of which were nearly a foot across. Most of the feldspar is the flesh-colored potash variety, but some is white fine-grained plagioclase. Rough wedge-shaped mica crystals 10 inches in diameter were seen and smaller crystals from 4 to 6 inches across, with a fair cleavage over parts of the crystal, were found. Some of these crystals, however, contained a large proportion of tangle-sheet mica. The mica has a medium-dark, smoky-brownish color and part is specked.

CHESTER HEIGHTS DEPOSITS.

Several deposits of pegmatite have been worked for feldspar near Chester Heights. Some of these are on the north side of the railroad about one-third of a mile west of Chester Heights station, and others are on the south side of the railroad about one-third of a mile southwest of Chester Heights. Only one of the quarries was in operation at the time of the examination, in 1915. Part of the feldspar from these quarries is very pure and is used in dentistry. The quarry in operation is about 250 yards northeast of the railroad, on the Aston-Concord township line.

[78] U. S. Geol. Survey Geol. Atlas, Philadelphia folio (No. 162), 1909.

The country rock as mapped by F. Bascom [74] is mica gneiss of the Wissahickon gneiss formation, into which has been intruded masses of gneissoid diorite or gabbro. These rocks strike east of north and have a high easterly dip. The pegmatite forms large deposits, which cut the inclosing gneiss both parallel and at angles with the bedding. Both rocks have been partly decomposed, but in places the pegmatite outcrops in hard, fresh masses. The pegmatite ranges from fine grained to coarse grained and contains crystals of pinkish feldspar 2 to 3 feet thick. It contains also some finer-grained white plagioclase feldspar and some biotite. Crystals of mica are scattered in pockets and streaks through the pegmatite. At the time of the examination mica suitable only for cutting into small sheets, for punching, and for grinding was seen, but some crystals 15 to 18 inches in diameter are said to be found. The mica has a clear, rather dark green color and good cleavage.

BRANDYWINE SUMMIT FELDSPAR CO.

According to E. S. Bastin [75] the Brandywine Summit Feldspar Co. has operated a quarry 1½ miles south of Brandywine Summit station, where three large pits have been opened in an area of about 4 acres. Cream to flesh colored orthoclase and microcline feldspar occur in pure crystals, some of them a foot thick. No graphic granite was seen. Quartz occurs in rather small granular gray masses. Mica occurs in crystals of sizes up to 18 inches across, but none of it is suitable for use in sheets. The smooth sheets of this mica are specked between the laminae with thin films of magnetite.

SOUTH CAROLINA.

GENERAL FEATURES.

Earle Sloan [76] describes several deposits of mica in South Carolina and gives the location of others. Most of these deposits lie in the Piedmont Plateau, in Oconee, Anderson, and Greenville counties. Some of them have been worked on a fairly large scale and have yielded good mica. A brief examination of those described below was made in October, 1913.

The rocks seen in the region around the mica mines consist mainly of mica schist and mica gneiss, with which are associated some kyanitic and garnetiferous rocks, and diorite, hornblende schist, and granite gneiss. The mica and garnet schists and gneisses are probably parts of the Carolina gneiss, which is described by Keith in the

[74] U. S. Geol. Survey Geol. Atlas, Philadelphia folio (No. 162), 1909.
[75] Feldspar deposits of the United States: U. S. Geol. Survey Bull. 420, pp. 70–71, 1910.
[76] Catalogue of the mineral localities of South Carolina: South Carolina Geol. Survey Bull. 2, 4th ser., pp. 142–149, 1908.

Geological Survey's geologic folios covering areas in western North Carolina (folios 90, 116, 124, 143, 147, and 151). In this part of the Piedmont Plateau weathering has been extensive, and in places the rocks are decomposed to depths of many feet.

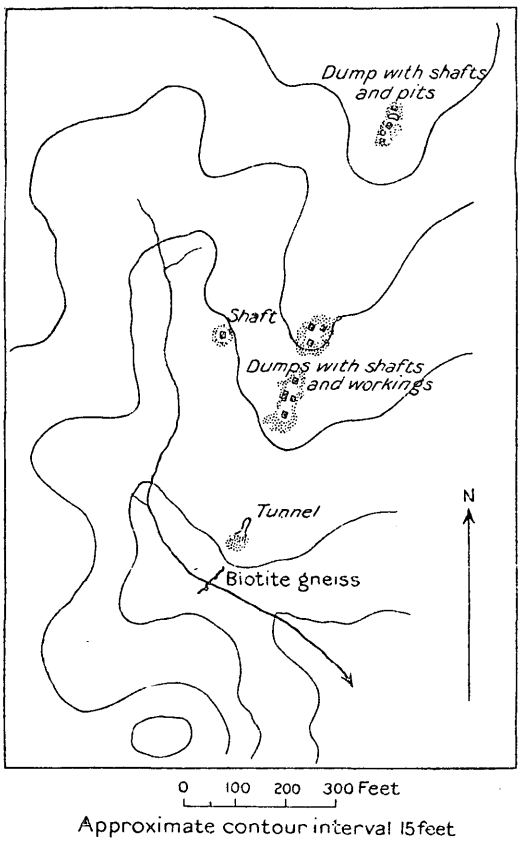


FIGURE 81.—Plan of Gaillard mica mine, 6 miles S. 75° W. of Starr, Anderson County, S. C.

ANDERSON COUNTY.

GAILLARD MINE.

A deposit of mica has been worked extensively on the Warren Gaillard place (formerly the J. J. Fretwell place), about 6 miles S. 75° W. of Starr, at two different periods, but the mine was idle at the time it was examined. The principal workings fall within a distance of about 900 feet in a line extending N. 20° E., as shown in figure 81. Eight shafts, ranging in depth from 15 to 40 feet, and several pits have been made. Drifts were run from the shafts and stopes wherever rich vein material was found. Many of the workings have caved in and could not be examined.

The country rock as exposed in the branch south of the mine is strongly folded biotite gneiss, into which is injected granite and pegmatite. The strike and dip are variable, but the strike averages northeast and the dip southeast. The gneiss and the pegmatite exposed in the workings are both deeply weathered. Masses of white quartz were encountered in the three main groups of workings. In the middle group the quartz is still exposed as an irregular vein, 2 to 3 feet thick, inclosed in the decomposed pegmatite and lying about 3 feet from the west wall of the vein. In places the quartz is gray, and some of it is smoky. The thickness of the pegmatite varies, being at least 18 feet in the middle workings and probably ranging from about 8 to 25 feet, including streaks or horses of mica

gneiss. Whether the three main groups of shafts and the tunnel to the south are all on the same body of pegmatite could not be determined. The mica is evidently pockety and irregularly scattered through the pegmatite but is most plentiful in the decomposed feldspar next to veins and masses of quartz. Some of it is partly intergrown with quartz. Most of the mica seen was either in small crystals or in larger crystals cut by ruling into ribbons and small plates. Crystals yielding sheets 10 inches square are reported to have been obtained when mining was in progress. The mica is clear and of good quality, splitting well.

Several tons of scrap mica could be obtained by screening and washing the waste mixed with kaolin on the dumps, and if such material had been saved during the first operations it would have gone far toward defraying the cost of mining.

A shaft sunk about 150 feet west of the main workings struck a body of pegmatite like that in the main workings, and a quantity of small mica was removed.

FRETWELL PROSPECTS.

Prospecting has been done on the old Hall place, now owned by J. J. Fretwell, about 1½ miles west of Barnes, where a belt of mica has been traced for nearly a mile northeastward. Three deposits that crop out on small knolls about 200 yards apart were examined. The pegmatite crops out as white gravelly quartz soil, through which are scattered blocks of white quartz and plates of mica. This soil can be traced rather plainly over the fields, because it contrasts with the darker earth and red clay soil formed by the decomposition of the inclosing schists. The outcrops trend about N. 60° E., as shown in figure 82. They are probably on separate bodies of pegmatite and do not represent one continuous mass. The country rock is mica gneiss, which includes many layers of schist. Both the mica gneiss and the pegmatite have been deeply weathered.

Practically no work has been done on the middle and southwest masses of pegmatite, but weathered sheets of mica are abundant at the prospects marked X in figure 82. An opaque crystal of yellowish beryl was found at the place indicated in the sketch map. At the northeast end of the area examined two prospect pits had been opened on each side of a small gully. Nothing could be seen of the pegmatite in the pit on the south side, but the later work on the north side, at the place marked *A* in figure 82, yielded some mica. A cross section of the formations encountered at this place is shown in the figure. The pegmatite appears to be a nearly horizontal bed inclosed in mica schist, but it may have an easterly strike and a northerly dip. The mica schist on the west wall strikes north by

east and dips about 25° E. Fifty feet west of the prospect the schist strikes N. 40° E. and dips 35° SE. Blocks of massive white quartz lie east of the prospect. The mica occurs in pockets or in bunches of crystals, or is scattered irregularly through the pegmatite. Crystals of mica as much as 8 inches across have been found, and specimens were seen that would cut to 2 by 3 inches. The mica obtained near the surface is rather badly clay stained, but the better pieces are of a clear light rum color and have good cleavage.

The pegmatite is decomposed and can be easily excavated. The deposit should be prospected by a cut run back into the north side of the gully as far east as mica can be found, and further work should be carried on at places where the showings of mica are best.

Another mica prospect has been opened on land owned by Mr. Fretwell, on the northeast bank of Savannah River about a quarter of a mile above the mouth of Big Generostee Creek. This prospect is about a mile south of the Gaillard mine, 7 miles S. 65° W. of Starr. An open cut made years ago around an outcrop of quartz on the hillside revealed pegmatite with crystals of mica of promising size and crystals of potash feldspar 18 inches across. Bluish-green and yellowish crystals of beryl were found, one of which was more than 4 inches in diameter. A 30-foot tunnel was driven in under the open cut, but without encouraging results. The country rock is fine biotite gneiss and is cut irregularly by the pegmatite.

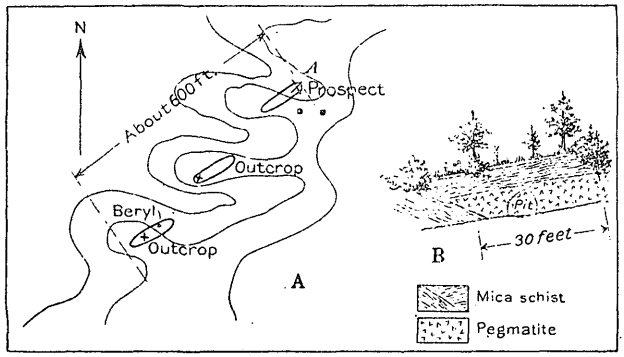


FIGURE 82.—Outcrops at Fretwell mica prospect, 1½ miles west of Barnes, Anderson County, S. C. A, Sketch plan; B, cross section at prospect marked *A*.

WHARTON MINE.

Mica was mined several years ago on the Sam Wharton place, 6½ miles N. 82° W. of Iva. The workings consisted of an open cut 40 feet long run N. 60° E. along the northwest side of a small branch, two crosscuts from the hillside, and a crosscut tunnel with a room at the end a few feet northeast of the open cut. The country rock is decomposed mica schist inclosing streaks of hornblende schist striking northeast and having a variable dip. The pegmatite cuts the country rock irregularly and pinches from a thickness of 15

feet in the open cut down to a few inches in the tunnel at the northeast end of the workings. The rocks are weathered and are easily excavated. Rough sheets of mica 8 inches across were seen on the dump, and a few pieces were found that would cut 2 by 3 inch plates. This mica has a greenish cast and splits well.

Another prospect pit was made 200 feet west-southwest of the main workings. Blocks of hard pegmatite containing small mica were left on the dump.

SHERARD MINE.

Mining has been carried on intermittently on the old Vandiver Sherard place, 6½ miles N. 80° W. of Iva, about a quarter of a mile southwest of the Sam Wharton mine, on the same belt of mica deposits. The first working was a 30-foot shaft from which drifts were run. Later a 25-foot shaft was sunk about 100 feet N. 20° E. of the first shaft, and drifts were run to the north and south. A crosscut tunnel 140 feet long was next driven in from the hillside below, on the east, and the mine was worked through it. About 70 feet from the portal this tunnel cut another vein, on which drifts were run. After this crosscut tunnel caved in a new shaft was sunk west of the vein to a depth of 35 feet, and a crosscut was made to the vein. These workings are very irregular and include some unnecessary work.

The country rock is diorite or hornblende gneiss, containing streaks of mica schist. The bodies of pegmatite cut the inclosing rocks irregularly. The main vein is as much as 15 feet thick, strikes N. 20° E., and has a westerly dip. It contains segregations of quartz, two veins of which are exposed in the first shaft made. The body of pegmatite cut in the crosscut tunnel is about 10 feet thick, and includes horses or streaks of mica schist. Only small crystals of mica were found in this vein. The mica obtained from the main vein has a slightly smoky color and part is specked. It has a good cleavage, and some of the small crystals seen were clean and sound. Good-sized sheets are reported to have been obtained during mining.

TERRY PROSPECT.

A mica prospect was opened on the old Terry place, about 6 miles west of Iva, by an open cut, 35 feet long, in the side of a knoll. Massive white quartz is abundant on the summit of the knoll and much mica in small sheets has been left around the pit.

McCONNELL PROSPECT.

A prospect opened on the place of J. N. S. McConnell, 3¼ miles north of Anderson, yielded promising specimens of mica with beryl crystals of good color, reported to be nearly emeralds. When

examined the workings consisted of a trench 45 feet long, 15 feet wide, and 5 feet deep, run N. 70° E., and a crosscut trench that entered it at the west end. The country rock is weathered to a dark reddish-brown sandy soil, and no outcrops were seen near the prospect. The soil has probably been formed by the weathering of a biotite or hornblende granite and carries small blocks of diorite. The pegmatite is not now exposed, but the dump contains kaolinized feldspar, blocks of massive white quartz, smoky and colorless quartz in rough crystals, weathered plates of mica 8 inches or less across, large dark-red garnets, black tourmaline, limonite pseudomorphs after pyrite, and black stains of manganese oxide. The mica remaining after the weathered parts are trimmed off is clear and of good quality. The principal workings are along the summit of a ridge extending north by west down to Little River. The deposits have been tested by pits for 75 yards S. 15° E. up the ridge. The deepest pit was probably not more than 15 feet deep, and most of the openings are partly filled. The country rock is mica gneiss, but its relations to the pegmatite were not visible. The pegmatite is at least 20 feet thick. Massive ledges or veins of the white quartz form part of the pegmatite. Only small sheets of mica were seen around the mine, but large crystals are reported to have been found. The mica is of a clear light rum color and of good quality.

WELBORN PROSPECT.

A prospect reported to be about 10 feet deep was opened several years ago on the land of W. C. Welborn, about 6 miles east-southeast of Pendleton, but has now been filled. The country rock at this place is badly weathered mica gneiss, which strikes N. 60° E. and dips 55° SE. Small beds of pegmatite exposed in the roadside cut the bedding nearly perpendicularly. Blocks of white quartz were left on the surface. So much scrap mica is mixed through the soil around the prospect as to indicate that the deposit is rich. It may have been abandoned because the mica is rather heavily specked, as at one time that variety was not in strong demand. Some of the mica has A structure but would yield good sheets from the parts between the A markings. A few rough sheets 8 inches in diameter were seen.

GREENVILLE COUNTY.

WILLIMON MINE.

One of the largest mica mines in South Carolina is that of R. C. Willimon, 9 miles southeast of Greenville. This mine has been operated intermittently for many years and has recently been leased by J. E. Burleson, of Spruce Pine, N. C. The operations here have

been fairly extensive, but none of the underground workings were accessible at the time of the examination. Openings have been made for 200 yards N. 60° E., and a few prospect pits, not in the same line, have been dug. The position of the numerous openings is shown in figure 83, and it is said that there was considerable drifting and stoping. The deepest shaft is more than 100 feet deep. The rocks are so soft that many of the workings have caved in, and in the endeavor to find new ground and avoid old workings many

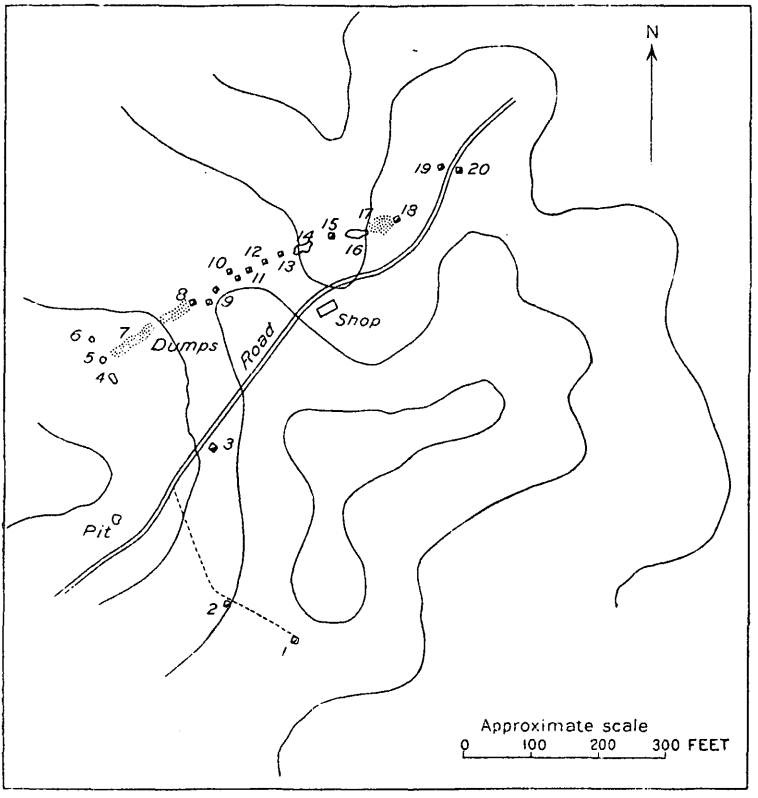


FIGURE 83.—Plan of Willimon mica mine, 9 miles southeast of Greenville, Greenville County, S. C. See text for explanation of numbers.

shafts have been made. The following observations were made at the openings shown by numbers in figure 83:

1. A shaft 25 feet deep in decomposed mica gneiss and pegmatite. The pegmatite is about 3 feet thick, strikes N. 60° E., and dips 75° NW. Mica in sheets 2 to 3 inches across.

2. Shaft 30 feet deep, partly caved in. Pegmatite 5 feet thick in decomposed kyanite-mica gneiss, both striking N. 60° E. and dipping 80° NW. Considerable small mica in dump.

3. Shaft 40 feet deep in decomposed mica and kyanite gneiss inclosing pegmatite.

4. Prospect trench; did not cut the vein.

5 and 6. Old shafts partly filled by caving. Only small mica left on the dumps.

7. Rather large dumps of waste removed from 8; contains some decomposed porphyritic granite.

8 and 9. Extensive underground workings, now mostly caved in. Pegmatite inclosed in decomposed mica gneiss.

10. Two new shafts, 10 and 30 feet deep, in mica gneiss on northwest side of the pegmatite.

11. Shaft more than 30 feet deep. Red clay near surface; decomposed pegmatite below. Small mica blocks of pegmatite and massive quartz on dump.

12. Old shaft in pegmatite.

13. New shaft 30 feet deep with water in bottom.

14. Old workings badly caved in. Much small mica on dumps.

15. Old shaft 20 feet or more deep, badly caved in. Small mica on dump.

16. Large pit or open cut on vein.

17. Large dumps of waste removed from 18.

18. Deep shaft, drifts, and stopes; badly caved in. Was equipped with steam pump, hoist, etc. Much mica obtained from these workings.

19. Prospect pit; no pegmatite found in the decomposed mica gneiss.

20. Prospect pit in pegmatite. Small mica found.

A view of the workings northeast from the shafts at (10) is given in Plate XXIV, *B* (p. 260).

The country rock is composed of mica schist and gneiss, kyanitic in places, cut by porphyritic granite and pegmatite. All these rocks have been weathered to soft earth to a depth of at least 30 feet. Four veins of pegmatite have been tested, one of which has proved large and continuous. This vein is more than 10 feet thick in places and contains segregations or masses of quartz. The veins of pegmatite are approximately conformable with the inclosing rock, striking about N. 60°–65° E. and having vertical to high northwest dips.

Little could be learned of the quantity of mica the mine has produced or of the size of the better sheets. Possibly 25 tons of small sheet and scrap mica was lying around the workings. This mica could be screened and used for grinding. The small-sheet mica seen had a clear amber to rum color and good cleavage. Some of it was considerably ruled.

OCONEE COUNTY.

LEROY PROSPECTS.

Several deposits of mica have been prospected on the G. W. Leroy place, 5 miles northeast of Seneca. The mining or prospecting here was done by Thaddeus Leroy, who owns other mica prospects on land adjoining on the west. Some of the smaller prospects were tested by a few days' work, and the mica obtained is said to have paid wages of over $3 a day for the work.

Other prospects for mica have been tested or are known on the properties of John Dyer, half a mile, and J. F. Smith, three-quarters of a mile south of Leroy's.

SOUTH DAKOTA.

GENERAL FEATURES.

The mica deposits of South Dakota have been worked intermittently for many years. According to C. C. O'Harra[77] the earliest exploration for mica was made in 1879, when the McMacken mine (later called the Crown) was opened. Between 1879 and 1884 this mine is reported to have yielded 45,000 pounds of cut mica, valued at $135,000. Other mines were opened soon after the McMacken, and in 1881 plates of mica measuring 4 by 10 inches were reported as coming from the La Barres mine,[78] near Custer. Other valuable deposits opened during this period were the New York, Lost Bonanza, and Climax. Between 1884 and 1899 mica mining was at a low ebb in South Dakota, and little more than assessment work was done. In 1889 and 1900 more active mining was resumed. In 1906 the industry received a big impetus with the reopening of the New York, White Spar, and other mines by the Westinghouse Electric & Manufacturing Co. These mines were operated for several years on a large scale but are now all closed. Other mines have been worked since 1910 by the McBride Bros. for different companies, and these and a few small deposits have been the only producers since the Westinghouse mines were closed down, in 1911. During the years of largest production of mica in South Dakota—that is, from 1907 to 1911—the annual output ranged from several hundred thousand to more than a million and a half pounds of rough sheet mica and from 300 to 1,000 tons of scrap mica.

Most of the mica deposits that have been tested are within a radius of 10 miles of Custer, in the southern part of the Black Hills. This area includes the better deposits of mica so far located, but other deposits occur 12 to 15 miles north of Custer, in the Keystone region, on the north side of Harney Peak. Several of the deposits were briefly examined in August, 1908, when the descriptions given below were prepared.

GEOLOGY OF THE BLACK HILLS.

The geology and mineral resources of the Black Hills have been described by many writers. Of the reports on geology, those of Newton and Jenny[79] and of Darton,[80] taken together, furnish good

[77] The mineral wealth of the Black Hills: South Dakota School of Mines Bull. No. 6, pp. 75–77, 1902.

[78] Eng. and Min. Jour., vol. 32, p. 44, 1881.

[79] Newton, Henry, and Jenney, W. P., Geology and resources of the Black Hills of Dakota: U. S. Geog. and Geol. Survey Rocky Mtn. Region, 1880.

[80] Darton, N. H., Preliminary description of the geology and water resources of the southern Black Hills: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 4, 1901; Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming: U. S. Geol. Survey Prof. Paper 65, 1909.

descriptions. The mica resources have been treated in the reports of the South Dakota Geological Survey and have been mentioned in the annual reports on the mineral resources of the United States published by the United States Geological Survey. A booklet containing a geologic map, by Samuel Scott,[81] of Custer, S. Dak., serves as a useful guide to the general geology of the Black Hills.

The Black Hills form a group of mountains that rise to a maximum elevation, in Harney Peak, of 7,240 feet above the sea, or 3,000 to 4,000 feet above the surrounding plains. They constitute an oval uplift about 125 miles long from north-northwest to south-southeast and 60 miles wide. The core of this uplift is composed of highly metamorphosed slates, gneisses, and schists of pre-Cambrian age and granitic intrusives. This core of ancient rocks is completely encircled by strata of later formations, which dip away from the core on all sides and were evidently once continuous over its top as a dome. The oldest of these strata is a conglomerate and sandstone formation of Cambrian age, called the Potsdam by Newton and Jenney and the Deadwood by Darton. The Deadwood formation is overlain by other formations, among which are limestone of Carboniferous age, red beds and shale of Triassic (?) and Jurassic age, Upper and Lower Cretaceous sandstones, shales, and limestones, and Tertiary "badland" formations. These formations crop out at successively greater distances from the central core of metamorphic rocks, and some of the outcrops form hogbacks with scarps toward the center of the uplift.

Newton and Jenney call attention to a marked difference between the metamorphic rocks of the northeastern part of the area and those of the southwestern part. Those of the northeastern part are less metamorphosed and more nearly like slates in texture and structure, whereas those of the southwestern part are highly metamorphic, micaceous, chloritic, hornblendic, and quartzitic gneisses and schists. Newton and Jenney call the gneisses and schists "Older Archean" and the slates "New Archean." In a report on the Cretaceous formation of the Black Hills,[82] the northeastern metamorphic area is called Algonkian and the southwestern area Archean. Whatever may be the age of these formations, that in the southwestern part, in which the mica deposits occur, is composed of true gneisses and schists, in which the mashing has been extreme and the development of metamorphic minerals extensive. In comparing typical specimens of the slates and mica slates of the northeastern area with the gneisses and schists of the southwestern area, the writer was impressed with the extreme difference in the degree of metamorphism

[81] Rocks, minerals, and other resources of the Black Hills.

[82] Ward, L. F., Jenney, W. P., Fontaine, W. M., and Knowlton, F. H., U. S. Geol. Survey Nineteenth Ann. Rept., pt. 2, pl. 53, 1899.

they had undergone. Newton and Jenney state that granites occur only in the "Older Archean" rocks and that granitic pebbles were found in the Cambrian conglomerate overlying them. They therefore conclude that the granite is pre-Cambrian and older than the slate.

Sidney Paige,[83] after a detailed study of the pre-Cambrian area, has concluded that the slates, schists, and gneisses composing the core of the hills are all of one age. All these rocks have undergone regional metamorphism, but those of the southern part of the hills have been further metamorphosed by the large intrusions of granite and pegmatite. The metamorphism of the rocks in the immediate region of the igneous intrusions has been extensive and has led to the uncertainties regarding the identity of rocks having appearances so diverse as those of the pre-Cambrian in the northern and southern parts of the Black Hills.

The granite formation of the Black Hills is most conspicuously seen around Harney Peak and southward to Custer. Other smaller bodies of granite and the pegmatite into which it appears to grade in some places occur in different parts of the highly metamorphosed area. Many of the masses of granite and pegmatite form prominent outcrops. Some of the granite outcrops assume on weathering characteristic columnar or needle-like forms, such as are seen in the Harney Peak region. (See Pl. XXV, *A*, p. 261.) Many of the deposits of pegmatite form large sheetlike outcrops that stand prominently above the low ground or on the hillsides.

Much of the granite has a very coarse texture, and in some places it is difficult to decide whether to classify the rock as granite or pegmatite. The pegmatite occurs both in the metamorphic rocks and in the granite. The prevailing trend of the gneisses and schists and of many of the inclosed pegmatites in the region of Custer is northwest to north. The dip is more variable, though in the many localities noted it was to the southwest or vertical. The gneisses and schists are much folded in places and are to some extent crinkled with minor folds.

The mica-bearing pegmatites of the Black Hills exhibit a rather uniform mixture of feldspar and quartz, which in some places is very coarsely crystallized. In other pegmatites, noticed especially in connection with deposits of rose quartz, the minerals occur in large segregations. At Samuel Scott's Rose Quartz mine, 6½ miles S. 50° E. of Custer, the pegmatite incloses a vein of quartz, part of it rose-colored, which is 6 to 15 feet thick and 10 to 30 feet high and extends for more than 100 yards. In the mica-bearing pegmatites examined the feldspars were chiefly orthoclase or microcline,

[83] U. S. Geol. Survey Geol. Atlas, Black Hills folio (in preparation).

with some plagioclase, albite, and oligoclase. The mica is a variable constituent of the pegmatites.

A number of accessory minerals have been found in the pegmatites of the Black Hills. In several of the deposits north of Harney Peak cassiterite, large crystals of spodumene, amblygonite, columbite, and beryl have been found. In the mica deposits near Custer these minerals are rare. In nearly every one of the mines examined around Custer black tourmaline was found, and in many of them large crystals were abundant. J. A. Holmes[84] mentions this occurrence and contrasts it with the general scarcity of tourmaline in the tin-bearing pegmatites north of Harney Peak. He also says that mica is apparently not found plentifully in commercial sizes in the pegmatite of the tin region. Holmes[85] estimates that in some parts of the New York mine mica forms 10 per cent of the whole body of pegmatite, but that in others it forms not more than 1 per cent. Figures furnished by Joseph Pyne, the superintendent, show that the rough mica obtained along the walls of the pegmatite (the only part of it worked for mica in this mine) amounts to 6 or 7 per cent of the rock. The interior of the pegmatite at this mine carries very little mica, about one-half of 1 per cent; this estimate would give about 2.5 per cent of mica in the whole mass of pegmatite. The mica-bearing pegmatites around Custer tend to have an evenly granular texture or irregular segregation of mineral masses rather than a banded structure. In much of the rock, however, there is a rough banded arrangement in the segregation of the mica crystals along one or both walls. This structure does not resemble a vein so much as the bands of a single mineral, such as quartz or feldspar. A few of the crystals of feldspar and irregular masses of quartz are several feet across. Some of the bodies of pegmatite occur in regular sheets, whose outcrops can be traced for several hundred yards; others are typically lenticular. Some lie parallel with the schistosity of the inclosing rock; others cut across the rock. In their general features those around Custer resemble dikes, the veinlike type being rare.

CUSTER COUNTY.

NEW YORK MINE.

The New York mine, called mine No. 1, of the Westinghouse Co., is 5¼ miles southwest of Custer, between Hay and Four-mile creeks. The mine is in a small, prominent hogback-like knob 700 feet long and 250 feet wide. (See Pl. XXV, *B*, p. 261.) This knob is nearly 200 feet higher than the level of Hay Creek, on the south-

[84] Mineral Resources of the United States, 1898, Mica: U. S. Geol. Survey Twentieth Ann. Rept., pt. 6 (continued), p. 699, 1899.

[85] Idem, p. 693.

east, and about 100 feet higher than the gentle slope from its base to the valley of Hay Creek.

The earlier work at the New York mine consisted of open cuts, inclines, and stopes, which in one place extended from the surface nearly to the 100-foot level. The workings of the company have been systematic, and at the time of the examination consisted of a vertical shaft to the 200-foot level, at the bottom of which was a 16-foot sump, and drifts with stopes on the 50-foot, 100-foot, and 200-foot levels. According to Jesse Simmons[86] the shaft had been carried to a depth of 315 feet at the time of his visit, a few years later. The mine was equipped with a 400-horsepower boiler and engine, of Westinghouse make. Power was transmitted electrically from two 150-kilowatt generators. The mine was lighted with incandescent electric lights and the camp with arc lamps. The hoist, grinding plant, and shop were also operated by electric power. Air drills were used throughout the mine.

The country rock is biotite gneiss and schist, striking northwest and dipping about 50° SW. The pegmatite is approximately conformable with the inclosing gneiss. The contact of the two is sharp, though there are gentle rolls along the strike. The pegmatite has a thickness across the dip of about 30 feet at the surface, 25 feet on the 100-foot level, and 28 feet on the 200-foot level. The mica occurs along each wall of the pegmatite in two streaks or "veins" from 1 foot to 8 feet thick. The interior of the pegmatite is nearly barren of mica or is too poor in it to pay for working. Although the streaks vary in thickness and richness they are unusually regular for mica. Through the greater part of the mine that was opened before the time it was visited the veins were sufficiently rich to pay for working, and in places the mica was very abundant. Many of the crystals of mica occur in flattened or tabular blocks that lie perpendicular to the walls of the pegmatite, though they have no other definite orientation. The crystals generally range from 2 to 8 inches in diameter and from 1 inch to 5 inches in thickness. Crystals a foot across are not rare, and some measure a yard.

Figure 84 represents a generalized cross section of the pegmatite "veins" and workings at the New York mine. The first operations at this mine were influenced largely by the position of the outcrop of the pegmatite, which forms the top and southwest side of the knob in which the mine is located.

The footwall of the pegmatite crops out along the top of the knob, and the hanging wall lies near the surface along the south-

[86] Mica in the Black Hills of South Dakota: Min. World, p. 221, 1910.

west side. The relations are shown in Plate XXVI, *A*, in which the workings on the footwall are seen on the summit of the knob and those along the hanging wall on the left side.

Many small openings have been made on the outcrop, and drifts have been run to the northwest on each "vein" on the 50-foot level. The entrance to the 50-foot level is made from an open cut on the outcrop of the vein about 50 feet below the top of the hill. The drift on the hanging-wall "vein" was run about 130 feet and a small amount of stoping was done. The "vein" was rich in mica to a point within 15 feet of the end of this drift, but at the end the mica content was small. A crosscut connects this drift with the footwall "vein," the drift on which was carried about 250 feet to the northwest. For 100 feet of this length the "vein" had been stoped out, to the top of the knob, 50 feet above, and beyond this stretch good

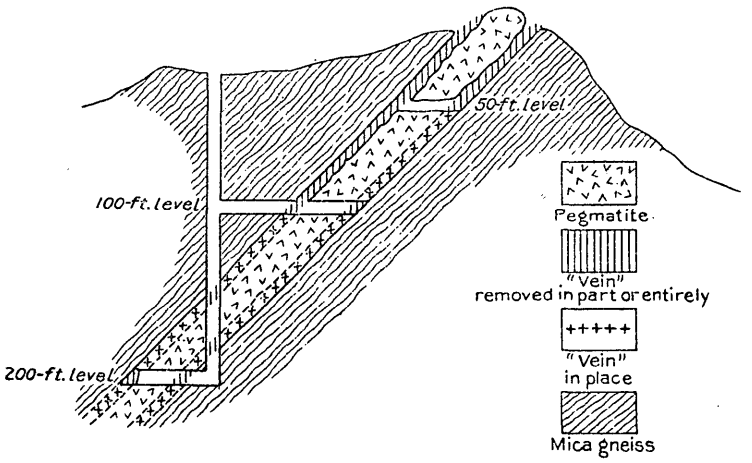


FIGURE 84.—Generalized cross section of No. 1 or New York mica mine, near Custer, S. Dak.

vein matter was held ready for stoping. At the southeast limit of the surface workings, about 200 feet from the shaft, the pegmatite contains a large quantity of black tourmaline in crystals ranging in diameter from 1 inch to several inches, some of them many feet long. The mica content of the pegmatite is very small at this point.

The shaft starts southwest of the pegmatite and cuts through it between the 100-foot and 200-foot levels. Only the hanging wall had been worked on the 100-foot level at the time of the examination. This level is connected with the shaft to the southwest by a short crosscut. Drifts have been run from the crosscut about 300 feet northwest and 250 feet southeast. The vein was stoped out to the 50-foot level for 200 feet northwestward and work was being carried farther. The pegmatite at the end of this drift was very poor in mica and was composed of large crystals of feldspar, massive

quartz, and black tourmaline. The drift was to be carried farther in search of richer "vein" matter. In the southeast drift much of the "vein" has been stoped out to the surface for about 240 feet from the crosscut. At this point the vein becomes poor in mica and carries abundant black tourmaline like that seen in the surface workings. Some of the tourmaline crystals measure 10 inches in diameter. They do not appear to have any definite position relative to the wall of the pegmatite. The vein was rich nearly to the end of each drift and in the large stopes. The strike of the contact of the vein is nearly straight throughout the length of the drifts except at a point a few feet southeast of the crosscut, where the mica schist wall elbows out into the pegmatite for several feet across the strike of the vein.

A room was made southeast of the shaft on the 200-foot level for an electric pump, for loading cars on the cage, and for other purposes. A crosscut run 10 feet from this room to the southwest cuts the foot-wall of the pegmatite, which is about 28 feet thick. Mica was seen in the foot-wall "vein" here, but it had not been developed at the time the mine was visited. Drifts were started to the northwest and to the southeast on the hanging-wall "vein" and when seen were each in about 20 feet. These drifts have since been carried farther. At the end of the southeast drift an irregularity in the "vein" or a fault was encountered. The vein matter seen in the 40 feet of drift on the 200-foot level was very rich and contained considerable mica in large blocks. Several blocks more than a foot across and a large number of smaller blocks were seen in the walls.

The richness of a part of the pegmatite in mica is shown in Plate XXVI, *B*, which is a view on the 200-foot level a few feet southeast of the crosscut from the shaft. Records kept by Mr. Pyne, the superintendent of the mine, showed an average of 60 pounds of rough mica every square foot of the surface of the "vein." The thickness of the "veins" averaged about 5½ feet. If a cubic foot of pegmatite weighs 163 pounds the rough mica obtained averages about 6.6 per cent of the vein matter.

WHITE SPAR MINE.

The White Spar or No. 2 mine of the Westinghouse Co. is 1¾ miles S. 40° W. of Custer. This mine was equipped with two 45-horsepower boilers, a bucket hoist that served also as a pump, electric lights, air drills, mine cars, and tracks. The surface equipment and appearance of the mine are shown in Plate XXVII, *A*. The mine was opened irregularly from the surface by open cuts, inclines, and drifts to a depth in places of nearly 40 feet. The workings of the Westinghouse Co. consisted of a vertical shaft

110 feet deep, 10 feet at the bottom serving as a sump, a crosscut and drift on the "vein" at the 100-foot level, and drifts and stopes on the 50-foot level. The shaft was sunk in the "vein" for 50 feet from the surface down and then passed through the footwall into the country rock.

A general plan of the workings of the Westinghouse Co. on the 50-foot and 100-foot levels, as seen in August, 1908, is given in figure 85. The "vein" is about 40 feet thick at its outcrop, 25 feet thick at the 50-foot level, and 18 to 20 feet thick at the 100-foot level.

The country rock is biotite gneiss containing prominent highly schistose beds, some of which are much crumpled. The gneiss strikes N. 30°–60° W. and dips about 45° SW., though the dip is variable from place to place. The course of the "vein" of pegmatite is roughly conformable with the schistosity of the gneiss, though it is at some places very irregular. On the 50-foot level the pegmatite pinches out at a distance of 40 feet southeast of the shaft and the gneiss folds around it, as indicated in figure 85. In places the contact of the pegmatite and gneiss is straight, though it is generally somewhat curved and rolling.

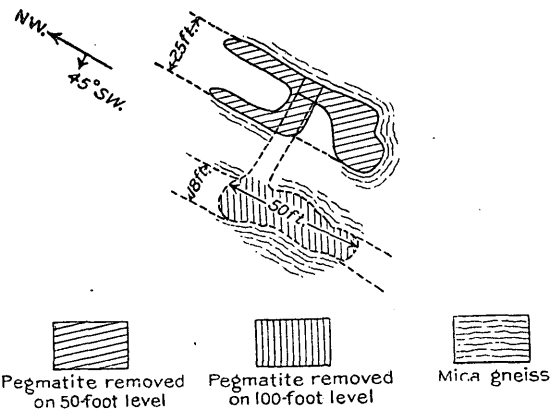


FIGURE 85.—Plan of No. 2 or White Spar mica mine, near Custer, S. Dak.

The mica is irregularly distributed through the pegmatite. At one place southeast of the shaft on the 50-foot level nearly half the "vein" was mica, which was in blocks of various sizes, some of them a foot in diameter. The edge of one block of mica, or of several blocks closely joined together, which projected from the floor of the room southeast of the shaft, was nearly 5 feet long and 2 to 12 inches thick. The crystals of mica appear to have no definite orientation but are mixed with the quartz and feldspar of the pegmatite. The feldspar is coarsely crystallized; a crystal of orthoclase 4 feet through was seen in the wall. Quartz occurs in the pegmatite in large, irregular masses several feet across. Other minerals found are black tourmaline, garnet, and white to pale-greenish beryl. One broken crystal of beryl 6 inches in diameter and 8 inches long was seen. The mica is suitable for electric work, and some of it could be used for glazing.

Part of it contains flattened garnets between the laminae and tourmaline, which has grown through the crystals at different angles.

Ledges of pegmatite are plentiful in the neighborhood, and two other large ones crop out 50 to 80 feet southwest of the main ledge. The Westinghouse Co. intends to continue the crosscut on the 100-foot level to cut one of these ledges.

NO. 4 MINE.

Mica mine No. 4 of the Westinghouse Co. is 5 miles N. 15° E. of Custer, in a ridge between two branches of the headwaters of French Creek. The mine is about 300 feet higher than the valley on the northwest. The greater part of the work was done by operators who preceded the Westinghouse Co., which stopped work temporarily after doing a small amount. Openings have been made at two places, one on a small knob, the other about 200 yards S. 65° E. of it. These openings are apparently on different bodies of pegmatite. The ledge of pegmatite running through the knob strikes N. 15° W. and dips 60° E. The ledge at the other opening is complex and its direction was not determined. Between the two openings a strong ledge of pegmatite crops out with a strike of N. 65° W. and a dip of 40° N. This ledge extends to that on the knob, by which it seems to be cut off. Other bodies of pegmatite that show similar variations in direction occur in the vicinity.

The body of pegmatite that cuts through the knob is about 25 feet thick and has been traced southward along the knob for nearly 100 yards. It is composed of large, irregular masses of feldspar and pale rose-colored quartz, variable quantities of mica and black tourmaline, and small quantities of biotite mica, apatite, and garnet. The mica seems to occur principally along the hanging wall and has been worked by an open cut on the north end of the knob. Many crystals of mica project from the pegmatite for some distance along the outcrop.

At the other opening a tunnel was run N. 60° W. from an open cut. At the entrance to this tunnel biotite gneiss was exposed in the floor and on one side. Its foliation strikes N. 65° W. and dips about 30° N. In the open cut the pegmatite dips in the opposite direction. The mica found in this opening seems to have been plentiful and to have been of fairly large size.

CROWN MINE.

The Crown mica mine of the Chicago Mica Co. is 2½ miles northwest of Custer. It has been worked by several open cuts—the main one about 130 feet long and 25 feet deep and wide—a 20-foot incline from the bottom of the cut, a 100-foot shaft with a crosscut to the "vein," a drift, and a stope. The stope reaches about half way to

the bottom of the incline. The mine has been equipped with a 40-horsepower boiler, a hoisting engine, an air-drill compressor, three pumps, a storage and loading house, and an office.

The country rock is muscovite-biotite gneiss, which has straight slaty cleavage in some places and a plicated structure in others, especially near the bodies of pegmatite. The schistosity of the gneiss strikes about N. 35° W. and has a variable dip. The body of pegmatite is about 10 feet thick and is in part at least conformable with the schistosity of the gneiss. It has the form of an anticlinal fold whose axis pitches southeastward at an angle of about 10° or 15° down the slope of a low ridge. At the northwest end of the open cut the crest of folded pegmatite forms a blanket over the top of a small hill and has been worked for a width of 40 feet by a shallow open cut. The northeastern limb of the fold has been followed down on a dip of about 40° by a 20-foot incline. Sufficient development work has not been done to determine the dip of the other limb of the fold to the southwest. The open cut has been made along the axis of the fold and cuts through the pegmatite.

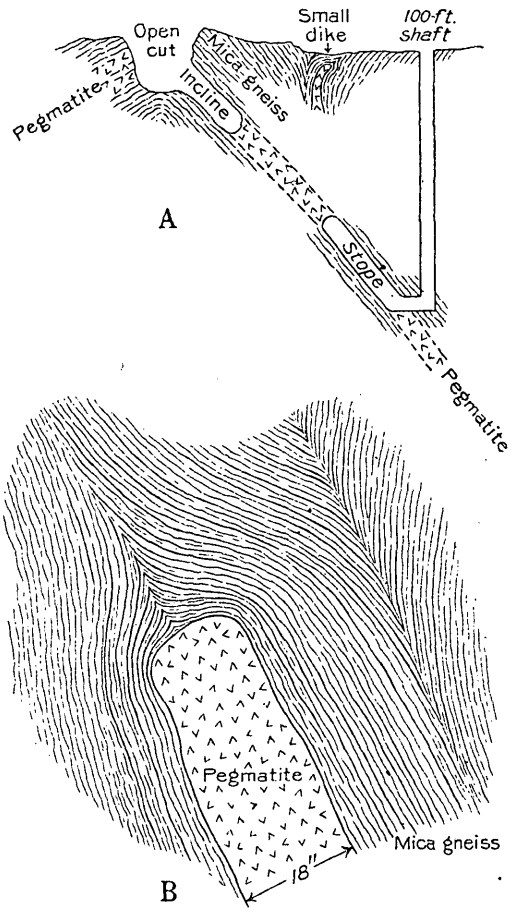


FIGURE 86.—Crown mica mine, near Custer, S. Dak. A, Generalized cross section; B, sketch showing relation of pegmatite dike to inclosing gneiss.

While assessment work was being done an 18-inch pegmatite dike was encountered about 50 feet northeast of the main body. This pegmatite failed to reach as far as the present surface by several feet. It is conformable with the strike of the inclosing gneiss, which it has split apart and crushed in the direction of its intrusion. The mica gneiss between this small dike and the main one is somewhat plicated and has been folded into a syncline. Figure 86 gives at *a*

a generalized cross section of the formation and development work at the mine looking northwest, and at *b* is a sketch of the small dike and its relation to the inclosing gneiss as seen from the northwest. Plate XXVII, *B*, is a reproduction of a photograph of the same small dike showing its relation to the gneiss. The main body of pegmatite contains inclusions or horses of mica gneiss in long streaks that lie parallel to the walls and that range from a few inches to 3 feet in thickness.

The pegmatite remaining in the mine contains much small mica. The small dike does not carry merchantable mica so far as it has been opened, but it illustrates the method of intrusion of a pegmatite dike and the way in which such dikes, and consequently some mica "veins," pinch out abruptly.

The Crown mine was later acquired by the Westinghouse Co. and was worked during the last year or two that the company operated in the Black Hills.

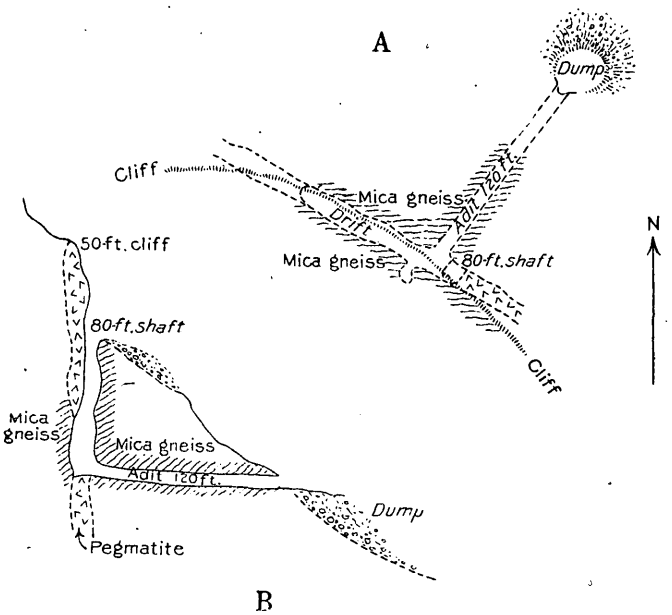


FIGURE 87.—Plan (A) and cross section (B) of Great Northern or Old Mike mica mine, near Custer, S. Dak.

OLD MIKE MINE.

The Old Mike mica mine, now called the Great Northern, is $3\frac{3}{4}$ miles N. 20° W. of Custer, on the north end of the ridge that extends northward from Buckhorn Mountain. The pegmatite at this mine forms a cliff which faces northeastward and rises about 50 feet above the steep slope at its base. Other cliffs rise back of and above this one, to the southwest. The mine has been opened by a shaft 80 feet deep, a crosscut or adit 120 feet long, and a drift with stopes on the vein. (See fig. 87.) Some work has been done at the

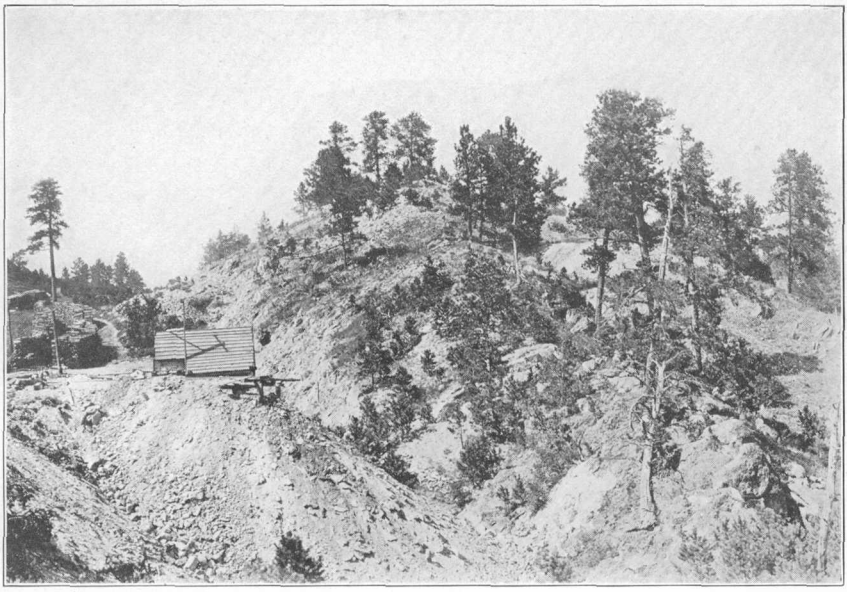
base of the cliff. The country rock is muscovite-biotite schist, which strikes nearly east and has a northerly dip. The body of pegmatite cuts across the schist with a strike of N. 65° W. and a vertical dip. It is 10 to 15 feet thick in the drift and has irregular curving walls. The mica is distributed irregularly through the pegmatite, and at some places where the pegmatite bulges out into the schist it is abundant. Here and there the pegmatite is fine grained and barren of merchantable mica. Mica is exposed in the face of the cliff, where a little work has been done. Most of the work in the cliff has been done to obtain columbite and cassiterite. Masses and crystals of columbite weighing several pounds have been obtained alongside of and in a streak of quartz in the pegmatite cliff. Crystals of brownish to black cassiterite occur in places through the finer-grained parts of the pegmatite, and boulders of tin-bearing pegmatite lie on the slope of the mountain below the mine. The mica from this mine has a rum color and appears to be clearer than that from many of the other mines in South Dakota.

FIRESTONE MINE.

The Firestone mica mine is 4¾ miles S. 20° W. of Custer. It has been opened by a crosscut run through the schist and the barren part of the pegmatite, an open cut 20 feet deep, and an incline on the "vein." The incline was reported to be 75 feet deep and has a 30-foot drift to the northeast at the 20-foot level, below which it is filled with water. The country rock is muscovite-biotite schist striking N. 25° E. and dipping 60° NW. The pegmatite is about 15 feet thick and is conformable with the inclosing rock. A few thin sheets or partings of schist are included in the pegmatite and lie parallel with its walls. Near the outcrop on the southwest side of the open cut, part way down the incline, the streak of mica lies along the hanging wall and is about 1 foot thick. In the northeast face of the cut the streak is in the pegmatite and is about 4 feet thick. The contact of the pegmatite and gneiss in the northeast face of the open cut is shown in Plate XXVIII, *A*. This part of the pegmatite contains little mica. In the drift also the "vein" is in the body of the pegmatite and is several feet thick. Mica seems to be plentiful in parts of the "vein," and some crystals several inches in diameter were seen. The feldspar and quartz of the pegmatite occur in irregular masses 2 or 3 feet across. Some of the quartz has a pale-rose color.

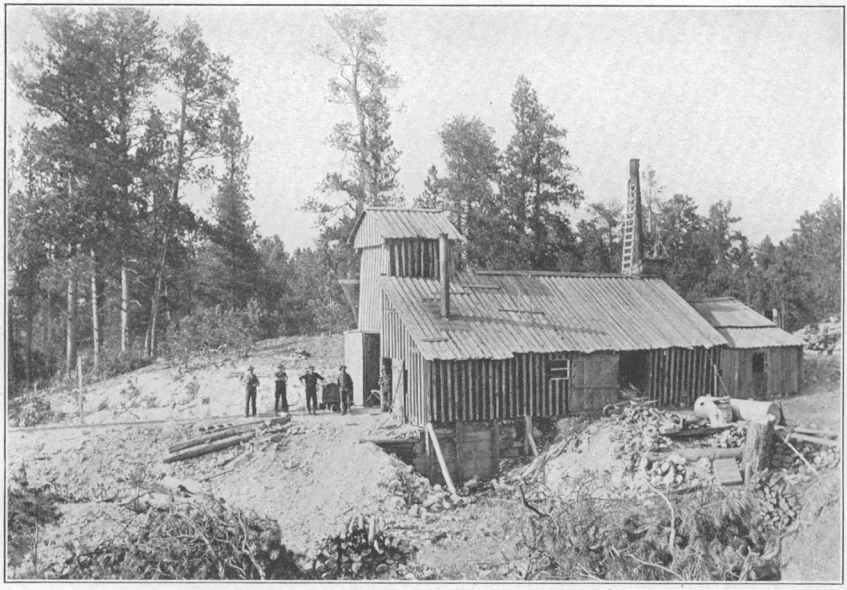
LOST BONANZA MINE.

The Lost Bonanza mica mine is 1¾ miles due north of Custer, on the east end of Buckhorn Mountain. The pegmatite cuts through a small knob with a strike of N. 80° W. and a dip of 40° S. and is

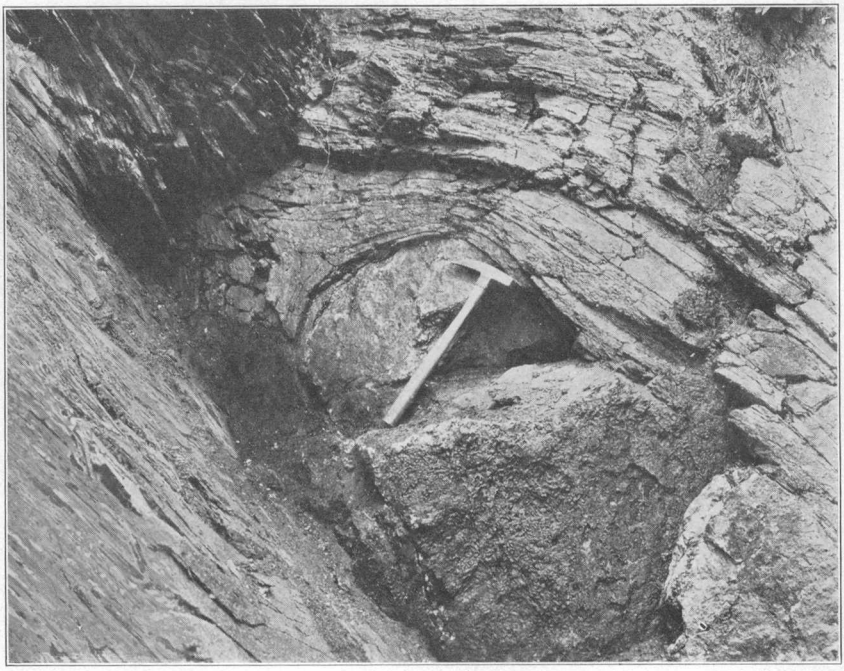


A. VIEW NORTHWARD ALONG PEGMATITIC OUTCROP AT NEW YORK MICA MINE, NEAR CUSTER, S. DAK.

B. CRYSTALS OF MICA IN PEGMATITE AND BLASTED LOOSE ON 200-FOOT LEVEL OF NEW YORK MICA MINE, NEAR CUSTER, S. DAK.

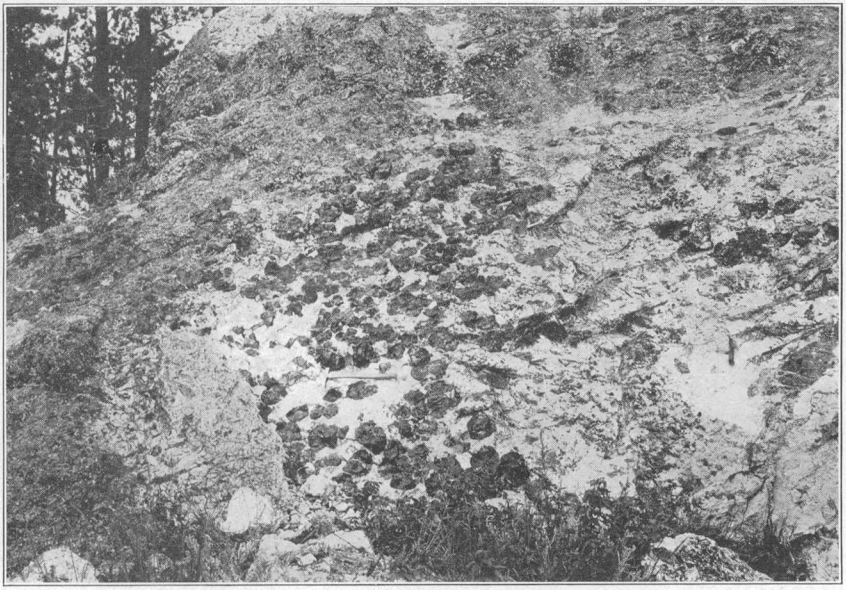


A. VIEW NORTHWARD TOWARD ENGINE AND SHAFT HOUSE OF WHITE SPAR MICA MINE, NEAR CUSTER, S. DAK.



B. END OF INTRUSION OF SMALL DIKE OF PEGMATITE AT CROWN MICA MINE, NEAR CUSTER, S. DAK.

A. CONTACT OF PEGMATITE AND GNEISS IN NORTHEAST FACE OF OPEN CUT AT FIRESTONE MICA MINE, NEAR CUSTER, S. DAK.



B. LARGE CRYSTALS OF BLACK TOURMALINE EXPOSED IN SMALL CUT ALONG WALL OF PEGMATITE AT PHILIP GEERING'S MICA PROSPECT, NEAR CUSTER, S. DAK.

A. SURFACE EQUIPMENT OF CHAMPION NO. 2 MICA MINE, AMELIA COUNTY, VA.

B. INTERIOR OF MICA-TRIMMING HOUSE OF RIDGEWAY MICA CO., RIDGEWAY, VA.

conformable with the inclosing muscovite-biotite gneiss. The mine has been worked by an open cut, an incline, and a tunnel more than 200 feet long, with stopes. The tunnel is about 40 feet lower than the top of the hill, and nearly all of the "vein" between the two has been worked out. The outcrop of the pegmatite is exposed for nearly 100 yards along the strike. The pegmatite ranges in thickness from 15 inches to more than 8 feet. At the east end of the open cut a part of the pegmatite is nearly barren of mica and carries crystals of black tourmaline, some of which are 10 inches in diameter.

CLIMAX MINE.

The Climax mica mine is 2 miles due east of Custer. It has been opened by three shafts, not more than 50 feet apart, connected by drifts. One of these shafts was more than 60 feet deep. The country rock is schistose biotite gneiss, striking northeastward and having a high dip, and the pegmatite is approximately conformable with the schistosity. As seen in the outcrop, the pegmatite is about 20 feet thick and carries mica in pockets containing crystals of many sizes, some of them several inches in diameter. Regular streaks of mica may have been found in the workings. The mica is of good quality and has a wine-yellow color. Black tourmaline and smoky and opalescent quartz occur in the pegmatite.

About 100 yards northwest of the old workings another body of pegmatite, 2½ to 4 feet thick, has been opened by a shaft, drifts, and a small open cut. This "vein" is conformable with the inclosing biotite schist-gneiss, which strikes N. 45° W. and has a vertical dip. The mica is scattered through the pegmatite.

ST. LOUIS MINE.

The mine of the St. Louis Mica Co. is on the south side of French Creek, 4½ miles S. 65° E. of Custer. The outcrop of pegmatite at this mine forms a bare floor, nearly 100 feet square, on the gentle slope of a hill. It contains several small streaks of mica gneiss, which strike N. 70° W. and dip 65° SW. Streaks of mica that contain numerous small crystals occur in the pegmatite, and two of them strike northeast and have a vertical dip. The work done here consists of shafts and several open cuts, now badly caved. Large blocks of mica are said to have been found.

GALESBURG MINE.

The mine of the Galesburg Mica Co. is across French Creek from the St. Louis mine, in a sharp spur that rises from the bottom land of the creek, 4½ miles S. 70° E. of Custer. The spur is a hogback formed by the outcrop of a ledge of hard pegmatite, which strikes

about N. 70° W., dips 45° N., and is more than 25 feet across. The hanging wall is biotite gneiss. The footwall and the full thickness of the pegmatite are not exposed. Next to the hanging wall is the "vein," the streak rich in mica, from 6 inches to 2 feet or more thick; next 10 to 15 feet of ordinary pegmatitic material; next a streak of massive quartz 6 to 10 feet thick; and then more pegmatite, containing rosettes of feldspar, in part at least albite. Black tourmaline occurs through the pegmatite, as usual.

PHILIP GEERING PROSPECT.

The Philip Geering prospect is $2\frac{3}{4}$ miles S. 25° W. of Custer, on the southwest side of a prominent outcrop of pegmatite, which is about 35 feet across and stands 25 feet above the level country around it. The country rock is mica gneiss and, with the inclosed pegmatite, strikes N. 25° W. and dips about 45° SW. An interesting feature at this prospect is the abundance of crystals of black tourmaline in the pegmatite. This occurrence of tourmaline-bearing pegmatite is shown in Plate XXVIII, *B*. These crystals range from 1 inch to 6 inches in diameter and compose nearly 50 per cent of the pegmatite in an area of 40 square feet. They apparently lie nearly normal to the wall of the pegmatite. Little mica was seen in the pegmatite, and it was not learned whether a good pocket had been encountered.

WYOMING LODE.

The Wyoming mica lode, owned by F. T. Peterson, is $5\frac{3}{4}$ miles S. 15° W. of Custer. Pegmatite or pegmatitic granite forms a large part of the country rock at this prospect. Little mica schist is exposed, but what was seen occurs in streaks in the pegmatite and has a north by west strike and a southwest dip. The mica was found in a pocket or streak at one place; the greater part of the pegmatite in the outcrop is rather fine grained and carries only small mica. The mica obtained from the prospect has a rich rum color. Pink orthoclase, some containing graphic intergrowths of quartz, is exposed in the pit in masses several feet across. Black tourmaline and some pale rose-colored quartz are also found.

TEXAS.

GENERAL FEATURES.

A glance at a geologic map of Texas shows two widely separated areas of pre-Cambrian rocks in which mica deposits might be found, one in Llano and Mason counties, in central Texas, and the other, which consists of two districts, in Culberson and El Paso counties, in western Texas. Prospects have been found in both areas.

CULBERSON COUNTY.

TEXAS MICA CO.'S MINE.

Outcrops of mica were discovered in the Van Horn Mountains, in Culberson County (formerly El Paso County), between 1890 and 1893, by Ben Kraus, of Pecos. The deposits lay idle until 1910, when they were located by the Texas Mica Co., of Pecos, which purchased two sections of land from the State. The prospects lie on the west side of the Van Horn Mountains, about 15 miles S. 20° W. of Van Horn. Van Horn is on the Texas & Pacific Railway, but the nearest railroad station is Dalberg, on the Southern Pacific line, about 9 miles northwest of the mine. The dirt road to Van Horn crosses the railroad about 6 miles north of the mine.

The mining developments are not extensive and at the time of the examination in 1913 consisted of two open cuts on the principal deposit and several smaller workings elsewhere. Trails and roads have been built from the camp to some of the prospects. A small grinding mill was erected for experimental work with some of the products mined. The mill is operated by an 18-horsepower gasoline engine, which also furnishes power for an air compressor and drill. The company has been interested in the development of two products, mica and micaceous rock suitable for giving a "micolithic" finish to cement and other structural material.

The Van Horn Mountains consist of a main range more than 15 miles long with a scarp on the east, broken plateaus and ridges in the middle, and a less prominent range on the west. This smaller western range trends west of north, diverging from the main mass of the mountains, and sinks into the surrounding basin or plains a few miles north of the mica deposits. These deposits occur in the rough hills formed by valleys and eroded surfaces of the west range of the mountains. Most of the hill slopes are steep, in places breaking into rocky cliffs. The elevations near the deposits range from about 4,200 feet above sea level at the camp to more than 5,000 feet at the north end of the property. The Van Horn Mountains are higher, reaching an elevation of 5,622 feet in the Van Horn Peaks, 2 miles east of the mica prospects.

The region is a typical desert and has the characteristic desert vegetation, including sagebrush and several species of cactus. Water for general camp use is caught during rains in a natural cistern or reservoir in a draw about 200 yards east of the camp. Drinking water is hauled from a well about 1½ miles west of the camp.

The mica deposits occur in an area of pre-Cambrian crystalline rocks, which are exposed by the erosion of overlying sedimentary formations. Most of the adjacent sedimentary rock is rather heavy

bedded gray limestone, cherty in places, including a little limy shale, and is probably of Carboniferous (Pennsylvanian) age. An area of such rock in about the proper position for correlation, in the south end of the Carrizo Mountains, 8 miles north of the mica prospects, has been mapped as the Hueco formation by G. B. Richardson.[87]

The crystalline rocks consist of quartz-mica gneisses and schists, biotite schist, hornblende schist, and pegmatite. The quartz-mica gneisses and schists are composed chiefly of quartz, muscovite, biotite, and feldspar in variable quantities. They range from fine to medium grained and from light to dark gray according to the proportion of biotite they contain. Some of the outcrops have been made red and reddish brown by iron oxide. The biotite schist is a black, strongly laminated rock composed of coarse lustrous scales of biotite and small quantities of quartz and feldspar. The hornblende schist is a medium-grained greenish-black foliated rock, in which hornblende is a prominent constituent. At one place it is highly garnetiferous and contains crystals of garnet as much as half an inch in diameter. The pegmatite is prevailingly reddish and exhibits many of the irregularities of texture common to that rock. In most of the outcrops it is composed chiefly of feldspar and quartz but carries small quantities of mica. At some places mica is abundant. Most of the feldspar is reddish orthoclase or microcline, which occurs in small grains mixed with quartz, with or without mica, in typical granite texture, as graphic granite, and at some places in crystals measuring more than 2 feet in thickness. The quartz occurs also in irregular gray to white masses or segregations ranging in thickness from 1 inch to 5 feet. These masses of quartz are apparently scattered at random through the pegmatite. Most of the mica in the pegmatite is muscovite. It ranges from small scales to crystals a foot across. The crystals of mica occupy no regular position in the rock and vary greatly in abundance in different bodies of pegmatite and in different parts of the same body.

The crystalline rocks outcrop in an irregular-shaped area about 2 miles long from north to south and a little more than half a mile wide. They have been complexly folded, as shown by the dip and strike marks in figure 88. These pre-Cambrian gneisses and schists have been cut by pegmatite both parallel to and across their schistosity. The pegmatite, however, does not cut the surrounding limestones, which overlie the crystalline rocks unconformably and dip away from the area on all sides at varying angles. The structure is that of an elongated dome from which the overlying sedimentary

[87] Notes on northern border of the Chispa quadrangle, made during areal mapping of the Van Horn quadrangle.

beds have been eroded, exposing the core of underlying crystalline rocks.

The mica of value as sheet mica and for grinding into pure products is found in pegmatite, which is abundant in the area of crystalline rocks and occurs in ledges and streaks ranging in width from a few inches to more than 100 feet. Sheet mica of promise has been found in only a few of these deposits. The principal working is on the east side of a draw about 150 yards from the camp. It consists of two open cuts in a steep hillside. The larger cut is about 65 feet long from north to south and 5 to 20 feet deep. The other opening, a crosscut trench, lies a few feet to the northwest and is about 35 feet long and 15 feet deep at its inner end. A view of the main open cut from the south is given in Plate IX, *B* (p. 62). The rocks around this cut are gneiss and pegmatite. The hills capped by sedimentary rocks are in the background. These workings are on a large pegmatite dike having a northerly strike. The west wall of the pegmatite is not exposed, but on the east there is a rather fine grained red gneiss, composed of quartz, feldspar, biotite, and muscovite. The pegmatite incloses horses or streaks of both hornblende and quartz-mica schists parallel with its own strike.

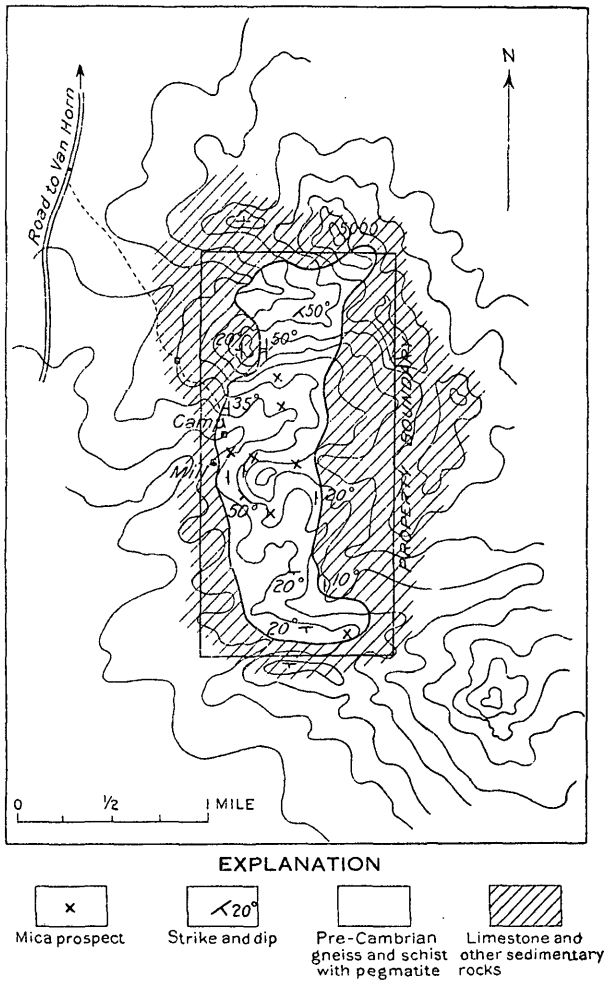


FIGURE 88.—Sketch of Texas Mica Co.'s claims, 15 miles southwest of Van Horn, Culberson County, Tex., showing topography and geology.

The mica was richest in an irregular streak developed by the largest open cut. Several crystals are commonly found near together, scattered through nearly barren pegmatite at intervals of a few feet. From 4 to 5 tons of mica were taken from this cut. Much of the mica is small, but some seen in the storage house would trim into sheets 4 by 6 inches. The better crystals are firm and split fairly well. Most of the sheet mica mined would be punched into washers and cut into small sheets. The mica has a greenish-brown color in sheets one-sixteenth of an inch thick. Most of it is slightly specked and some is rather strongly specked with magnetite. Some of the larger mica crystals seen had been badly crushed and ruled. Others were wedge shaped or showed A markings.

In two of the other prospects good sound mica in small crystals was observed. Only a little work had been done on these prospects.

At several places on the property the crystalline rocks have a composition which makes them useful, when ground and properly mixed with other ingredients, for giving a natural-rock finish ("micolithic" finish) to cement and other construction material. The special rock used in the different mixtures varies with the effect desired. Several kinds of the quartz-biotite-muscovite schist and gneiss have been ground for this purpose. A large body of coarse biotite schist supplies an abundance of black mica with which to vary the tone of the "micolithic" finish. This biotite schist occurs as a bed in contact with pegmatite. Several feet from the contact it is even-grained, finely laminated schist, composed largely of biotite in plates or scales as much as an eighth of an inch across. Within 3 feet of the pegmatite the biotite scales are coarse, ranging in diameter from a sixteenth to more than half an inch. They are bunched at all angles, and the rock shows little schistosity. This rock may be called massive biotite.

MASON COUNTY.

A little mica has been found in Mason County. The only valuable specimen seen was an irregular-shaped sheet measuring 3 by 5 inches, sent to the United States Geological Survey in 1914 by C. E. Lyman, of Minneapolis, Minn. This specimen came from the northwestern part of Mason County. It has a fine flat cleavage but is rather heavily specked with minute, thin brown to black flakes of magnetite between the laminae.

UTAH.

A little excitement was caused by the opening of a mica prospect near the head of City Creek, above Salt Lake City, Utah, in 1897.[88] Crystals 8 inches across were reported to have been found.

[88] Eng. and Min. Jour., vol. 64, p. 589, 1897.

VERMONT.

Mica deposits have been reported in Vermont, but the only deposit of which there is any record in the United States Geological Survey is that on the land of A. L. Stone, 2 miles north of Chester, Windsor County.

VIRGINIA.

GENERAL FEATURES.

Mica mining began in Virginia about the same time as in North Carolina. T. L. Watson[89] states that the mines near Hewlett, Hanover County, were the first ones operated. Work was started there in 1867 and was continued for four years. The next work was probably done in Amelia County, where, according to Watson, the Jefferson mine was opened in 1873. The Berry, Pinchbeck, Rutherfoord, and Winston mines, near Amelia, and the Schlegal mine, near Jetersville, were started soon afterward.

The Virginia mica mines, like those of other States, have been operated intermittently, a few having been worked at four or five times. Some of the mines have been equipped with good machinery and plants for the preparation of the mica, but many of them are without these advantages. Trimming houses have been erected at some of the mines, and a few mica-grinding mills have also been added to the equipment. These small mills have been destroyed or have been idle most of the time, and the bulk of the scrap mica from the Virginia mines is treated by the Richmond Mica Co.

Mica deposits have also been worked in Amherst, Bedford, Charlotte, Franklin, Goochland, Henry, Pittsylvania, and Prince Edward counties. Indications of mica are reported by Watson also in Buckingham, Caroline, Cumberland, Powhatan, and Spottsylvania counties. The deposits described below were briefly visited by the writer at different times between 1912 and 1915, and the descriptions given show the conditions found at the time of the examination.

The mica deposits of Virginia lie in the counties within the Piedmont Plateau, southeast of the Blue Ridge. Parts of the region are strongly dissected by river valleys and contain monadnocks and residual hills or small mountains. The relief in the eastern counties, from Hanover to Charlotte, which are in typical Piedmont country, is comparatively slight, but the relief between valley and residual hill in some of the more western counties in which mica has been found, such as Bedford and Franklin is so great that the region appears almost mountainous.

The rocks in the different mica regions consist of pre-Cambrian gneisses and schists of many varieties. The Amelia-Goochland-Han-

[89] Mineral production of Virginia in 1908: Virginia Geol. Survey Bull. 1–A, p. 104, 1909.

over county belt is in an area mapped as "granite, granite gneiss, with schists, often intruded with pegmatites, etc.," by T. L. Watson.[90] Deep weathering of the rocks in this belt makes it difficult to distinguish the underlying type of rock, but mica and garnet gneiss and schist were observed rather plentifully around the mica deposits. Watson maps the rocks in part of Prince Edward, Charlotte, Pittsylvania, Henry, and Franklin counties as "crystalline schists and gneiss." These rocks are the northeasterly extension of the Carolina gneiss and Roan gneiss of Keith, in North Carolina. The mica-bearing pegmatites occur principally in the gneisses and schists in the Amelia-Hanover county belt, but a few may be associated with the granite gneiss. In the western belt the deposits occur in both mica and garnet gneisses and in hornblende gneisses.

The occurrence of the pegmatite in the Virginia mica mines presents few unusual features outside of the mineral associations in some deposits. Feldspar for pottery and agricultural use and mica are quarried together at some mines, the one as a by-product in mining the other. At a few places gem and specimen minerals have been found in more or less abundance with the mica, the deposit at Amelia yielding amazon stone, blue chatoyant oligoclase, albite, spessartite, and rare-earth minerals.

AMELIA COUNTY.

RUTHERFOORD MINE.

The A. H. Rutherfoord mine is 1¼ miles north of Amelia Courthouse. It has been almost as famous for the gem and specimen minerals it has yielded as for its mica. The output of mica was rather large during the early days of working, but about 1908, during the last operations for gem minerals by the American Gem & Pearl Co., the output was small. Descriptions of the mine and its minerals have been given by W. H. Fontaine,[91] T. L. Watson,[92] E. S. Bastin,[93] and D. B. Sterrett.[94] Fontaine mentions evidences of early work by Indians or others here and at other mica mines of this region. The mica vein is reported to have been removed to a depth of 10 feet on the outcrop and the rubbish to have been thrown back or washed into the workings.

The deposit was mined at two points about 90 yards apart on a line running southwestward. The opening to the northeast, which

[90] A geological map of Virginia, Virginia Geol. Survey, 1911.

[91] Notes on the occurrence of certain minerals in Amelia County, Va.: Am. Jour. Sci., 3d ser., vol. 25, pp. 330–339, 1883.

[92] Mineral resources of Virginia, Virginia Jamestown Exposition Comm., pp. 282, 385–392, 1907.

[93] Quartz and feldspar: U. S. Geol. Survey Mineral Resources, 1910, pt. 2, pp. 971–973, 1911.

[94] Gems and precious stones: U. S. Geol. Survey Mineral Resources, 1912, pt. 2, pp. 1045–1048, 1913.

Fontaine called No. 1, is on a low hill; the other opening, called No. 2, is in a bottom close to a branch. At the time of Fontaine's examination in 1883, or earlier, there was a shaft, less than 80 feet deep, at each place. In August, 1912, opening No. 1 consisted of a pit about 75 feet long in an easterly direction and 40 feet wide and a shaft east of the pit. The pit was formed by the caving in of old shafts and tunnels. The shaft was made by the American Gem & Pearl Co., of New York, and is reported to be 90 feet deep. A 40-foot drift is run from it at the 55-foot level. At opening No. 2 there is a pond about 50 feet wide and 150 feet long from east to west, showing the surface area of the old work. It is reported that the deepest work here was a shaft sunk 150 feet.

The exposures of "vein" and country rock around the "vein" are very poor. The country rock is biotite schist and gneiss containing considerable feldspar. An exposure of a slightly garnetiferous phase of this gneiss on the hillside between the two openings showed a strike of N. 55° W. and a dip of 20° NE. The extension of the workings indicates nearly parallel "veins" striking about east. Fontaine believes openings Nos. 1 and 2 were on the same deposit but calls attention to the difference in the mineral associations. The impression gained by the present writer is that the two deposits are not connected, at least not near the surface.

The "veins" are pegmatite of somewhat unusual composition and texture for the southern Appalachian region. The normal minerals of pegmatite are present, but they occur in great variety and are associated with minerals that are of interest as gems or specimens. Quartz occurs both in irregular masses and in crystals, the largest weighing 8 or 10 pounds. The ordinary quartz is glassy and opaque gray and the crystals are semitransparent to clear white, colorless, or smoky brown. The mica is muscovite of fine quality, which in sheets a millimeter or more thick has a clear light-brownish color. Large quantities of fine stove mica were obtained, and sheets measuring 22 by 24 inches are reported to have been cut from some of the crystals.

The specimen and gem minerals obtained here have already been described,[95] but they will be briefly mentioned because of their unusual interest. The variety of feldspars is unusually great for a single deposit of pegmatite. Potash feldspar occurs chiefly as grayish-white, bluish-green, and green microcline. Some specimens of this mineral are slightly translucent and the colors are bright, qualities which adapt it to use as a gem. The other feldspars are albite

[95] Gems and precious stones: U. S. Geol. Survey Mineral Resources, 1912, pt. 2, pp. 1045–1048, 1913.

and oligoclase. The albite occurs in clusters of white to colorless tabular crystals, the largest half an inch thick and 3 inches long. Masses of these clusters were 18 inches thick. The oligoclase is the sodic variety of feldspar. It occurs in rough crystals, some of which have perfect cleavage and measure several inches across. On certain faces some of the crystals exhibit a beautiful pearly blue chatoyancy. Crystals of this variety make fine specimens, and some of them are suitable for gems. Transparent reddish-brown spessartite garnets that cut into beautiful gem hyacinth were also found. Some of the spessartite crystals are reported to have measured 3 inches in diameter.

Among other minerals found were crystals of smoky and colorless quartz, large crystals of beryl, the chlorophane variety of fluorite, remarkable for the strength of its phosphorescence, fine crystals of monazite and microlite, columbite, allanite, orthite, helvite, apatite, galena, stibnite, zircon, and pyrochlore.

The presence of these various gem and specimen minerals should be taken into consideration in making plans for mining, for they could be made to pay part of the cost of the work and might prove to be the most profitable part of the output.

JEFFERSON OR CHAMPION MINES.

The Jefferson mines are about 2½ miles N. 20° E. of Amelia Courthouse, along the west side of the public road. They were the first mica mines opened in the Amelia region and have a good reputation among the early miners as large producers, especially the old Champion mines Nos. 1 and 2. The Jefferson mines have been worked by different persons under lease, and the last work was done by J. Boyd Bland, of Richmond, in 1913 and 1914. Most of the work was done at three places, all within 75 yards of the road. Champion mine No. 1 is in the middle, No. 2 is 350 yards to the southeast, and the third mine is about one-third of a mile to the northwest. The mines were visited briefly in 1912 and again in August, 1914. In 1912 all the mines were idle and in 1914 Champion mine No. 1 had just been closed down and prospecting was in progress at the working No. 2. No work has been done at the northern working for several years.

At the time of the first visit to Champion mine No. 1 there was a pit about 40 feet long, 20 feet wide, and 10 feet deep where old workings had caved in, and large dumps were spread over the nearly flat ground around them. The dumps had been pretty thoroughly worked over for small sheet and scrap mica that had been thrown away during earlier mining. The later work done by Mr. Bland consisted of a shaft more than 130 feet deep, and irregular stopes and tunnels where rich streaks of mica were found. The shaft was 80 feet deep

vertically and 50 feet deeper to water, on an incline of about 50° west by south. Work had been abandoned a few days prior to the examination, and the shaft was filling with water. The approximate positions of the stopes with respect to the shaft and incline are shown in plan and cross section in figure 89. The stopes are so irregular that they would be termed "ground-hog workings" in some mining regions, but they served to remove all pay rock with the least labor. The mine equipment consisted of a 75-horsepower boiler, an engine hoist, a head frame, a track, and a mine car.

The country rock is biotite gneiss, apparently granitic, which strikes northwest and dips southwest at a high angle. The pegmatite appears to be a short, thick lenticular chimney or shoot that extends to a depth of more than 130 feet. It has been opened for not more than 50 feet north and south and its thickness is 25 to 30 feet. It consists of various mixtures of feldspar, quartz, and mica. It contains both potash feldspar (orthoclase or microcline) and soda feldspar (albite). The orthoclase incloses some small scales of mica along the cleavage planes. Some of the albite occurs in tabular crystals as much as one-eighth of an inch thick and 2 to 3 inches across, intergrown at different angles. The interstices are filled with finer-grained feldspathic material containing small crystals of black tourmaline. Quartz occurs in large opaque masses and crystals and smaller smoky-gray, and colorless translucent to clear masses and crystals. The mica is not regularly distributed through the pegmatite, but occurs in pockets and streaks, some of which were very rich. Mr. Bland removed about 200,000 pounds, from which 15,000 pounds of sheet mica was trimmed, the rest going for punch and scrap. Mr. Bland states that some sheets 12 inches wide could be cut from the larger crystals. The mica has a clear brown color and splits with a smooth, flat cleavage. The sheet mica is suitable for stove windows.

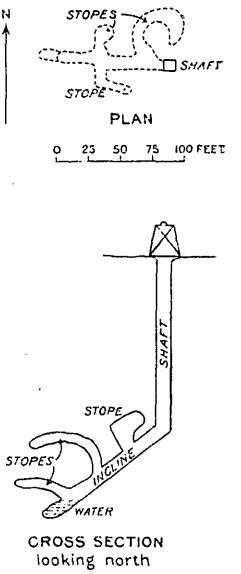


FIGURE 89. — Plan and section of Champion mine No. 1 of Jefferson mines, 2½ miles N. 20° E. of Amelia, Amelia County, Va.

At mine No. 2 the old workings consisted of a shaft about 60 feet deep, 200 to 300 feet of drifts and stopes, and several prospect pits. The old workings have caved badly or have been filled with muck and mud and could not be examined. New work by Mr. Bland consisted of two shafts about 60 feet deep and 60 feet apart on a line running from northeast to southwest, and tunnels driven from

them, as shown in figure 90. One tunnel was driven from the northeast shaft to the old shaft and abandoned because of caving ground. Another tunnel was cut between the two new shafts around the east side of the old shaft. This cut into old workings that had been partly filled with washes of muck and mud. An old tunnel to the east, now filled, is reported to have been driven 200 feet. The surface arrangement is shown in Plate XXIX, *A* (p. 301). The southwest shaft is in the foreground and the northeast shaft is beyond the engine shelter.

The country rock is somewhat granitic biotite gneiss having a northwest strike and southeast dip. The pegmatite cuts the bedding of the gneiss, but the exposures were not plentiful enough to permit a determination of its strike and dip. Apparently it is elongated eastward, but it is at least 60 feet thick and probably as much as 75 feet thick from north to south. It contains horses of gneiss. The formations are thoroughly decomposed to the depth of the lowest workings, 60 feet. The pegmatite varies in grain, part of it being rather fine, almost like coarse granite, and part very coarse, containing masses of white quartz several feet thick. The mica occurs in streaks and is segregated around the masses of quartz. Two streaks of mica were encountered. One of these, found in the earlier workings, was reported to be rich; the other, near the north shaft, was rich in places, but most of the mica was in small crystals. Much of the pegmatite is nearly barren of mica. The best mica obtained during the last work yielded sheets 4 by 6 inches and of the same good quality as that from mine No. 1.

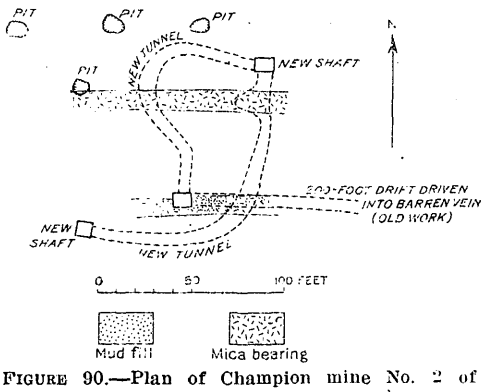


FIGURE 90.—Plan of Champion mine No. 2 of Jefferson mica mines, 2¼ miles N. 20° E. of Amelia, Amelia County, Va.

Future work would have to be directed toward deeper mining, probably 75 feet and lower, to avoid the danger of caving and to cut the richer mica streak at a lower level.

At the north working an open cut 30 feet wide and 20 feet deep extends eastward 60 feet. The formations are soft and the walls have caved in, partly filling portions of the pit. The country rock is decomposed gneiss, probably garnetiferous granite gneiss. The pegmatite evidently occurs in a large lenticular mass, probably 50 to 60 feet long and 25 feet thick, for no exposures have been left in the north, south, or west walls, and a streak only about 18 inches

thick is exposed in the east end of the cut. Colorless to translucent and clear smoky quartz had been thrown on the dumps, and some small crystals and weathered sheets of mica had been left mixed with the waste.

MINES OF VIRGINIA MICA PRODUCING & MANUFACTURING CO.

Several deposits have been opened by the Virginia Mica Producing & Manufacturing Co. (formerly the Virginia Mica & Mining Co.) on the old Pinchbeck property, 3 miles N. 17° E. of Amelia Courthouse. These deposits were idle at the time of the first visit, in August, 1914, but one of them was being worked when visited in June, 1915. There were two principal mines; the others were only prospects. The first large deposit worked is on the east side of a plantation road and will be called mine No. 1. The second is on the west side of the road about 350 feet southwest of it and will be called mine No. 2. The position of these workings is shown in figure 91.

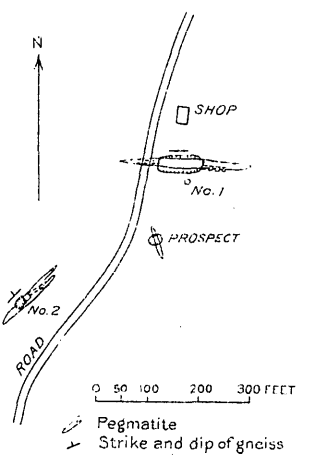


FIGURE 91. — Sketch showing position of workings at mines of Virginia Mica Producing & Manufacturing Co., 3 miles N. 17° E. of Amelia, Amelia County, Va.

Work on mine No. 1 had been stopped prior to August, 1914, and at the time of visit the last of the sheet mica from it was being split and trimmed. The workings consist of an open cut 30 feet wide and 25 to 35 feet deep, which extends eastward for 80 feet and inclines to the east and west, and of a shaft 35 feet deep, run from the bottom of the cut. The equipment for this work consisted of a boiler, a hoisting engine, a derrick, incline tracks, a car, and a steam pump.

The country rock is decomposed mica gneiss, which strikes variably between east and northeast and dips high to the north and northwest. The pegmatite cuts the gneiss with an easterly strike and an almost vertical dip. It has a maximum thickness of about 20 feet and has been followed in the workings for about 150 feet. It is 5 feet thick at the east end of the open cut and 10 feet thick at the west end. Large masses of quartz were encountered and had to be removed in mining. Some of it was shipped. Mica was obtained in fairly large quantity, but it contained a large proportion of rough crystals good only for scrap. Some clear sheets measuring 8 by 10 inches, suitable for stove windows, were cut from the best crystals, but most of the sheet mica cut was much smaller. The mica has a clear light apple-green color where it is free from stains produced by weathering, but much of it is stained yellowish by limonite washed into the cleavages.

Mine No. 2 was in operation in June, 1915. There was a small open cut, a shaft 45 feet deep on the northeast side of the cut, and a 25-foot drift run N. 60° E. from the 40-foot level. The country rock is much folded biotite gneiss having a general northeast strike and northwest dip. The pegmatite also strikes northeast. The tunnel cuts slantwise across the pegmatite, which forks at the northeast end. The pegmatite is 3 to 10 feet thick and has been decomposed to a depth of nearly 40 feet, below which weathering has affected it but little and the potash feldspar is fresh. The pegmatite exposed in the workings is rich in crystals of mica, some of which are more than 18 inches across. Much of the mica is the A variety, or ruled, and some is rather badly stained with limonite from surface weathering. The staining is not so bad as that in the mica from mine No. 1, but the color and quality are otherwise similar.

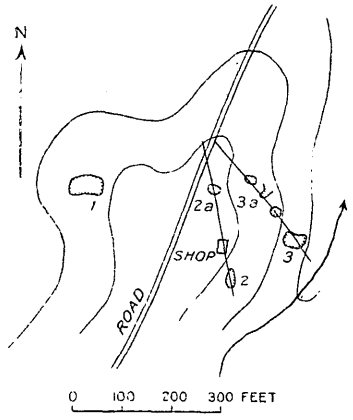


FIGURE 92.—Sketch showing position of workings at Pinchbeck mica-feldspar mines, 3 miles northeast of Amelia, Amelia County, Va. See text for explanation of numbers.

The company has a shop and trimming house near mine No. 1 and has experimented with a locally made wet grinding machine. At the time of visit this had not been perfected.

PINCHBECK MINES.

Several mines have been worked on the Pinchbeck property, about 3 miles northeast of Amelia Courthouse. Most of the workings lie within an area of about 600 by 300 feet, as shown in figure 92.

At least three veins were opened, one in the large open cut at 1, another in the cut at 2, and a third in the large open cut at 3. It is possible that the vein at 2 continues northwest to the pit at 2a, and the vein at 3 probably strikes into the workings at 3a. E. S. Bastin [96] describes the deposit at 1, and some of the following notes are taken from his description. The open cut at 1 is nearly 100 feet long east and west, 60 feet wide, and 15 to 18 feet deep to water. The depth of water in the bottom was not determined but is probably at least 10 feet. A hoisting frame and platform had been built over the pit on the north side. The country rock is partly weathered dark mica schist and gneiss, containing muscovite and biotite. It has been much folded and crumpled but has prevailing

[96] Quartz and feldspar: U. S. Geol. Survey Mineral Resources, 1910, pt. 2, p. 972, 1911.

northeast strike and northwest dip. The body of pegmatite is about 35 feet thick at the west end of the cut and one prong of it at the east end is 20 feet thick. Smaller streaks fork out into the gneiss near the southeast corner of the cut. The minerals are segregated into rather large masses. Quartz and feldspar occur in nearly pure masses 3 to 4 feet thick. The feldspar is the light cream colored potash variety. Some of the quartz is clear and glassy and has rough crystal form. A micaceous streak 8 to 12 feet thick lies along the north side of the pegmatite. Most of the mica in this streak is small and of poor quality, but some good sheet material has been obtained.

At 2 a small body of pegmatite 2 to 6 feet thick was opened in a cut 30 feet long and 20 feet deep. The schist and gneiss here strike N. 50° W. and dip vertically, and the pegmatite cuts them with a similar strike and southwest dip. At 2a part of a pegmatite is exposed in a shaft. The mica schist on the northeast wall of the pegmatite here strikes northwest and dips vertically.

At 3 there is a large open cut, which is filled with water to a point within 10 feet of the surface. No exposures of pegmatite were seen. The shafts and open cuts at 3a expose a promising-looking deposit of pegmatite, in which quartz and feldspar are segregated into masses 2 to 3 feet thick. Good mica also occurs in this vein and some was removed in mining.

Much of the sheet mica from the different workings has a clear rum color and smooth cleavage and is suitable for stove windows. Some of it contains imperfections, such as tangle-sheet structure, rulings, and clay stains. As the mining extends deeper the clay staining will probably disappear. Feldspar has been shipped from the larger workings of the Pinchbeck mines for use in making pottery.

PATTERSON MINE.

The Patterson mine is a little more than 2 miles N. 20° E. of Amelia Courthouse. It is an old mine in the bottom of a small valley and consists of an open cut 50 feet wide, which extends 80 feet eastward and is filled with water. It is evidently deep, and one shaft is reported to have been sunk to a depth of 90 feet. Large dumps have been piled northeast and southwest of the cut. A small open cut has been driven from the south side of the main cut into the hillside and exposes the only rock now visible in the workings. In this exposure the country rock is biotite gneiss, which strikes N. 15° E. and dips east at a high angle. Only a small bed of pegmatite was opened in this cut. Potash feldspar, albite, mica, a little garnet, and allanite were observed on the dumps. Only small crystals of mica were left in the dumps, but they are clear brownish-

colored crystals that have a smooth cleavage and are of a good grade. The mine is reported to have been a good producer.

PROSPECTS OF INTERNATIONAL MICA CO.

The International Mica Co., represented by L. J. Bussey and J. A. Crabtree, of Philadelphia, tested two prospects during 1915. One of these is about 125 yards northeast of the Patterson mine, just described (see fig. 93, A, or a little more than 2 miles N. 20° E. of Amelia Courthouse. The other prospect was opened after the writer's visit in June, 1915, near the workings of the Virginia Mica Producing & Manufacturing Co. The prospect near the Patterson mine was opened several years ago at the side of a small branch and is reported to have found good mica. The last work consists of a shaft 40 feet deep about 20 feet northwest of the old work.

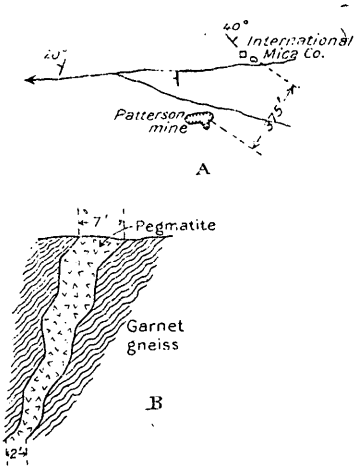


FIGURE 93.—Mines of the International Mica Co., 2 miles N. 20° E. of Amelia, Amelia County, Va. A, Sketch showing location of deposit and Patterson mine; B, ideal cross section of pegmatite in shaft of International Mica Co.

The country rock is garnetiferous biotite gneiss in which the garnets are of a rose-pink color and have an average diameter of 2 millimeters. The gneiss has a northwest strike and a variable dip, approximating 40° NE. The pegmatite has a northwest strike and a dip averaging about 65° NE. It is conformable with the gneiss for a few feet and then cuts across its bedding by offsets through the next few feet. (See fig. 93, B.) The pegmatite presents no unusual features in its composition. Only small mica was seen, but some of good size is reported to have been found. The mica has a clear brown color and splits with a smooth flat cleavage. The International Mica Co. closed its prospects toward the end of 1915.

MARSHALL MINES.

Several deposits have been opened on the H. O. Marshall property, $1\frac{3}{4}$ to 2 miles N. 25°–30° W. of Amelia Courthouse. One of these is just northwest of the public road and railroad. It was worked by two large pits or medium-sized open cuts, extending N. 60° W. The pits are about 18 feet deep to water. The country rock is weathered biotite gneiss. A quantity of massive quartz and small mica was thrown on the dumps and masses of quartz and mica "capping" crop out near the pits. Little could be learned of the output of mica from these openings.

Another deposit was opened 250 yards north of the one on the railroad and a third is about 250 yards west of north of the second. Small plates of mica of good quality were left on the dumps. Other deposits lie about a third of a mile west of north of the one on the railroad. Little could be seen of the formations in them and only small crystals of mica had been left on the dumps. These prospects are reported to have yielded small quantities of valuable mica.

BERRY MINE.

The old Berry mine, now owned by Mr. Richeson, is 1¼ miles N. 35° E. of Amelia Courthouse, on the southeast side of the Southern Railway track. At the time it was visited, in August, 1912, there was a pit 35 feet across and 15 feet deep to water, with a cribbed shaft 12 feet square in the bottom. This pit has since been filled up and leveled off for farm cultivation. The country rock in the vicinity is decomposed biotite gneiss, which has slight dips in various directions and shows gentle folding. The pegmatite appears to have an east to an east by south strike. The exposures were poor and the character of the pegmatite had to be learned from material in the dump. The dump contained a little unweathered orthoclase, numerous fragments of bluish-green microcline or amazon stone, most of them partly weathered, and small crystals of mica. One small crystal of columbite was found. A block of brown and yellow stained chalcedonic quartz, 15 inches thick, had been left on the dump. It contained crystal-lined cavities but was suitable for cutting into a semiprecious stone. The mica is clear and is of light-brown color. About 100 yards north of this deposit three other pits were opened for mica. These had been filled up and little could be seen of the formations.

KEYSTONE MICA CO. MINE.

The Keystone Mica Co. mine is 4⅔ miles N. 80° W. of Amelia Courthouse and 4½ miles N. 25° W. of Jetersville. It was worked first in 1907 and again in 1914, after a period of idleness. The work consists of a shaft 40 feet deep with a small open cut. A shaft house and engine house have been erected over the workings. The shaft is filled with water to a point within 18 feet of the surface.

The country rock is schistose diorite, which strikes N. 15° W. and dips vertically. Two bodies of pegmatite have been worked, one 6 to 8 feet thick and about conformable with the inclosing gneiss, and the other 3 feet thick, probably a branch of the main "vein," but not worked at the point of branching. Both pegmatites are reported to carry mica in good quantity, but the larger one yielded the largest crystals. The mica is clear and has a rather dark greenish-brown

color. It splits smoothly and yields sheets suitable for the glazing trade. Mr. F. W. Corson, of Jetersville, the manager, states that the crystals are sound and clean as mined and yield about 40 per cent of sheet mica suitable for punching and trimming.

SCHLEGEL OR NORFLEET MINE.

The old Schlegel mine, now belonging to Mrs. K. P. Norfleet, is 1 mile N. 70° W. of Jetersville. The mine was opened between 1880 and 1885 and the last work was done about 1900. The workings consist of an open cut 18 feet deep and 60 feet long, run northwestward, and two shafts. It is reported that one of these shafts is about 100 feet deep and has drifts and stopes run from it, but both were filled with water at the time of the examination, in August, 1912. The dumps are large and show considerable work. A mill for grinding feldspar was erected at the mine at the time of the last operations.

The country rock is chiefly highly schistose diorite, in which some schistose granite is interbedded. At the mine these formations strike N. 15° W. and have a vertical or high east dip. The pegmatite is large in the main part of the mine but pinches to about 10 feet thick in the northwest end of the open cut. It cuts the bedding of the inclosing rocks. Fragments of fresh pinkish-gray potash feldspar were seen on the dumps. The mica is clear but is darker in color than most of that found in Amelia County.

Other outcrops of pegmatite occur in the Norfleet property, one of which has been traced more than a quarter of a mile northward. The outcrops are 10 to 30 feet wide and contain large crystals of feldspar, segregations of quartz, and bunches of "mica capping" or crystals of A and wedge mica mixed with quartz or feldspar.

BEDFORD COUNTY.

AMERICAN ASBESTOS CO.'S MINE.

Mica was mined several years ago by the American Asbestos Co. on property now owned by Frank Mosher and associates, 9 miles east by south of Bedford City, Bedford County. The deposit was worked by an open cut 40 feet long, and 20 feet in greatest depth, and a shaft, now filled with water, reported to be 30 feet deep, in the end of the cut. The open cut was driven northwestward into a hillside about 30 feet above a creek. A hoist was arranged over the shaft, and a tram extends from it to the shop and storehouse, about 40 feet to the northwest. The position of the workings and shop is shown in figure 94.

The country rock is hornblende schist or schistose diorite, badly weathered to a reddish-brown earth. The pegmatite is approximately conformable with the inclosing schist, striking N. 30° E.

and having a nearly vertical dip. Where exposed in the open cut it is nearly 20 feet thick. The east half is highly feldspathic and the west half contains more quartz and is richer in mica. The quartz occurs in irregular masses and in small sheets or lenses parallel with the walls of the pegmatite. A horse or sheet of hornblende schist 1 foot thick is also included in the pegmatite. Opaque reddish garnets are abundant, and some flattened garnet crystals are inclosed between the sheets of mica. Much of the mica has the A structure but would yield good sheets from the part between the A lines. Crystals of mica 8 or 10 inches across were seen in the shop, where several tons of rough mica is stored.

The mine could have been worked to better advantage from a lower level on the hillside about 75 feet to the southwest, as indicated

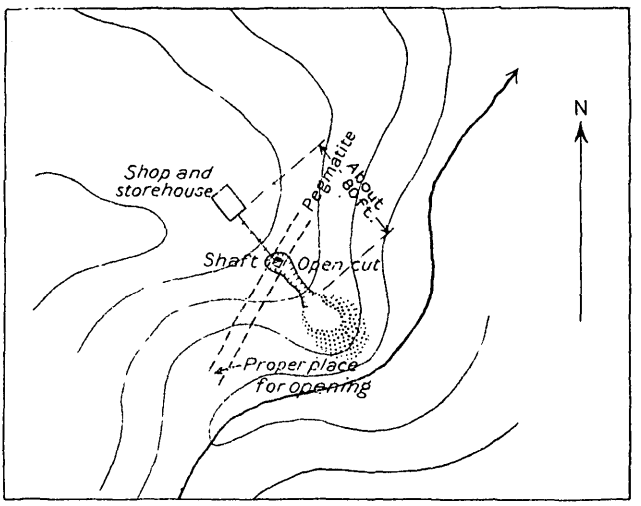


FIGURE 94.—Plan of the mica mine of the American Asbestos Co., 9 miles east-southeast of Bedford City, Bedford County, Va.

in figure 94. A crosscut prospect trench would have located the pegmatite at this point, if continuous as indicated in the figure, and mining could have been carried on by open work or drift with stopes to the northeast.

FRANKLIN COUNTY.

CHESTNUT MOUNTAIN MINES.

Mica has been mined and prospected at several places in the Chestnut Mountain region, about 12 miles southeast of Rocky Mount, Franklin County. The principal work was done by the Chestnut Mountain Mica Co., on the east side of the mountain, and consisted of an open cut 50 feet long and 5 to 12 feet deep along a steep hillside on the outcrop and a shaft connecting with drifts and a crosscut tunnel about 20 feet lower at the foot of the hill.

The country rock is mica and kyanite schist and gneiss. The strike of the inclosing schist as measured varied from N. 40° E. to N. 70° E. and the dip from 40° to 60° SE. The pegmatite cuts the country rock with a strike ranging from N. 80° W. to nearly west and a variable dip of about 60° N. The pegmatite ranges in thickness from 2 feet in the east end of the cut to more than 8 feet in the west end. The feldspar content has been strongly kaolinized, and the inclosing schist has been badly decomposed. Mica seemed to be rather plentiful but consisted chiefly of small and ruled crystals, so that the yield of sheet mica would not be large. Under favorable conditions of transportation it might pay to work the mine for scrap mica alone. A rotary screen had been set up to dry-clean the scrap mica from dirt and would not need much improvement to meet ordinary requirements. Several tons of scrap mica could be cleaned up from waste now lying around the mine.

A small open cut had been made about 200 feet west of the mine and about 50 feet higher up the hill. It may be on the same body of pegmatite as the lower working, but the pegmatite at this place contains more quartz and a quantity of "mica capping," or quartz mixed with small mica crystals. The property was examined in 1913. Since that time more work has been done and some large mica is reported to have been found in openings to the southwest on the hill.

About a quarter of a mile north of the mine a 15-foot shaft or pit had been sunk on a pegmatite near the main road to Rocky Mount. The pegmatite exposed in this opening was 10 feet thick. It was badly decomposed and the inclosed mica had been strongly broken and ruled into small sheets. A mica crystal 18 inches across was seen, but it was so badly crushed that only small sheets could be cut from it. Plates nearly a foot in diameter are reported to have been found. The mica is rather plentiful, but most of it is in part "specked." Large black tourmaline crystals were found in the pegmatite.

About 1½ miles northwest of the main mine there is an old prospect for mica consisting of a shaft about 20 feet deep. The country rock here is mica schist, which strikes N. 35° E. and dips 70° SE. The pegmatite is approximately conformable with the inclosing rock and is about 2½ feet thick near the surface. Hard blocks of mica capping 2 feet thick had been removed from the shaft. Only small crystals of mica about 2 inches across were left on the dump. The pegmatite contains black tourmaline and opaque red garnets.

GOOCHLAND COUNTY.

IRWIN MINE.

The old Irwin mica mine, now owned by Mr. Fink, is 2½ miles N. 45° W. of Maidens or 2 miles N. 60° W. of Goochland. It had been idle

for about 15 years prior to the time of the examination, in September, 1912. The workings consist of a pit or open cut 25 feet across and 20 feet deep and a shaft, reported to be 50 feet deep, in the bottom.

The country rock is biotite gneiss, into which are injected streaks and lenses of pegmatite. The mica-bearing pegmatite is only 2 feet thick where it is exposed in the side of the pit but was apparently much thicker where worked. This tendency to lenticular development is shown by the small bodies of pegmatite inclosed in the gneiss near the mine. The " vein " strikes north of east, dips north, and incloses streaks of gneiss. Only small crystals of mica were seen on the dumps, but these had a clear light rum color. The mine is reported to have yielded a good quantity of marketable sheet mica.

REED MINE.

The mine of Mrs. E. P. Reed is $1\frac{3}{4}$ miles N. 20° W. of Maidens. No work had been done for 12 or 15 years prior to the time of examination, in September, 1916. The workings consist of an open cut 75 feet long, 25 feet wide, and 20 feet deep, run southeastward, and some shaft work now caved in. Little could be seen of the formations. Small plates left on the dump show that mica of good quality, having a clear light rum color and flat cleavage, was obtained.

HANOVER COUNTY.

C. W. SAUNDERS MINES.

Several prospects and mines have been opened on land now owned by C. W. Saunders, 2 or 3 miles south of Hewlett. According to T. L. Watson,[97] this property was worked first from 1867 to 1870 by Barr, Johnson & Co., of Erie, Pa., and produced more than 60,000 pounds of trimmed stove mica. A little more work was done in 1883 and more in 1907. Four workings were visited in August, 1914, Mr. S. A. Butler, of Hewlett, acting as guide. These were called mines Nos. 1, 2, 3, and 4. Mines Nos. 1 and 2 are close to each other, No. 1 being near the south bank of Little River.

Mine No. 1 was worked by an open cut 60 feet long, run northeastward, which was 35 feet deep at its southeast or deepest end. Mr. Butler states that this cut now contains 15 to 20 feet of rubbish. The large dumps built out on the river bank show that much vein matter was removed. The country rock consists of interbedded garnet gneiss and granite gneiss.

Mine No. 2 is about 100 feet southeast of No. 1, on the east side of a small valley that drains into Little River. It was opened by a long trenchlike cut that extends nearly 100 feet southwestward into

[97] Mineral production of Virginia in 1908: Virginia Geol. Survey Bull. 1–A, p. 104, 1909.

the end of a ridge. The northeast half is about 30 feet deep but at the time of examination was half filled with water, and the southwest half is about 10 feet deep. A track and car were used to carry the waste rock to the main dump in the flat ground across the branch.

The country rock is garnet gneiss, which strikes N. 30° E. and has a variable northwest to rolling, nearly flat dip. The pegmatite cuts across the gneiss with a strike of N. 70° E. and a vertical dip and is about 10 feet thick where the deep work was done and 2 feet thick in the southwest end of the cut. Both the garnet gneiss wall rock and the pegmatite are fresh and hard. The pegmatite contains translucent to clear quartz, potash feldspar, some of which has a moonstone-like chatoyancy, and a few garnets. Rough crystals of feldspar 8 to 10 inches thick and a few blocks of graphic intergrowths of feldspar and mica were seen on the dump. The mica is of good quality, has a smooth, flat cleavage, is of rather dark or smoky rum color, and splits into clear light-colored sheets suitable for stove windows.

Mine No. 3 is about three-quarters of a mile south of Nos. 1 and 2, in the northeast side of a spring branch. It was worked by an open cut 100 feet long driven east into the hillside. The cut is 18 feet deep to water at the inner end, but the depth below water could not be learned. The workings are overgrown by vegetation and show great age. The dumps are large, and the mine is reputed to have been a good producer.

Mine No. 4 is about half a mile west of south of Nos. 1 and 2. It was opened by a cut 70 feet long, which extended eastward across the summit of a small ridge, but the work was not carried deep, and the results are said to have been indifferent. The rock formations have weathered down to a reddish-brown clay soil, such as would be produced by the decomposition of garnet gneiss. Large blocks of white quartz had been thrown on the dumps.

Mr. Saunders has some pale-green microcline (amazon stone) which is said to have come from these mines, but was probably brought from the Rutherfoord mine, near Amelia Courthouse, when Mr. Henry Mackay moved machinery and mine supplies from Amelia County in 1907. No specimens of amazon stone were observed on the dumps or around the mines.

HENRY COUNTY.

GENERAL FEATURES.

Mica has been mined and prospected for at several places near Ridgeway, in Henry County. Attention was drawn to the deposits some years ago by Capt. McCray, of Ridgeway, who opened many of them and interested some persons from Pittsburgh, Pa., by whom

most of the mining has been done. The writer visited the region around Ridgeway early in the autumn of 1913, when the descriptions given below were prepared.

Ridgeway is in a rather strongly dissected part of the Piedmont Plateau. Some of the hills have moderate slopes, but in places the valleys have steep walls. The elevation at a United States Geological Survey bench mark near the Norfolk & Western Railway station is 834 feet above sea level. Some of the ridges in the vicinity, such as that on which the town of Ridgeway is situated, rise at least 100 feet higher.

The country rock along the mica belt in the region is chiefly diorite, more or less schistose and in places cut by fine aplitic granite and pegmatite. Streaks of mica schist and garnet schist and a belt of soapstone are inclosed in the diorite country rock near the belt of mica. The strike of the formations is in general northeast, ranging from N. 20° E. to N. 60° E. The dip of the bedding is generally high to the west or nearly vertical, but a few exceptions were noted.

RIDGEWAY MICA CO.'S MINE.

The Ridgeway Mica Co., of Ridgeway, is an outgrowth of the former Pittsburgh Mica Co. The new company was formed by P. Lippert, of Pittsburgh, Pa., and associates after a period of idleness that followed rather extensive operations by the Pittsburgh Mica Co. The Ridgeway Mica Co. owns a large area of land around Ridgeway on which both mica and feldspar have been mined or prospected for. In 1913 the principal mine, about a quarter of a mile northwest of the railway station, was operated for mica, and prospecting was carried on at some of the other deposits.

The mine has been worked by open cuts, shafts, and stopes for about 160 feet in a line running N. 25° E. to a depth of about 120 feet, as shown in the generalized sections in figure 95. The workings are irregular in shape, corresponding to irregularities in the vein. Mining has been carried on from different openings, beginning with the cut at the north end and working southward and deeper to the present shaft and down stope from its bottom. Large stopes have been made, which elbow out in places where there were bulges in the vein.

The country rock is schistose diorite, which strikes about N. 25° E. and dips west at a high angle. The dip and strike vary locally, especially around the irregularities of the pegmatite. In places the wall rock has been metamorphosed to quartz-biotite schist by contact with the pegmatite. The pegmatite as a whole is approximately conformable with the inclosing schistose diorite. It does not all lie between two plane parallel walls, but elbows out to the west by a

series of bulges, so that the average dip is about 75° W. Notes on the pegmatite at the different places numbered in figure 95 are given below:

1. Pegmatite 6 feet thick; contains fine mica, some in crystals weighing several hundred pounds.
2. Pegmatite 4 feet thick, becoming thicker above; contains good mica.
3. Pegmatite 1 foot thick.
4. Pegmatite 30 feet thick; yielded much mica.

5 and 6. Bulges in pegmatite. Schist roof over 5.

7. Pegmatite 30 feet thick, pinching to 4 feet at 8.

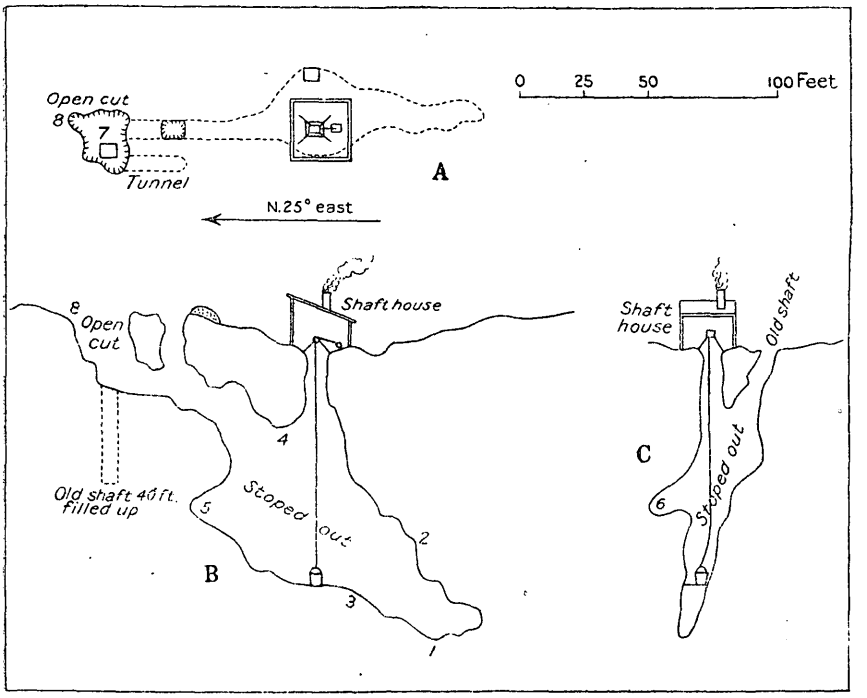


FIGURE 95.—Plan and sections of Ridgeway Mica Co.'s mine at Ridgeway, Henry County, Va. A, Plan; B, longitudinal section looking S. 65° E.; C, cross section looking N. 25° E. See text for explanation of numbers.

Mining has revealed a pay shoot of mica pitching about 35°–40° S. 25° W. in the body of the pegmatite. On the surface the pegmatite was traced about 250 feet S. 25° W. by prospect pits in which a little mica was found. Two pits 15 feet deep, about 400 feet south of the mine, opened mica-bearing pegmatite, but it is possible that these were not on the same vein.

The pegmatite consists of a fairly even mixture of feldspar, quartz, and mica. The feldspar is white albite and rarely occurs in crystals more than a foot thick. The quartz is the light smoky-gray variety and occurs chiefly in irregular masses, few of which

are more than 2 feet thick. The largest crystals of mica are more than 2 feet in diameter, but many of them have the A structure strongly developed. A part of a mica crystal measuring 18 by 20 inches and weighing about 42 pounds was presented to the United States National Museum by the Ridgeway Mica Co. This specimen has the A structure strongly developed on one side but has perfect cleavage over the full width of the crystal on the other side. Such a crystal would yield good sheet mica between the A lines. Crystals that would yield plates 12 by 20 inches were obtained during the summer of 1913. The mica has a light-smoky or brownish-green color and is classed as No. 1.

At the time of the visit 10 men were employed at the mine, 5 below ground and 5 above, including two expert mica trimmers from Mitchell County, N. C. The interior of the trimming house is shown in Plate XXIX, *B* (p. 301). The clear flat sheets of mica on the bench come from the same crystals as the A mica, being split by the cutter in the foreground. The equipment includes a storage and trimming house, a boiler house, an engine and shaft house, a hoisting engine with bucket hoist, a steam drill, and a mine car. The Pittsburgh Mica Co. had a grinding mill near the site of the present trimming house, but this mill was burned down several years ago, and the scrap mica is now shipped to mills in other places.

Another mica deposit was worked by the Pittsburgh Mica Co. about 250 feet S. 25° E. of the main mine. The workings were fairly large but are now rather inaccessible. The body of pegmatite was at least 30 feet thick in one part and was approximately conformable with the schistose diorite country rock. The feldspar of the pegmatite was considerably decomposed. The country rock was metamorphosed to biotite schist along the contact with the pegmatite. This mine is reported to have yielded good mica.

Several other mica prospects and mines have been opened on both sides of the road along the ridge northeast of the principal mine, on land belonging to the company. Most of these were discovered by Captain McCray. The deposits will be described in the order of their location northeastward from the main mine.

Good mica was found in some pits a few hundred yards north of the mine on the west side of the ridge.

Across the road and about 100 yards north of east of the mine two test pits had been made for feldspar in a semidecomposed pegmatite. Fairly fresh potash feldspar had been found at a depth of several feet. About 600 yards northeast another opening had been made for feldspar on semidecomposed pegmatite.

Two-thirds of a mile northeast of the mine a pit had been opened on mica-bearing pegmatite southeast of the road. Only small crystals of mica had been left around the prospect, and the sheets had a greenish cast. About 200 yards north of this prospect, on the northwest side of the road, a shaft had been sunk 27 feet on a promising vein, and good mica is reported to have been found. About 60 feet southwest a mass of pegmatite, inclosing a 2-foot vein of quartz, crops out in a plantation road. Mica in sheets as much as 4 inches across occurs in the decomposed feldspar along the southeast side of the streak of quartz.

About 1 mile northeast of the main mine and 100 yards northwest of the road a trenchlike open cut runs for 60 feet N. 60° E., and a 25-foot shaft had been made on a body of mica-bearing pegmatite. This work was done by Captain McCray several years ago and is said to have yielded about $1,500 worth of mica. The pegmatite body is 6 feet thick in the end of the cut and is inclosed in schistose diorite. The feldspar of this pegmatite is chiefly albite. About a quarter of a mile to the northeast, 150 yards northwest of the road, Captain McCray sank another shaft about 30 feet deep on a promising deposit of mica.

About a quarter of a mile southeast of the prospect last mentioned, or 1¼ miles northeast of the main mine, several shafts with short drifts had been made. These shafts were from 18 to 30 feet deep and cut decomposed pegmatite in schistose diorite. Some small crystals of mica having fine, smooth cleavage were found. This mica is somewhat specked and part of it may be classed as No. 2 stove and part as good electric mica.

Captain McCray has opened several other prospects in this region, in some of which he reports fairly promising mica veins.

The Ridgeway Mica Co. owns a feldspar quarry, from which several carloads of feldspar have been shipped, and other mica prospects on the same property about 2 miles south of Ridgeway.

KNIGHT PROSPECT.

Several mica prospects, none more than 12 feet deep, have been opened on land now owned by H. A. Knight, 250 yards east of the railway station. These prospects are several years old. They fall within an area about 150 feet long measured N. 25° E. and 100 feet wide. The country rock is diorite cut by aplite and inclosing several bodies of pegmatite. In the last prospect opened the pegmatite was 12 feet thick at the surface and 6 feet thick at a depth of 7 feet. The southeast wall of the pegmatite strikes N. 25° E. and has a vertical dip, and the northwest wall dips about 45° SE. Rough crystals of clear mica 6 or 8 inches across were found during prospecting.

HENRY AND PITTSYLVANIA COUNTIES.

GENERAL FEATURES.

Mica has been prospected and mined on a small scale at several places in the vicinity of Axton, Va., near the border of Henry and Pittsylvania counties. This region forms a part of the dissected Piedmont Plateau of Virginia and is similar in aspect to the Ridgeway country, already described. The elevations range from 700 feet above sea level in the valleys to more than 900 feet on the ridges.

The country rock of the Axton region consists of mica and garnet schist and gneiss and included beds of hornblende schist, all cut by granite and pegmatite. The strikes of the schists and gneisses measured were chiefly between north and N. 30° E., but wide variations from these directions were noted. The dips are diverse.

TURNER MINE.

The C. S. Turner mine is on the summit of a hill about one-third of a mile N. 70° E. of Axton. It has been opened for about 100 yards N. 25° E. by several shafts and pits and by a trench at the southwest end. One shaft is reported to have been 40 feet deep. The pits ranged in depth from a few feet to 15 feet. The country rock is decomposed mica schist, cut by granite. The schist has an average strike of about N. 25° E. and a high dip to the east. The pegmatite occurs in overlapping lenslike masses, which are nearly conformable with the inclosing schist. Most of the mica is clear and rather dark green in sheets more than a sixteenth of an inch thick. Some of it is a little specked. A quantity of wedge and A mica crystals are obtained along with the good mica. Mr. Turner states that about 10,000 pounds of mica was removed from the trench and yielded about 500 pounds of sheet mica and 9,500 pounds of scrap. The largest mica would have cut into sheets measuring 6 by 8 inches, but was sold for $2.50 a pound in the rough.

HARSTON MINE.

The David W. Harston mine is about 3½ miles north of Axton, near the foot of a hill having a slope of about 15° WSW. The workings consist of a shaft about 20 feet deep, a tunnel extending 35 feet irregularly N. 60° E. from the shaft, and two small tunnels or gouges each about 6 feet across on the north and south sides of the shaft at about the same level as the main tunnel. A prospect pit had also been made about 30 feet north of the shaft. The position of the workings is shown in figure 96.

The country rock is mica schist cut by granite and pegmatite, partly decomposed to the depth of the workings. The schist near the mine strikes N. 60° E. and dips 35° SE. The body of pegmatite

is very irregular in shape. The workings expose a mass of about 15 feet thick in the bottom of the shaft with two branches forking out from it, one about parallel with the schistosity of the inclosing rock and the other cutting across it. These relations are shown in the cross section in figure 96. One arm of the pegmatite was opened by the prospect pit and the other was followed down by the shaft. Mica occurs in irregular-shaped bunches or pockets in the pegmatite, ranging from a few inches to more than 3 feet across, but a few crystals are scattered through the mass of the rock. Mica was rather plentiful in the 2-foot streak of pegmatite exposed in the shaft. The largest output was obtained from the tunnel. The minerals associated with the mica are partly decomposed potash feldspar, gray smoky quartz, and a little black tourmaline. One crystal of beryl 2 inches in diameter was observed on the dump.

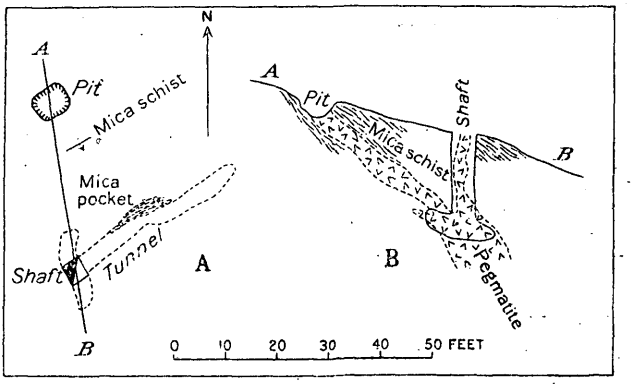


FIGURE 96.—Plan and section of Harston mica mine, 3½ miles north of Axton, Henry County, Va. A, Plan; B, cross section showing workings and geology.

It is reported that about 11,000 pounds of mica was shipped from this mine, from which possibly 2,000 pounds of sheet mica could have been obtained. The largest crystal weighed several hundred pounds. The mica is brownish green and rather heavily specked. Some of the crystals have been badly cracked and would yield only small plates, but others have a good smooth cleavage in large sheets.

About 250 feet S. 70° W. of the mine a mass of decomposed pegmatite 25 feet wide crops out in a road. Sheets of mica 3 inches in diameter were split from crystals found loose in the soil here. About 150 yards S. 80° W. a quantity of small sheet mica was plowed up in the light sandy soil of a cultivated field.

WILLIS MINE.

A mica deposit has been prospected on the land of L. C. Willis, 3 miles north of Axton, by an 18-foot shaft, a short tunnel, and three pits in a northeast direction. The workings fall within an area 75 feet long and 20 feet wide. The country rock is mica and garnet schist. The pegmatite contains potash feldspar, which is partly de-

composed; also a large streak of white quartz ranging in thickness from 2 feet in the shaft to about 6 feet a hundred feet to the southwest.

Only small mica was seen around the prospect, but larger and better material is said to have been carried away. Some of the small pieces examined have good cleavage, but larger rough sheets several inches across were less perfect. The mica has a dark-green color in thick sheets and some is a little specked. A specimen of sharply folded or crumpled mica was found at this prospect.

HOLLAND MINE.

Mica was mined or prospected at two places on the land of D. S. Holland, 2 miles north of Axton. Only one of these was examined. The workings consisted of a small open cut and a shaft 20 feet deep, filled with water. The country rock is schistose diorite and interbedded mica schist. The pegmatite is irregular in composition and grades into granitic pegmatite or coarse granite. Only small mica was seen at the mine, but about 2,000 pounds of better quality has been stored away. This mica is clear but rather dark green in thick sheets. Rectangular plates measuring 4 by 5 inches were seen at Mr. Holland's house.

PITTSYLVANIA COUNTY.

GEORGE EASLY MINE.

A mica deposit was worked on the land of George Easly, 5 miles south by west of Chatham, first between 1900 and 1905 and again about 1910. The workings consist of a shaft about 40 feet deep and two open cuts connected with each other and with the shaft by a 60-foot tunnel and other underground work. When visited the mine openings were badly in need of repair.

The country rock is garnetiferous mica schist and gneiss, much folded and crinkled around the mica workings. The schist and gneiss have a general northeast to north by east strike and a variable southeasterly dip in the neighboring region. The body of pegmatite is approximately conformable with the main bedding of the inclosing rock, having an east of north strike and a southeast dip, but it cuts some of the smaller features of the structure. The pegmatite is not fully exposed, but it is more than 8 feet thick. It is about a normal granitic pegmatite, but contains no large segregations of massive quartz. The feldspar has partly kaolinized. Mica occurs in bunches of small wedge and A crystals or "capping" and in flat crystals of fair size with good cleavage. Partly clay-stained sheets of mica, 8 inches in diameter, with slight A structure, were seen

around the workings. Three or four tons of scrap and mica suitable for small sheets and punching were left on the dumps and in an old shop at the mine. The mica has a clear, light apple-green color and good, smooth cleavage, but part of it is slightly specked.

WASHINGTON.

A mica deposit was discovered in 1897,[98] near Chelan Falls, Wash., but it was not successfully developed. Recently a deposit of micaceous material has been developed near Leavenworth, Chelan County, by the North American Ore Co. This is apparently a disintegrated mica schist and has been used chiefly in foundries for facing work.

WYOMING.

GENERAL FEATURES.

Mica has been found in at least two places in Wyoming, and other regions of pre-Cambrian rocks favorable to its occurrence are known. Prospects have been opened in the Hartville uplift, 3 to 5 miles northeast of Ironton, in Laramie County, and in the Medicine Bow Range, in Albany County. Other areas of pre-Cambrian rocks occur in the Front Range, in the Big Horn Mountains, in the Wind River Range, and near the northeast and the southwest corners of Yellowstone National Park. F. W. Clarke[99] mentions the occurrence of mica in the Wind River country.

ALBANY COUNTY.

In 1911 a mica prospect was opened by L. Learn in the Medicine Bow National Forest about 12 miles west of Fox Park, a station on the Colorado & Southern Railway, in Albany County. It is about 8,000 feet above sea-level. A quantity of mica was removed from a pit about 12 feet deep, sunk on a well-defined ledge of pegmatite. A sample of the mica sent to the Geological Survey was of fair quality.

A photograph was published by G. H. Lewis[100] showing a quantity of mica piled around a prospect in Albany County. This mica was obtained from a 20-foot shaft in a vein 9 to 20 feet thick. No name or location is given on the photograph, but the prospect is probably in the region mentioned above, and may be the same prospect.

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[98] Colles, G. W., Mica and the mica industry: Franklin Inst. Jour., p. 48, 1906.
[99] U. S. Geol. Survey Mineral Resources, 1883 and 1884, pp. 906–912, 1885.
[100] Min. and Eng. World, vol. 36, p. 289, 1912.

LARAMIE COUNTY.

The deposits in Laramie County were examined in 1906 by Sydney H. Ball,[101] whose description is given below. They are in the rugged hills of the Hartville uplift, among which Haystack Peak is the most prominent and consist of pegmatite cutting the pre-Cambrian schists. These schists, which form the uppermost member of the older sedimentary series are closely folded and intensely metamorphosed near the granite of the Haystack Hills. The mica-bearing area lies east of Whalen Canyon and west of Cottonwood Canyon, and its north and south boundaries are respectively McCanns Pass and an east-west line passing through Haystack Peak. The possibly productive area includes all or parts of secs. 25, 26, 27, 34, 35, and 36, T. 28 N., R. 65 W., and secs. 1, 2, and 3, T. 27 N., R. 65 W.

The first mica claim, named the Savage, was located by Joseph L. Stein in 1881. Other prospects were soon taken up, and work has been done on some of them to the present day, but with an unimportant exception no muscovite has been shipped. At present four prospects appear promising.

Muscovite in commercial quantities is confined to dikes of pegmatite, which cut the schists. These dikes were intruded after the schist became fissile and in consequence trend in the main parallel to the schistosity, although in places they cut across it. The dikes vary from thin stringers to irregular intrusive masses a quarter of a mile wide. In many places their width is constant, but here and there it chaanges markedly within a short distance. The pegmatite is composed of the following minerals, named in the order of their abundance: Feldspar (orthoclase, microcline, and albite), quartz, muscovite (white mica), black tourmaline, beryl, brown garnet, and biotite. It is in general coarsely granular, the mineral bodies ranging in diameter from a quarter of an inch or less to 2 feet or more. Such extreme variations are rarely seen in a single dike, although considerable changes in the sizes of grains take place within comparatively short distances. The distribution of the minerals in the pegmatite is, as a rule, fairly even, although locally muscovite in particular occurs in bunches of books. Liquids and gases originating from the pegmatitic magma have considerably metamorphosed bands of schist on either side of the dikes.

The principal mica prospects of the Hartville uplift are the Crystal Palace, the Savage, the New York, and the Minnie.

The Crystal Palace claim, owned by Lauck & Stein, is on the south side of a steep valley in the center of the NE. ¼ sec. 34, T. 28 N., R. 65 W. An open cut 60 feet long has been made on a pegmatite

[101] Mica in the Hartville uplift, Wyo.: U. S. Geol Survey Bull. 315, pp. 423–425, 1907.

dike 6 feet wide at its floor and from 15 to 18 feet wide at its top. At the southwest end of the cut the pegmatite is covered by talus, but it is exposed for a long distance along its strike, which is N. 60° E. It is a coarsely crystalline aggregate of feldspar, white quartz, muscovite, tourmaline, brown garnet, and a little beryl. The black tourmaline is not prominent and is largely confined to the edges. Quartz was the last mineral of the pegmatite to solidify, and a portion of it was still held in solution by the magmatic waters after the pegmatite had consolidated, as it also occurs in indistinct veins which cut the pegmatite. The distribution of the muscovite is bunchy, and in consequence an estimation of the quantity of muscovite in the walls of the open cut is difficult, although it probably forms from 10 to 15 per cent of the pegmatite. The muscovite tends to form hexagonal plates, some of which are 2 feet across and 3 or 4 inches thick. It is a good-grade "water" mica, although rulings are common, and in some of it plates of feldspar and quartz lie between the mica leaves. To the northeast across the gulch the pegmatite contains a greater proportion of tourmaline and beryl, and though muscovite is equally abundant, the plates are much smaller. At present there is 2 or 3 tons of mica on the dump. Some of this is high-grade material which could be used for sheets.

The Savage claim, also the property of Lauck & Stein, is near the center of the S. ½ sec. 26, T. 28 N., R. 65 W. An open cut is here located on a pegmatite dike 10 feet wide, which courses N. 65° E. About 200 feet farther southwest the dike either pinches out or plunges beneath the surface, and to the northeast it becomes narrower and the muscovite plates become smaller. The composition of this pegmatite is similar to that at the Crystal Palace claim, although bluish-green beryl is more abundant. In many places thin distorted crystals of tourmaline lie between the muscovite leaves. Muscovite in plates, some of them 12 inches in diameter, forms 10 to 15 per cent of the pegmatite. From this prospect sheets of mica 11 by 13 inches and free from flaws have been obtained.

The New York claim is in the northeast corner of sec. 25, T. 28 N., R. 65 W., and is owned by Mr. Frederick. At the open cut the pegmatite dike is from 6 to 10 feet wide; it narrows to 5 feet 350 feet to the west, but widens to 50 feet 500 feet farther west. The pegmatite varies considerably in the size of its constituent minerals. Muscovite occurs in plates as much as 20 inches in diameter, although the largest plates are commonly ruled. The larger flawless plates are from 6 to 8 inches in diameter.

The Minnie claim, southwest of the center of sec. 35, T. 28 N., R. 65 W., is also owned by Mr. Frederick. The largest sheets obtainable on this claim are 8 inches in diameter.

Plates of mica 10 inches across were seen in a pegmatite dike in the north center of sec. 35, T. 28 N., R. 65 W. This dike is characterized by beryl crystals 4 feet long. Plates of muscovite 8 inches in diameter occur in a pegmatite dike in the center of the SE. ¼ sec. 35.

The pegmatite dikes in which large sheets of mica occur range in width from 5 to 18 feet and carry from 10 to 15 per cent of muscovite. It is probable that at least in the four prospects described, muscovite is present in commercial quantities. There is a marked variation in the width of the dikes along both the strike and the dip, and the size of the mica plates is by no means uniform in different portions of the same dike. The mica is clear and of good quality, although varying quantities of it are ruled, and feldspar, quartz, and tourmaline occur between the leaves of some of the books.

Mica mines in the Western States are operated at a considerable disadvantage on account of the high freight rates to the eastern market, which also prohibit the utilization of feldspar and quartz, common by-products of mica mines, in the manufacture of pottery. These Wyoming prospects would furnish a considerable percentage of sheet mica for the glazing trade. Smaller plates could be used in making composite sheets of mica called mica board or micanite, and the waste mica could be shipped for grinding. The Crystal Palace and Savage claims can readily be reached by road, and the mica can be hauled to Ironton, Wyo., on the Chicago, Burlington & Quincy Railroad, for $1.25 a ton. The cost of transportation from the New York and Minnie claims would be somewhat greater. It is probable that under careful management mica of excellent quality could be produced in the Haystack Hills at a small profit.

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