MISCELLANEOUS NONMETALLIC PRODUCTS.

MICA DEPOSITS OF NORTH CAROLINA.

By DOUGLAS B. STERRETT.

INTRODUCTION.

The extensive commercial applications of mica have placed it among the important mineral products of the world. In value of production mica does not rank high as compared with certain other mineral products, though its properties render it indispensable in several important industries. The world's supply of mica is drawn chiefly from India, Canada, and the United States, with smaller amounts from Ceylon, southwest Africa, and Brazil. In the United States mica deposits have been found in about 20 States. The most important producers among these have been North Carolina, South Dakota, New Hampshire, Virginia, Colorado, New Mexico, Alabama, Georgia, and Idaho. For many years North Carolina has led in both quantity and value of output and during some years has furnished over half of the total production. The value of the mica production of the United States during 1908 was $267,925, and of this amount North Carolina is credited with $127,870. The value of the mica production in North Carolina during 1907 was $225,206, the total for the United States being $392,111.

Mica is used in various industries, such as the manufacture of electrical machinery, stoves, certain forms of lamp chimneys, fireproof materials, wall papers, lubricants, etc. The perfect insulating qualities of mica and the adaptability of its sheets to various forms of manufacture render it unsurpassed for use in electrical apparatus. By fitting together and cementing with shellac many small thin sheets, mica is built up into large sheets of "micanite" or "mica board," suitable for many forms of electrical insulation. The transparency, flexibility, and resistance to heat of mica are qualities that make it particularly suitable for use in stove windows and lamp chimneys. When ground, mica is used to impart a silvery luster to wall paper and for other decorative effects. Ground mica is also mixed with oils and grease for lubricating purposes. When mixed with shellac, ground mica is used in various types of electrical insulators under the term "molded mica."

The information for the present paper has been obtained at various times during the last five years in the course of work for both the United States Geological Survey and the North Carolina Geological Survey. The greater part of the mine descriptions were obtained during 1905, 1906, and 1907 and represent typical deposits in all those counties in which mica mines have been examined by the writer. A large number of other descriptions have been prepared also, which it is hoped will be used in a later report by the State Survey. The brief notes on the general geology of the region and on the mica deposits are largely taken from an earlier paper,[a] in which the occurrence of mica-bearing pegmatites and their origin were treated, rather than commercial mines.

A number of the mica deposits of North Carolina were opened in prehistoric times by aborigines. Some of these operations have been described in the early days of mica mining by white people, and several of the deposits where such work was done are described below. The present period of mica mining was begun in 1867 by L. E. Persons, of Philadelphia, previously of Vermont. Mr. Persons's attention was directed to Jackson County by someone in Philadelphia who had seen a crystal of mica exhibited at the state fair in Columbia in 1858 by D. D. Davies, of Webster. In the fall 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.[b] Shortly after this the mica industry began in Yancey and Mitchell counties with the opening of the Silvers mine by Thomas L. Clingman.

CHARACTERISTICS OF MICA.

Of the numerous varieties of mica there are but four that have commercial value. These are muscovite, phlogopite, biotite, and lepidolite. Muscovite and phlogopite have a wide application in both sheet and ground form. Biotite has only recently been used in the ground form. Lepidolite is used as a source of lithia salts and to a small extent for ornamental purposes. Muscovite is the only mica that has been mined extensively in North Carolina, and it is only within two years that a small demand has arisen for biotite for grinding.

Muscovite, like all the other micas, belongs to the monoclinic system of crystallization and has a symmetry approximating the hexagonal.

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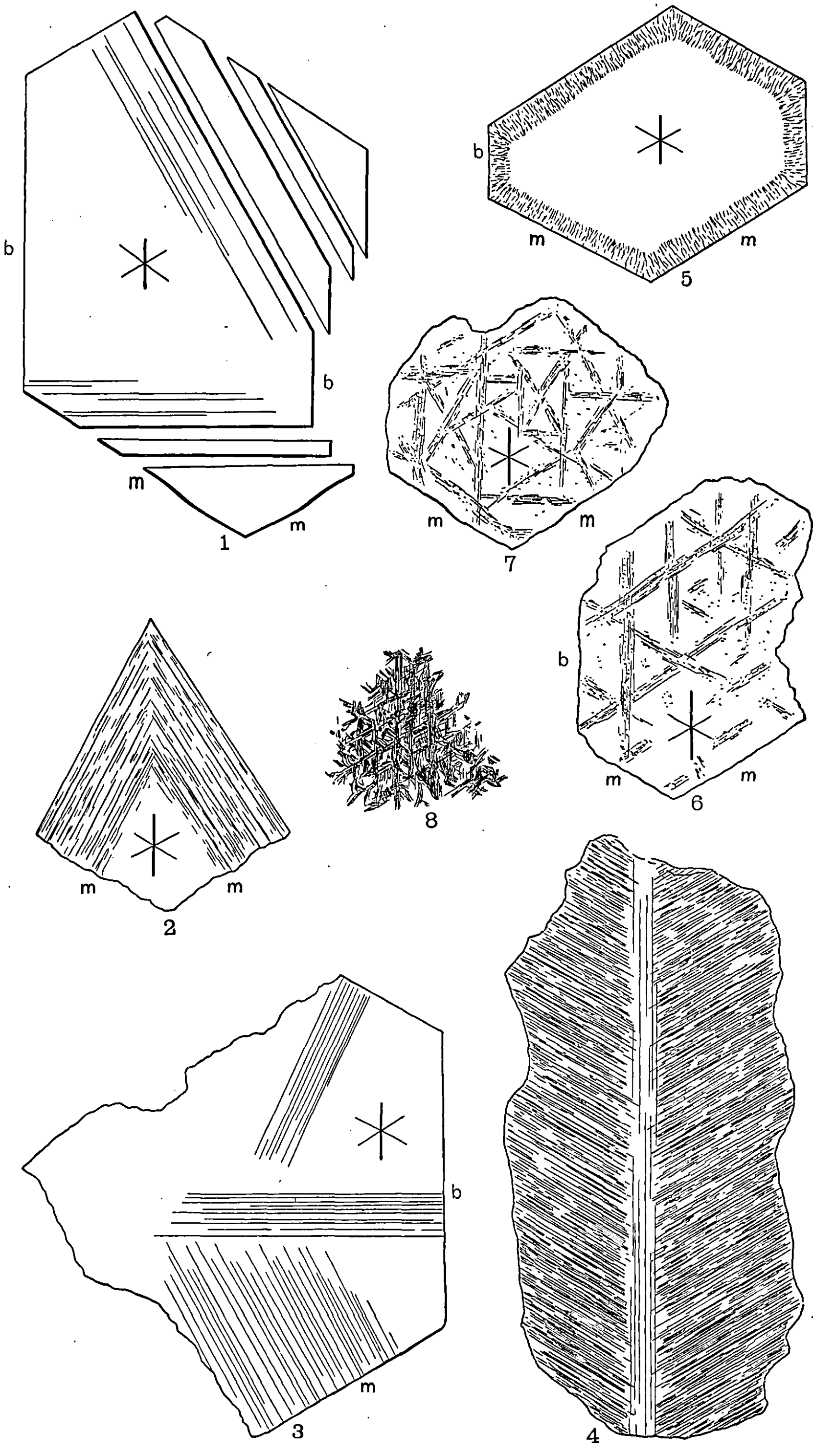
[a] Mica deposits of western North Carolina: Bull. U. S. Geol. Survey No. 315, 1907, pp. 400–422.

[b] This information was furnished by Judge D. D. Davies and Mrs. John L. Richardson, daughter of L. E. Persons, in a certified statement dated March 22, 1907.



SPECIMENS OF MICA OF VARIOUS STRUCTURE.

This symmetry is indicated by the nearly hexagonal outline often observed in the prisms, by the percussion and pressure figures, and by "ruled" and "A" mica, as described below.

Mica mined for commercial purposes is generally found in rough blocks, sometimes with an irregular development of 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. Very commonly a large part, if not all, of a block of mica has a ragged outline without plane surfaces. Occasionally fairly well developed hexagonal or rhombic prisms are observed in crystals of mica weighing hundreds of pounds.

Rough crystals, or "books" of mica, 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. This is accomplished by rough splitting or cleaving the large book into sheets one-eighth inch thick or less and trimming the edges with a knife held at a small angle with the cleavage. Further splitting is then easy, because the cleavage of mica is so perfect and the tangled outside edges of the sheets have been removed. By grinding a wedge edge on the sheets and using a thin, sharp knife mica can be readily split into sheets as thin as one one-thousandth of an inch or thinner.

A percussion figure is formed by three cracks or cleavages in a plate of mica crossing at a common point and making angles of approximately 60° with one another, commonly described as a six-rayed star. It may be produced by striking a sheet of mica a sharp blow with a pointed punch or thrusting the punch through the sheet. The same thing is produced occasionally on a large scale in a mine by a miner unintentionally striking the cleavage face of a block of mica with a pick. One of the rays, sometimes noticeably more prominent than the other two, corresponds in direction with the front axis of a mica crystal. The other two rays are parallel to the prism faces, *m*. (See Pl. XIV, 1 to 7.)

A pressure figure is very similar in appearance to the percussion figure, but oriented with its rays at angles of about 30° with those of the percussion figure. The pressure figure is seldom obtained with the same symmetrical, perfect development as the percussion figure and is often very difficult to obtain. By pressing with a punch against a sheet of mica one or more rays of the pressure figure may be produced, and if the punch is then thrust through the sheet a percussion figure will also be formed and the two may be seen with their approximate 30° relation to each other.

Mica has a number of physical peculiarities which give rise to different trade names and descriptive terms used by the miners. These are due to crystal structure, color, and inclusions. Structural peculiarities give "ruled" or "ribbon," "wedge," "A," "hair-lined," "fish-bone" or "herringbone," and "tangle-sheet" mica. Trade names for different colors of mica are "rum," "ruby," "amber," "white," and "black." Brown, green, and greenish-brown colors also occur in mica. Certain inclusions give "specked" and "clay-stained" mica.

"Ruled" or "ribbon" mica is formed by more or less clean, sharp parting planes cutting through the mica crystals and making an angle of a little more than 66° with the base or cleavage surface. This parting passes entirely through some crystals and in others extends only part way across the face or does not cut through the entire thickness. (See Pl. XIV, 1.) 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 about 30° 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.

"Ruling" lines occur more commonly in one series of parallel lines in mica. In some specimens these parting planes are present in two or even three directions, and their traces on the cleavage planes make angles of about 60° with one another, dividing the mica sheets up into small triangular plates. The value of large blocks or crystals of mica, otherwise of excellent quality, is sometimes rendered small or practically nothing by the presence of many "ruled" lines.

In "wedge" mica the crystals are thicker on one side than on the other. The difference in thickness on opposite edges may be greater than half an inch in some crystals 3 inches in diameter. This structure is due to an unequal development in the width of the laminæ. Some of the laminæ extend across the entire width of the crystal, but others do not, and generally they are not matched by similar laminæ extending from the opposite edge. In this way a greater thickness is developed on one side of a mica crystal than on the other. It is not uncommon for wedge-shaped sheets of quartz to be included between the laminæ of such crystals. The "wedge" structure is often associated with the "A" and "fish-bone" structure.

In "A" mica there are two series of lines or striations crossing the sheets at angles of about 60° with each other, whence the term "A." (See Pl. XIV, 2 and 3.) In some pieces these striations are caused by "wedge" structure developed in the mica crystals, with or without the presence of detached swordblade-like strips of mica replacing the sheets that have "wedged" out. In other specimens the striations are caused by small folds or crenulations in the sheets of mica. The "A" striations have the same orientation in the mica sheets as the "ruling" lines; that is, their position corresponds to the rays of the percussion figure. "Ruling" is sometimes present in "A" mica. Where the striations are caused by small folds the mica sometimes splits across them and the sheets have a commercial value, though not as high as perfect plates. Where the striations are due to the "wedging" out of sheets, only plates from between the "A" lines can be used commercially and the value of large crystals is thus materially affected.

In the "fish-bone" 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 along a center line or spine. This gives a structure resembling the skeleton of a fish, as shown in Plate XIV, 4. The "fish-bone" structure is probably caused by a twinning of two crystals of "A" mica, so that one set of striations in each fall together and the other two sets are inclined toward each other and meet at the twinning line. Mica with the "fish-bone" structure has no commercial value as sheet mica, but is used for scrap for grinding.

In "tangle-sheet" mica (a name little used) the laminæ split well over a portion of their extent but tear when split in other parts. This is due, in some places, to the failure of certain laminæ to form perfect sheets and the intergrowth of portions of one sheet with that lying next to it. Such imperfections sometimes extend through half an inch or more of the thickness of a crystal of mica. In this way an apparently sound crystal of mica is rendered of little value or worthless for sheet purposes.

The color words descriptive of mica are self-explanatory, except the "white" and "black" mica of commerce. In speaking of the color of mica the miners or dealers ordinarily consider the color of sheets a sixteenth of an inch or more in thickness. Such colors as "rum," "ruby," "green," etc., observed in the thicker sheets of mica, practically disappear when the mica is split into thin sheets for trade purposes. The mica is then called "white" mica to distinguish it from phlogopite or "amber" mica. By "black" mica is generally meant muscovite "specked" with magnetite, as described below, but in some cases 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 the glazing trade. Dark-brown and brownish-green mica has to be split much thinner than "rum" mica to gain the desired transparency and is therefore generally classed as "No. 2," even when flawless and clear.

Some muscovite shows color variations arranged in accordance with the crystal structure. These more commonly appear in zonary bands following the crystal outline. Thus, to one looking through the sheets there may appear a center of dark "rum" color with a fringe of light "rum" or yellow surrounding it and possessing a hexagonal or rhombic outline; or the center may be light colored and the border zone dark, as in Plate XIV, 5. In some sheets there are alternations of bands of varying color. Such color variations generally entirely disappear when the mica is split into sheets of the thickness required by the trade.

The pleochroism of mica is strong and may be well observed in small crystals with prism planes sufficiently smooth to transmit light. It will be found that crystals of such mica viewed edgewise are far more transparent than sheets of the same thickness. The color is also quite different in these two views.

Muscovite containing inclusions between the laminæ of spots or particles of different-colored minerals is called "specked" and sometimes also "black" mica. Magnetite is the most common inclusion between the laminæ 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. These tufts of magnetite are very thin and rarely penetrate appreciable thicknesses of mica. The dark-brownish color of many of these spots is due to the translucency of the thin films of magnetic iron. The arrangement of the streaks of spots in the mica is in some cases parallel to the direction of the rays of the percussion figure (Pl. XIV, 6) and in others apparently parallel to the rays of the pressure figure (Pl. XIV, 7). Each spot owes its dendritic appearance to the arrangement of still smaller particles of magnetite in lines following, in some cases at least, the rays of the percussion figure. (See Pl. XIV, 8.) From these lines of particles other particles branch off at more or less definite angles. By decomposition the magnetite is sometimes partly or entirely altered to hematite or limonite and the "specks" become red or yellowish brown. In this way striking patterns in colors are produced, which give rise to the name "hieroglyphic" mica and which were once thought to be the inscriptions of the aborigines.

In the zone of surface weathering, and principally within a few feet of the surface, mica crystals are sometimes "clay-stained." This is due to the working in of clayey solutions between the laminæ. The solutions penetrate large areas of some crystals and work in between many of the laminæ, greatly damaging the value of the mica.

"Specked" or "clay-stained" mica has little if any value in the glazing trade, though either can be used in electrical manufacture. Their application even in the latter industry is less extensive than that of clear or "white" mica. Mica with "specks" of magnetic iron is not satisfactory for insulation where electric currents of high potentiality are used, because the "specks" tend to weaken the insulating qualities by acting as lines of less resistance.

Occasionally crystals or sheets of biotite are included in the muscovite crystals, or vice versa. In such a case the two micas generally occur in parallel intergrowths and have a common cleavage plane. Large crystals of muscovite sometimes inclose smaller ones with no definite orientation. The cleavage of the included crystal is generally inclined or at right angles to that of the host.

DISTRIBUTION OF DEPOSITS.

Mica deposits have been opened in 18 or more counties in western North Carolina. The deposits occur in an area nearly 75 miles wide and 200 miles long, extending in a northeast and southwest direction through the State. (See fig. 51.) For convenience this area may be divided into three belts—the Cowee-Black Mountain belt, the Blue Ridge belt, and the Piedmont belt. The Cowee-Black Mountain

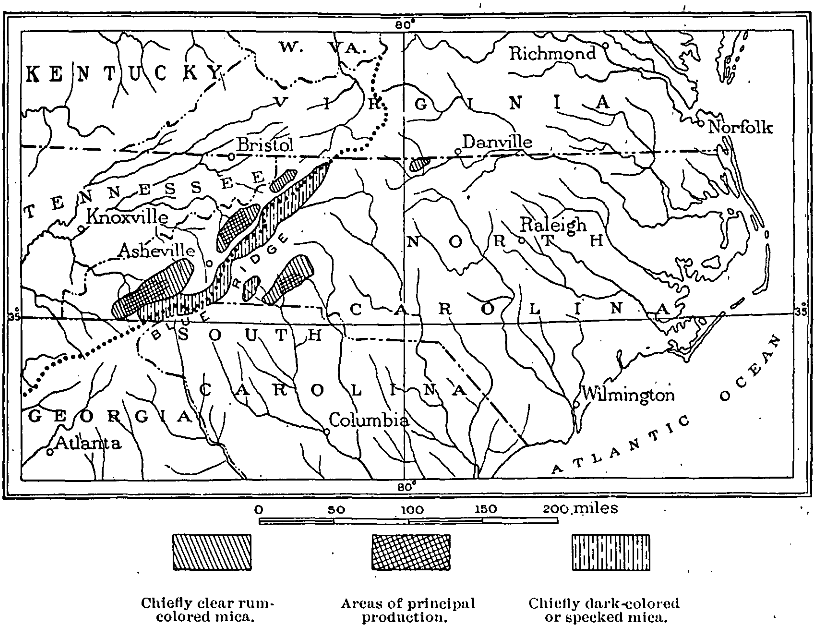


FIGURE 51.—Map showing areas in North Carolina in which mica has been mined.

belt extends nearly through the State, parallel to and near its northwest border. It lies northwest of the Blue Ridge and 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 of small importance compared to the other two. Mines have been opened in Jackson, Transylvania, McDowell, Caldwell, and Wilkes counties in this belt. The Piedmont belt lies in the Piedmont Plateau and its small mountains, southeast of the Blue Ridge. Mica mines have been worked in Rutherford, Burke, Cleveland, Gaston, Lincoln, Catawba, and Stokes counties of this belt. Mica deposits of commercial value have not been found in unbroken succession in any of these belts.

The quality of mica obtained from different localities varies considerably, though in a single belt or in adjacent portions of the same belt the quality is commonly very similar. In general, the mica of the Cowee-Black Mountain belt is clear and of a light color (as a rule "rum"). That from the Blue Ridge belt has a dark smoky-brown or greenish-brown color and much of it is more or less "specked." In a large part of the Piedmont belt, especially in Cleveland, Gaston, and Lincoln counties, the mica is of good quality and similar to that of the Cowee-Black Mountain belt. There are exceptions to these characteristics, in part connected with geologic conditions, such as the presence or absence of granite near by. Most of the mines described below are in the Cowee-Black Mountain belt. Exceptions are the Rochester mine in Jackson County, the Reed mine in Transylvania County, and the Triplett mine in Wilkes County, all in the Blue Ridge belt, and all the mines in Rutherford, Cleveland, Lincoln, and Stokes counties, in the Piedmont belt.

The Cowee-Black Mountain and the Blue Ridge mica belts are in the heart of the Appalachian Mountains. The deposits lie at various elevations between 1,500 feet above sea level and that of the highest mountains, or more than 6,500 feet. Some are high upon rugged slopes or summits where the soil covering is thin. Others are on the gentle slopes of valleys, or former plateau levels or terraces, covered by deep residual clays. Many of the deposits present ideal conditions for mine drainage. This is an important point, for the rainfall is excessive and the level of ground water is not deep. The deposits in the Piedmont belt occur in the low but locally steep ridges or in the few higher hills or mountains standing 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 more or less dissected by river and creek valleys 200 to 300 feet deep. The sky line seen from any prominent ridge is approximately level, with mountains or peaks rising above it at intervals. The problem of mining mica from deposits in the Piedmont belt is often difficult on account of their occurrence in hills with but slight elevation and gentle slopes, so that natural drainage can not be readily secured.

GENERAL GEOLOGY.

The mica deposits of North Carolina have been found in highly metamorphic rocks, probably all of Archean age. These rocks are mica, garnet, cyanite, staurolite, hornblende, and granite gneisses and schists. Other rocks occurring in the region, also of Archean age, are granites, diorites, and peridotites, with their derived soapstones and serpentines. Younger granites, volcanic rocks, diabase, and sediments occur in parts of the region. The folding, faulting, mashing, and recrystallization of the gneisses and schists have been so extreme that it is often difficult to determine the original igneous or sedimentary nature of the formations.

The major part of the mica deposits occur in two formations, as mapped by Keith[a]—the Carolina gneiss and the Roan gneiss. The Carolina gneiss includes most of the gneisses and schists mentioned above that are not hornblendic in composition. The Roan gneiss is composed of hornblende gneiss and hornblende schist with smaller beds of mica gneiss and mica schist included. In the mica region by far the most important formation is the Carolina gneiss. This formation is also the oldest in the region and is intruded by younger igneous rocks, as hornblende gneiss and schist, peridotite, granite, granite gneiss, and diabase. Beginning with the Carolina gneiss the formations have been gashed and cut by the later igneous rocks into irregular-shaped masses, in many places forking out into long tongues or occurring as long, narrow streaks in the intrusives, or vice versa. The diabase rocks are probably of Triassic age and 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 range from a fraction of an inch upward in thickness and locally pass into mica-bearing pegmatites. In some places this pegmatization is so thorough that mica gneisses become strikingly like granite gneisses.

OCCURRENCE OF MICA.

Mica deposits of commercial value in this State are confined to pegmatites. These rocks vary considerably in form, some being typically lenticular in shape and others more or less persistent in length. The lens-shaped bodies are generally conformable with the schistosity of the inclosing rock. They may lie in the same line of bedding or schistosity and be connected by smaller streaks or stringers of pegmatite, or by mere seams in the rock. Many of them, on the other hand, lie in planes of schistosity more or less separated from one another and form parallel or overlapping bodies. In cross section some of these lenses are short and bulky, with a length only two or three times the thickness; others are long and tapering and may constitute simply a bulge in a sheet of pegmatite. In many places the schistosity of the inclosing rock bends around the lenses.

Some of the more persistent pegmatites occupy straight fissures that hold their direction for a considerable distance. Elsewhere they are folded with the country rock or bent and twisted into various shapes. Many are more or less conformable with the bedding of the gneisses and schists. In that case they are in large measure subject

[a] Cranberry (No. 90), Asheville (No. 116), Mount Mitchell (No. 124), Nantahala (No. 143) Pisgah (No. 147), and Roan Mountain (No. 151) folios, Geol. Atlas U. S., U. S. Geol. Survey.

to the deformations of the country rock. In many places, however, the pegmatites are conformable for some distance and then branch out, cutting from one layer to another across the bedding. Locally there is an elbowing or bulging out on one wall, without a similar irregularity on the other wall of the pegmatite. It is not uncommon for pegmatite masses to cut across the country rock for long distances.

Though pegmatites have been worked for mica in regions of hornblende gneiss and hornblende schist, where they are directly associated with those rocks, most of the deposits are found in small biotite gneiss or schist masses included in the hornblende areas. Where the pegmatite is in contact with hornblende gneiss, the latter may be highly biotitic.

Pegmatites occur in irregular masses, streaks, lenses, augen, or balls, some of them having no visible connection with other pegmatite bodies. They range from a fraction of an inch up to many yards in thickness. The limit of size below which they can not be profitably worked for mica might be placed arbitrarily at 1 to 2 feet for rich and regular "veins." In the very large pegmatites the mica is not, in general, evenly distributed through the mass, but is richer in one portion than another, so that the entire bulk of the rock does not have to be removed in mining. The irregularities of pegmatites and the consequent difficulties in mining mica from them are well illustrated in road cuts or similar excavations, where pegmatized gneiss or schist has been exposed. The lenticular shapes, pinching and swelling, crumpling, folding, and faulting to be observed in these cuts are found to be nearly duplicated in larger pegmatites opened for mica. As stated before, these smaller masses may grade into those containing mica of commercial value. Here and there the two can be seen at the same locality.

Horses, or inclusions of wall rock, are common in pegmatite. Some of them are in the form of bands or sheets parallel to the walls, and the schistosity of these bands is also parallel to the walls. They range from an inch or two up to several feet in thickness, and their length may be many times their width. Elsewhere they occur as irregularly shaped masses, from a few inches up to several feet thick. 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 streaks of pegmatite ramifying through them and by the development of considerable feldspar and quartz through their mass. In such places no sharp line can be drawn between the pegmatite and the original horse.

Pegmatite is closely allied to granite in composition. As in granite, the essential constituents are feldspar and quartz, with more or less mica and other accessory minerals. Though hornblende is rather a common mineral in granite, it is less so in pegmatite. Orthoclase and microcline are the most common varieties of feldspar found in pegmatite. In many places, however, a variety of plagioclase, either albite or oligoclase, makes up part or all of the feldspar component. The feldspar occurs in masses and rough crystals, some of them with 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 a graphic granite texture in a portion of the pegmatite. Another common feature is the occurrence of large separate masses of quartz occupying various positions in the pegmatite. Such quartz masses may be irregular in form and but little influenced by the shape of the pegmatite or inclosing wall. Many of them, however, lie in bands or sheets parallel to the walls. There may be one or more of these quartz bands constituting varying proportions of the pegmatite. Their thickness ranges from a fraction of an inch up to 6 or more feet. Many of them are lenticular in shape, the length varying from four or five to twenty or more times the thickness. In numerous places these quartz streaks or veins are persistent through the whole length of the pegmatite exposed. Some inclose feldspar or mica bodies; others do not. The quartz of these segregations is massive and generally granular, though locally 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 feldspar or mica in appreciable quantity.

Muscovite is the common mica of pegmatite and is the only variety mined in North Carolina. Biotite occurs in moderate quantity in a few deposits, and in smaller amount 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 rock formations where the ferromagnesian minerals are abundant, such as hornblende or biotite gneiss and schist, is generally found to be clear and of light color. Where the pegmatite is closely associated with or occurs in granite with a paucity of the ferromagnesian minerals, the mica is generally of dark color and much of it is "specked."

The mica occupies various positions in the pegmatite. Where the rock has a typical granitic texture the mica may be found evenly distributed through it. More commonly the larger crystals will be found either in clusters at intervals through the "vein," in places connected by streaks of small crystals, or collected along one or both walls of the pegmatite, with some of the crystals partly embedded in the wall rock. Where there is a quartz streak within 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.

"Mica capping" is a miner's term 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 small commercial value. The idea conveyed, that the mica forms a capping to a regular "vein" below or near by, is not necessarily true, for some such deposits carry nothing but "mica capping." The mica of "mica capping" commonly occurs in "wedge" shaped blocks with the "A" structure, in many places is more or less distorted or twisted, and may contain inclusions of quartz.

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 large number of minerals have been found associated with mica in pegmatite. Some of these have commercial value in manufacturing industries, or as gems and specimens. The feldspar associated with the mica deposits of North Carolina has not yet been used commercially, but the kaolin formed by its decomposition has been mined extensively. Some of the kaolin deposits are worked for that mineral alone, as they contain little if any merchantable mica. Numerous deposits that may prove of value for both mica and kaolin are known.

DESCRIPTION OF MINES.

MACON COUNTY.

Smith or Baird mine.—The C. D. Smith mine is about a mile west of Franklin. It was worked on a large scale by aborigines, as described below. The mine was opened in the early days by C. D. Smith, and last in 1905 and 1906 by Mr. Eldridge, of Franklin. None of the operators were successful in finding large bodies of mica after the work of C. D. Smith. Some of the later workings cut through layers of scrap mica in old dumps and openings filled with rubbish. Some of this scrap mica was of sufficiently good quality for electrical uses. Several shafts were sunk near the old openings on the top of the ridge but failed to locate the "vein." One of the later tunnels from stream level encountered the filling material of ancient workings and could not be driven farther on account of the loose ground caving badly. About 75 yards northwest of the shafts, across a small branch, a small amount of work was done along a quartz ledge striking N. 60° W. The country rock at this mine is mica gneiss, containing more or less biotite and garnet, with a few diorite inclusions. 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 during the operations of C. D. Smith. The early operations at this mine have been well described by Mr. Smith [a] and his 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 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, and 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.

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. The last work was by the Franklin Kaolin and Mica Company in 1907. 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 good-sized open cuts. The deepest shaft is 65 feet deep and was sunk from the summit of the hill, 120 feet higher than the lowest opening. Two other shafts were sunk to depths of 40 and 45 feet and connected with underground works. The workings extend over a distance of 550 feet, starting in a northwesterly direction at the south end, swinging to north and south along the hilltop, and ending with a northeasterly trend at the north end. The kaolin formation and country rock have the same sweeping curved trend. The country rock is mica gneiss with associated hornblende gneiss streaks.

The pegmatite is irregularly conformable with the inclosing gneiss and may not be one body over the whole length of the developments. The thickness of the pegmatite body varies from a few feet to nearly 100 feet. In places the feldspar component is massive and has

[a] Smith, C. D., Ancient mica mine in North Carolina: Rept. Smithsonian Inst., 1876, pp. 441-443.

thoroughly decomposed, giving large masses of pure kaolin. In other places there is considerable mica and quartz, mixed through the feldspar, and these still remain in the kaolin. Large bodies of sugar quartz were encountered in the workings and a large mass outcrops on the hilltop west of the shafts. Bowlders of quartz are scattered over the hillside below part of the pegmatite outcrop and in the river along the west bank at the north end of the deposit. The greater part of the mica yield from this mine has been in small sizes. During 1907, however, one large crystal that weighed over 4,000 pounds was found in a small tunnel connecting with the 65-foot shaft. This crystal was somewhat irregular in shape, though possessing 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, though much material 12 to 18 inches square was obtained. The block was sold in the rough for $1,500. The quality of the mica from this mine is excellent and the color a rich "rum."

Chalk Hill mine.—The Chalk Hill mine is 1½ miles east of Burningtown. Operations have extended over a distance of 200 yards up the west side of a ridge to the top and for 150 yards down the east side. The principal workings with the deepest shafts are on the west side of the ridge considerably below the top. The country rock is interbedded hornblende and mica gneiss, with a strike of N. 80° E. and dip of 75° N. The main lead of the mica deposits is parallel with the schistosity of the country rock, though small streaks of pegmatite were observed cutting 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 "veins" have been developed by the main lead of workings. Thirty yards south of the point where the main lead crossed the ridge another pegmatite streak 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 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 Company, 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 with drifts and stopes, and a small prospect tunnel with 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 52. A hoist was located in the drift at the end of the crosscut tunnel.

The country rock is mica gneiss with a strike of N. 70° W. to east and west and a dip of 80° N. The pegmatite cuts across the country rock with a strike of N. 10° E. and a dip of 55° E. It varies from 6 to 12 feet in thickness and carries quartz streaks. One of these has a maximum thickness of 4 feet and is near the middle of the pegmatite. The mica yield is from the feldspar streaks between the quartz and mica gneiss walls. The quality of the mica from the Burningtown mine is excellent and the color a clear "rum." The production is said to have been large while the mine was in operation.

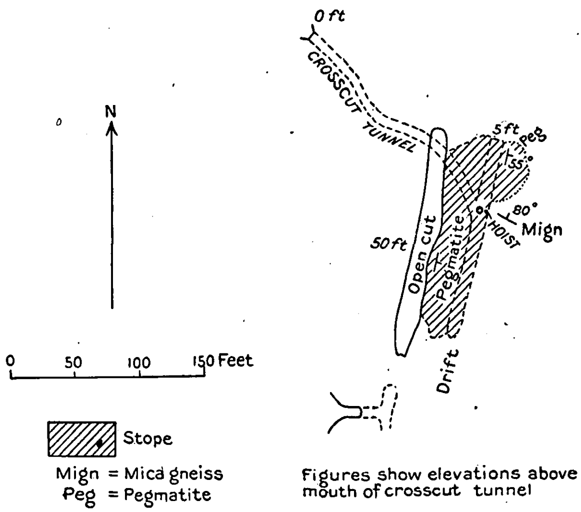


FIGURE 52.—Plan of Burningtown or Poll Miller mine, Macon County, N. C.

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. The relative position of the two mines, with a plan of the workings and details of the geology, is shown in figure 53. At the Hall mine the tunnels on the northeast were started nearly at stream level and were carried in as crosscuts and drifts on the "veins" to the bottom of a shaft 80 feet deep. From a higher level in this shaft a crosscut leads to extensive workings on the north. These workings and the shaft have partly fallen in. Farther up hill a line of pits and shafts shows the position of another "vein." Still farther south along the summit of the ridge is another line of outcrop workings with a shaft 40 feet deep at the east end. Openings have been made for a distance of nearly 250 yards along this lead and assume a southwesterly course 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 latter "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 pegmatite, and a 50-foot raise with stope has been made on the east side of the crosscut tunnel. The pegmatite forming the crest of the ridge is about 14 feet thick where cut by the tunnel. Two quartz streaks from 1 to 3 feet thick are inclosed in the pegmatite parallel with its direction. This pegmatite body cuts across the mica gneiss country rock in part, with a varying east-west strike and nearly vertical dip. The mica yield has come chiefly from the two outside feldspar streaks between quartz and mica gneiss walls,

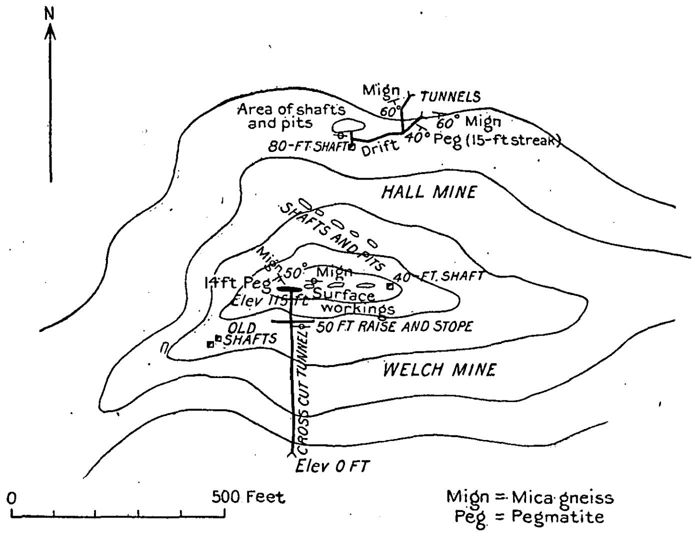


FIGURE 53.—Plan of Hall and Welch mines, Macon County, N. C.

but a small amount has been obtained between the two quartz streaks. The mica obtained from these mines is of fine quality, with a clear "rum" color.

Neal Bryson mine.—The Neal Bryson mine is 1 mile south of West Mills, on the east side of Little Tennessee River. The mine is in a small depression in a steep hillside. In this depression the soil has accumulated to a depth of several feet and carries mica from the breaking down of former pegmatite bodies. A small amount of "groundhog" mining has been done in this soil and débris for its mica content. The principal workings consist of an old shaft with drifts and stopes on the vein, a new 180-foot crosscut tunnel, and a shaft with other drifts. The mouths of the shafts are about 60 feet above that of the crosscut tunnel. The old stopes from the old shaft extend down to the level of the new tunnel. The drift from this tunnel to the east connects with the new shaft on this level and on a small level 15 feet above. The position of the workings, with details of the formation, is shown in figure 54.

The pegmatite has an irregular east-west strike, with a varying dip that shows considerable warping. The dip ranges from vertical to 70° N. in one place and to 30° S. at the west end of the workings. The "vein" varies from 1 foot in thickness in one part of the workings to 12 feet in others. A quartz streak varying in thickness with the thickness of the pegmatite is included near the middle of the pegmatite where the latter is over 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.

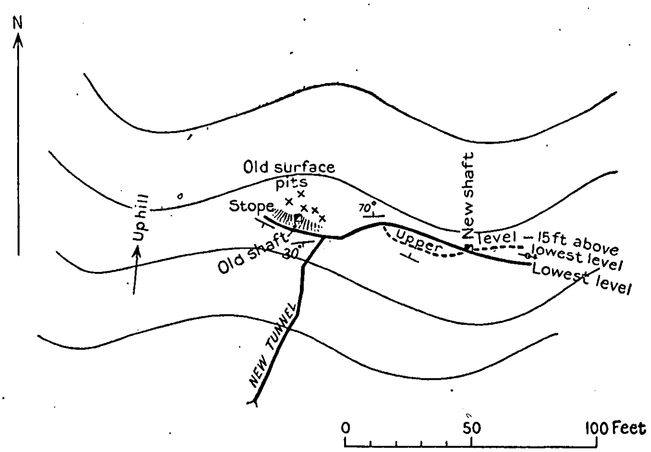


FIGURE 54.—Plan of Neal Bryson mine, Macon County, N. C.

Campbell or Higdon mine.—The Campbell mine is about 1½ miles N. 75° W. of Cowee Gap, where the Webster-Franklin road crosses. Over a dozen tunnels have been run in on probably two or more "veins." The mine is in a shallow cove or hollow on a steep mountain side. The soil accumulation in places in this cove is deep, especially over the lower part of the mine. This soil contains more or less sheet-mica débris from the disintegration of pegmatite veins. Mining through this soil is difficult, as landslides occur. One recent slip has taken place in the cove in which a large body of the soil has dropped down about 10 feet. This slip is evident on the surface above the workings. At the time of visit (1906) there were two tunnels open in hard-rock formation, an old one in slide material was being cleaned out, and another 250 feet long at the base of the old workings was being driven in search of "vein" matter. This tunnel was very crooked, because it was necessary to avoid loose slide rock in several places. In one of the hard-rock tunnels a good pegmatite "vein," about 10 feet thick, was encountered. It contained a 2 to 5 foot quartz streak within its mass. The yield of mica was from the partly kaolinized feldspar streaks between the quartz ledge and mica gneiss walls. The mine has yielded a quantity of fine quality of mica with a clear "rum" color.

Beasley mine No. 1.—The Beasley mine No. 1, also called "Bradley Butt," is one-half mile east of Mica City. It has been operated by a large open cut with a little stoping from its bottom and several tunnels at lower levels on the hillside. Some of these openings are on different "veins" from or branches of the main 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 and 2 feet wide with 4 feet of mica gneiss between them at the east end of the cut. The country rock is biotite gneiss. The pegmatite strikes about east and west, with a dip of 85° S. near the outcrop and of 30° S. at a depth of 25 feet. The pegmatite cuts sharply across the gneiss and horses of gneiss are included within it. The rock formations are unaltered and very hard at this mine, requiring much blasting. Irregular segregations of massive quartz occur through the pegmatite. Portions of the feldspar have a greenish cast, caused by stains from the partial decomposition of a small amount of sulphides scattered through it. A large pocket of mica, yielding a quantity of large sheets of high-grade mica, is reported to have been found in the open cut. Much of the mica from the Beasley No. 1 mine is of excellent quality, with a clear "rum" color, but some of greenish color with an "A" structure was found in one of the lower openings.

Beasley mine No. 2.—The Beasley mine No. 2 is about one-half mile south of 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 with drifts, large stopes, and an incline shaft connecting 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 has an east-west strike and a dip of 65° S. at the mouth of the tunnel. The pegmatite strikes about N. 70° W., with a dip of 40° SW. The pegmatite is more than 15 feet thick in places, 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. A small amount of biotite is associated with it.

Winecoff mine.—The Winecoff or old Jacobs mine is 2½ miles northwest of Franklin. It has been opened for a distance of about 300 yards, in a northwest-southeast direction, by numerous shafts, pits, cuts, and tunnels. A plan of the workings is given in figure 55. At 1 remains of ancient workings were found, and later four shafts with "groundhog" 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 a pegmatite ledge was exposed in an open cut varying 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 pegmatite ledge inclosing quartz bands. At 4 and 5 two shafts reported to be 65 feet deep exposed a pegmatite ledge

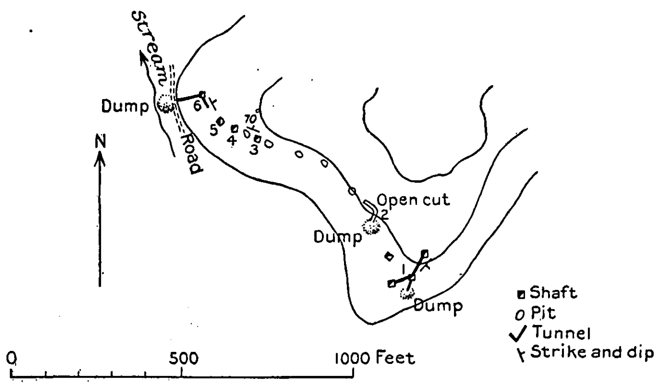


FIGURE 55.—Plan of Winecoff mine, Macon County, N. C.

varying from 2 to 8 feet in thickness and containing quartz bands. At 6 a shaft about 40 feet deep connecting with a crosscut tunnel and drifts encountered a pegmatite composed of a 6-foot streak of quartz with small feldspar streaks along the sides.

The workings at 1 are probably on a different pegmatite body from those to the northwest, though it is possible that a swing in the strike (northwest) at 1 might bring the same pegmatite ledge to 2 and other points. The strike and dip of the pegmatite are shown by appropriate marks 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. The principal yield of mica has been from the workings at 1 and 4 to 6. Possibly the same pegmatite was opened at the old Harris or Raby mine, about 75 yards northwest of and across a branch from the Winecoff mine. The mica from each of these mines has a clear "rum" color and is of fine quality.

JACKSON COUNTY.

John Long mine No. 1.—The John Long mine No. 1 is one-fourth of a mile northeast of the mouth of Wayehutta Creek, 4 miles southeast of Webster. It has been worked by a tunnel 90 feet long and nearly on the strike. At this distance the tunnel forks into two branches, which come together again about 45 feet farther on. Where the tunnels join, an incline working was sunk under the large pillar left between them. There has been some open-cut work on the outcrop—a shaft which passed to one side of the underground workings and an old tunnel now caved in. The position of the workings is shown in figure 56. The pegmatite formation has decomposed badly and is so soft that the tunnels require careful timbering. The greater part of the ground left between the branching tunnels is pegmatite, with the exception of a horse of mica gneiss several feet thick. The pegmatite contains quartz streaks or ledges lying parallel with its general course. Several large blocks of mica and many small ones were seen in the kaolinized feldspar. This mica was more or less fractured and contained a considerable quantity of clay stains between the laminæ. The mica has a clear "rum" color where the crystals have not been clay stained.

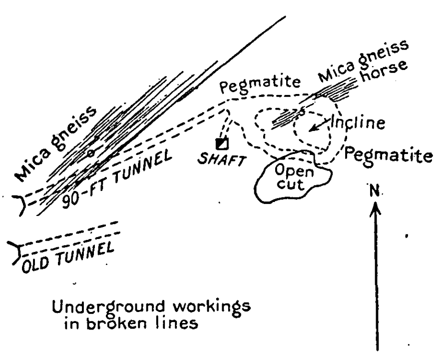


FIGURE 56.—Plan of John Long mine No. 1, Jackson County, N. C.

John Long mine No. 2.—The John Long mine No. 2 is at the mouth of Wayehutta Creek. The mine has been opened by a crosscut tunnel 60 feet long, driven from a point slightly above the creek level, with a 40-foot drift on the "vein." The latter has been stoped out to the surface for a distance of 20 feet and has been removed to a depth of 10 feet below the level of the tunnel. The country rock is biotite gneiss striking about N. 25° E., with a nearly vertical dip. The pegmatite is 10 to 12 feet thick and includes a number of streaks of gneiss. The mica occurs more plentifully along the east wall of the pegmatite and this portion is removed in mining to a width of 5 to 8 feet. 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 $400 worth of rough mica was obtained.

Painter mine.—The Painter mine is 2½ miles S. 65° E. of Sylva, in the northwest slope of a small mountain. The mine was opened many years ago by two shafts, with drifts, and a tunnel at a lower level but not connecting with the shafts. Later, more systematic operations resulted in a tunnel 175 feet long opening into a stope nearly 200 feet long. The stope was carried to a depth of 40 feet below the tunnel level and some 20 feet above, being very irregular in shape. A longitudinal section through the "vein" showing the shape of the workings is given in figure 57. 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 approximately conformable with the inclosing gneiss. The "vein" varies from 2 to more than 15 feet in thickness at the end of the stope. A large quartz streak in the middle of the pegmatite in this stope is left as a foot wall for the workings. The mica streak lies between this and the hanging wall. It is possible that more mica might be found by further prospecting the feldspar streak between the quartz streak and the foot wall. Several large blocks of mica were exposed in the face of the stope at the time of examination (1905). The mica is mostly clear and of good quality,

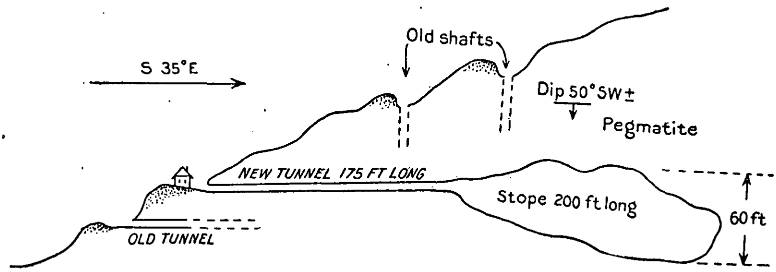


FIGURE 57.—Section in plane of the "vein" at the Painter mine, Jackson County, N. C.

though a small amount 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 the "A" structure slightly at each end, but was perfectly sound in the middle.

The mine is equipped with a hoisting engine and pump at the mouth of the tunnel and a track in the tunnel and stope.

Piney Mountain mine.—The Piney Mountain mine is 1 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 plan view in figure 58. Evidently work has been done on three separate "veins" with varying, nearly northerly strike 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 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.

The country rock is mica gneiss. It is cut by small masses and streaks of pegmatite in various directions. The pegmatite worked for mica ranges from 1 to 12 feet in thickness. A quartz streak is generally present in the interior of the pegmatite and oriented parallel with its walls. This mine is reported to have been a good producer of mica.

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 takes its name from the immense bowlder-like mass of white quartz that marks its outcrop. Several "groundhog" pits and tunnels have been made under the quartz mass, 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 with an east-west strike and a dip to the south. The "Big Flint" mass of quartz is about 40 feet across and at least 25 feet thick. It does not appear to have any connecting mass below, for excavations have been made under a large portion of it from each side and 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 have developed in the seams between these lenses. The feldspar, entirely altered to kaolin, is massive under the quartz mass. 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 formation is massive and contains streaks rich in small mica crystals. A wall of mica gneiss exposed here, probably a horse, has a north-south strike and dips 45° E. The mica obtained from this mine is principally in small sizes, but is of light color and good quality.

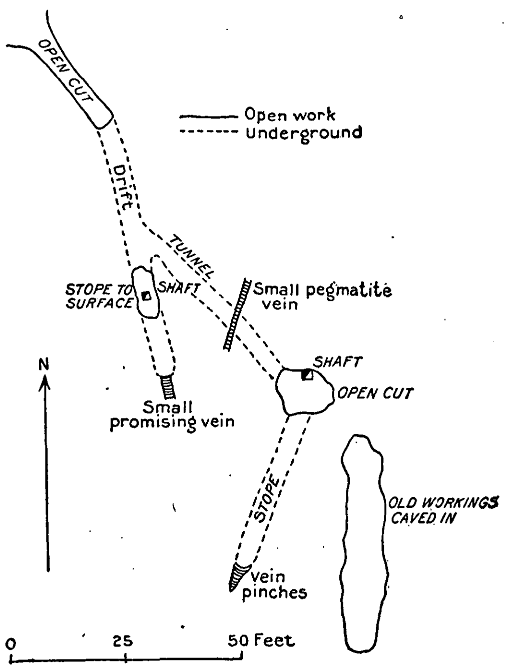


FIGURE 58.—Plan of Piney Mountain mine, Jackson County, N. C.

Wayehutta kaolin and mica mine.—The Wayehutta kaolin and mica mine is on the west side of Black Mountain, near the head of Wayehütta Creek and 3 miles due south of Willetts. The mine is 300 or 400 feet above the valley, on the side of a steep ridge, near and on the top. Developments consist of an 80-foot tunnel with 45 feet of crosscutting and two interior shafts on the pegmatite, with several other trial tunnels and openings. The latter do not expose the main body of the pegmatite. Figure 59 shows the position of the different openings and the formations encountered in each. The country rock is mica gneiss with a strike of N. 60° to 70° E. and 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 quartz vein 2 feet thick was encountered near the southeast side of the pegmatite. Another quartz ledge, 3 feet thick, outcrops on the top and 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 has altered to large masses of 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 amount of clear "rum" colored mica was found in parts of the workings.

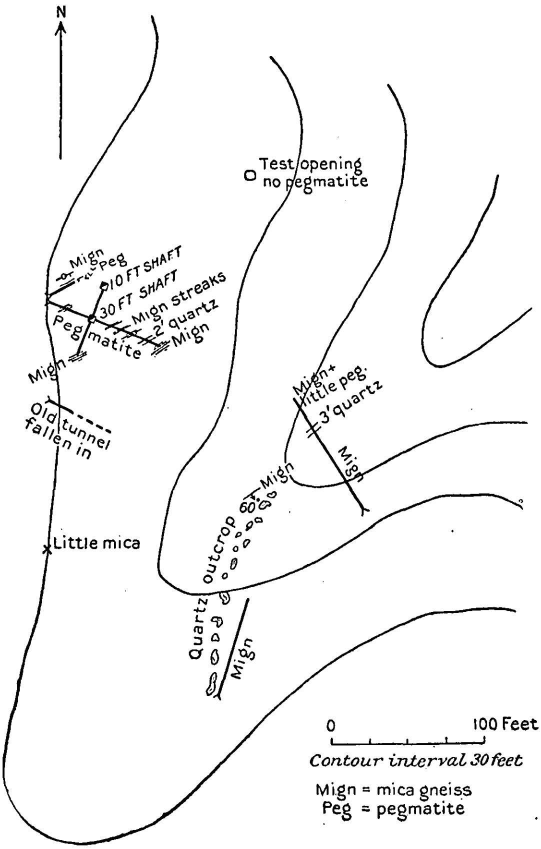


FIGURE 59.—Plan of Wayehutta kaolin and mica mine, Jackson County, N. C.

Cedar Cliff mine.—The Cedar Cliff mine is one-fourth of a mile east of the Deep Gap of Black Mountain. The mine is located in the face of a cliff of hard rock. It has been operated by an open cut nearly 60 feet high and 5 to 25 feet back in the face of the cliff. The country rock is garnetiferous mica gneiss, striking N. 45° E. with a northwest dip. The pegmatite cuts across the gneiss with a strike of N. 10° E. and nearly vertical dip. The "vein" varies from 1 to 3 feet in thickness and contains streaks of quartz parallel with its walls. Other pegmatites outcrop in the cliff and some show indications of mica in commercial sizes. The mica is clear and of good quality.

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 along the "vein" close to the roadside, and a crosscut tunnel under the road to remove waste. The country rock is mica gneiss, which strikes N. 50° E. with a dip of 75° SE. The pegmatite is conformable with the inclosing gneiss and has a thickness ranging from 5 to 12 feet. In the thicker portions the whole of the pegmatite was not removed, only that containing a "lead" of pockets in the interior being mined. The mica gneiss is very schistose near the contact with the pegmatite. The latter contains a few sheets of quartz lying parallel with its walls. One of these quartz streaks near the northeast end of the cut was 18 inches thick, pinching out in a distance of a few feet. The mica at this mine has a dark-brown color in sheets one-sixteenth of an inch or more thick, but is clear when split into thin sheets. Part of it is a little "specked."

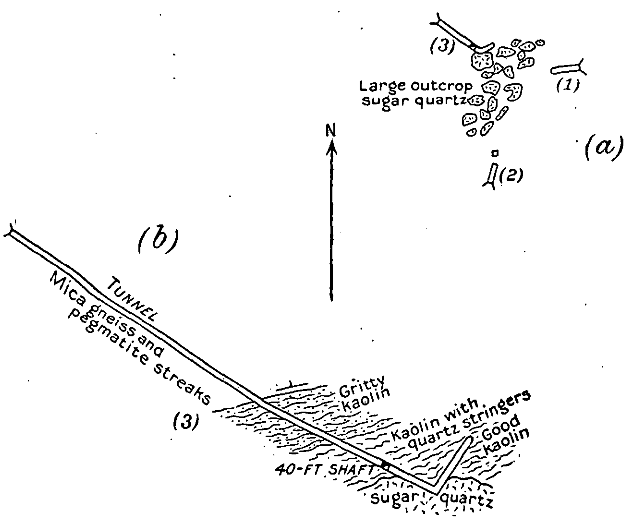


FIGURE 60.—Roda kaolin and mica mine, Jackson County, N. C. (*a*) Plan; (*b*) details of tunnel 3, shown in (*a*).

Roda kaolin and mica mine.—The Roda mine is on the south side of Tuckasegee River opposite the mouth of Caney 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 has a large outcrop of massive, coarse, sugary quartz over it, and this quartz was also encountered in the workings. The first work was for mica on the south side of the hill and in this the 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 driven 18 feet in a mass of fairly pure kaolin after passing through a number of feet of soil.

Pinhook Gap mine.—The Pinhook Gap mine is on the southwest side of the gap of that name in Tennessee Ridge. This mine has been worked extensively at various times. During 1905 a new deposit was opened about 250 yards southwest of the old workings. C. H. Wolford operated the Pinhook Gap mine during part of 1905 and 1906. He reported a production of about 600 pounds a week of merchantable sheet mica during part of this time.

The older workings consist of a large open cut with a crosscut tunnel driven from its southwest corner a short distance out into the pegmatite, and thence turning along the strike of that rock. This connects with a tunnel driven in from the southwest at a lower level. Other short tunnels were driven from the open cut in various directions. Numerous pits and crosscut trenches were made a short distance to the northeast. The pegmatite is irregular in shape, swelling from a thickness of a few feet to the southwest to 30 feet in the open cut and nearly 50 feet northeast of it. Quartz segregations and streaks 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 the "A" structure, with coarse garnets scattered thickly through it. The mica crystals ranged from a fraction of an inch to 3 inches across and the garnets from small size to nearly 2 inches in diameter. The garnets 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.

Operations at the later workings consist of a shaft 30 feet deep with a drift on the vein and a crosscut tunnel from the hillside below. The country rock is mica gneiss, which strikes N. 40° E. with a dip of 40° NW. The pegmatite is conformable or nearly so with the strike of the gneiss. The outcrop of the "vein" is marked by large masses of quartz. These quartz masses are irregular in shape and some of them pinch out at small depth. The feldspar part of the pegmatite is also irregular in shape. It is 6 feet thick at the surface in the shaft.

The mica from the Pinhook Gap mine has a brownish color and is partly "specked." Large-sized sheets are sometimes obtained, however, in which the "specks" can be eliminated by splitting.

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. It was worked by an open cut about 50 feet long and an open incline stope 20 feet deeper from its bottom. The country rock is mica gneiss with a layer of gritty talc schist a few feet southeast of the peg-

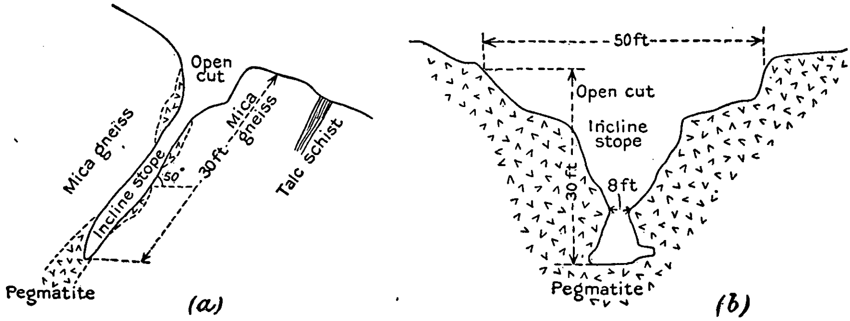


FIGURE 61.—Jim Wood mine, Jackson County, N. C. (*a*) Cross section; (*b*) section in plane of the "vein."

matite. The latter is conformable with the inclosing gneiss and strikes N. 70° E. with a dip of 50° N. The "vein" was rich in mica near the surface for the whole length opened, but was sufficiently rich to work for a length of 8 feet only near the bottom of the incline. At the bottom of the incline the "pay streak" became longer again. The whole thickness of the pegmatite was not removed, only that portion carrying the mica streak being mined. The workings and geologic relations are shown in cross and longitudinal sections in figure 61, (*a*) and (*b*). The mica has a dark-brown color in sheets of sufficient thickness, and part is "specked." Some of the crystals are well developed and others are partly "wedge" shaped.

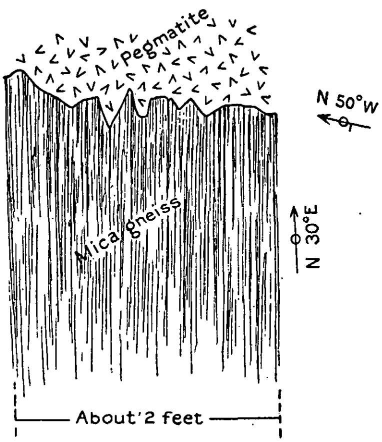


FIGURE 62.—Uneven contact of pegmatite and mica gneiss at the Gregory mine, Jackson County, N. C.

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 over 25 feet deep. The country rock is mica gneiss, which strikes N. 30° E. with a vertical dip. The pegmatite cuts across the gneiss with a strike of about N. 50° W. and a vertical or high southerly dip. It is at least 10 feet thick in places and contained large quartz streaks and masses, one 4 feet through.

The contact with the mica gneiss is not sharp, and in one exposure along the southwest wall was jagged, as shown in figure 62. Small mica is plentiful in parts of the "vein" and some good-sized crystals were left in a pillar over the stope. The mica has a "rum" color and is of good quality.

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 as wide as the pegmatite, 40 feet long into the mountain side, and with 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 a large amount of quartz and is very hard. Near the top of the cut the pegmatite forks, a small streak, worked out for several feet, running westward and the other streak running northwestward. The mica is of excellent quality and has a fine "rum" color.

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. The workings at the time of visit consisted of an old open cut, two old shafts from the surface, and an interior shaft 55 feet deep at the end of the crosscut tunnel, with drifts and stopes. The new work consisted of a tunnel 180 feet long run irregularly toward the old workings and at a level 65 feet lower than the old tunnel. A plan of these workings is given in figure 63. The new tunnel had to be driven a distance of about 25 feet to cut the pegmatite, which it is reported subsequently to have done.

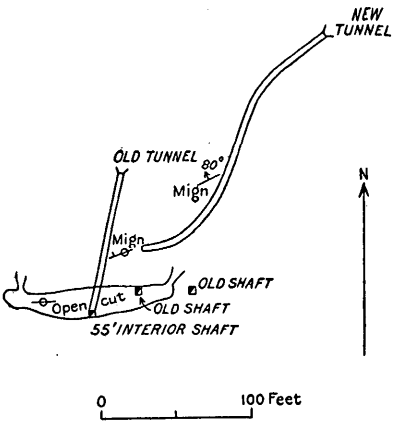


FIGURE 63.—Plan of Judge Ferguson mine, Jackson County, N. C. Mign, Mica gneiss.

The pegmatite strikes about east and west, with a vertical dip cutting across the mica gneiss country rock at a small angle. The latter has a strike slightly north of east and an approximately vertical dip. The pegmatite is about 12 feet thick in the old workings and contains a large quartz streak through part of its course. The mica occurs in the feldspar streaks between the quartz and wall rocks. It has a clear light color and much of it is of good quality, though a portion has the "A" structure.

J. H. Rochester mine.—The Rochester mine is one-third mile southeast of Ocala post-office. It comprises two workings on different pegmatite bodies. In the one to the northwest an incline had been run down on the "vein." The country and wall rock at each opening is pegmatized mica gneiss striking N. 30° E. and dipping 50° SE. The pegmatite is conformable with the inclosing gneiss and 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 principal work was done 75 yards to the southeast and consisted of an open cut 10 to 20 feet deep and 50 feet long on the outcrop, with a crosscut tunnel and drifts, about 100 feet in all, at a lower level and under the open cut, as shown in figure 64. The pegmatite is from 1 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 with a tinge of green.

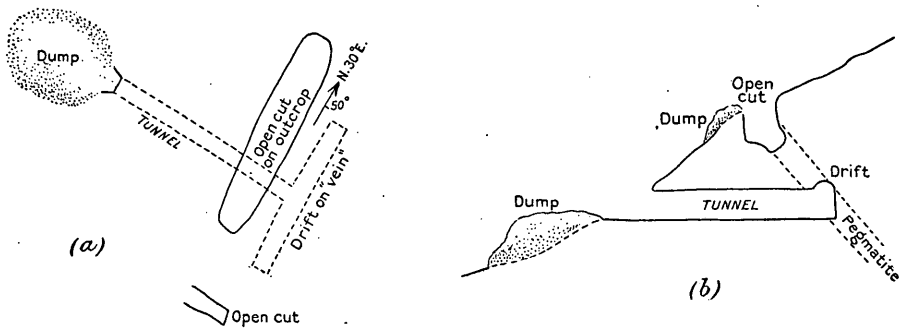


FIGURE 64.—J. H. Rochester mine, Jackson County, N. C. (*a*) Plan view; (*b*) cross section.

TRANSYLVANIA COUNTY.

Bee Tree Fork mine.—The Bee Tree Fork mine is on the hillside opposite the mouth of Bee Tree Fork, on the headwaters of French Broad River. It was opened some years ago by Tarry McCall, and after lying idle many years was reopened in 1905 by C. H. Wolford. It has been operated by an open cut 50 feet long and 35 feet deep at the deeper end in the hillside. The cut is but little wider than the thickness of the "vein." The country rock is mica gneiss, which strikes about northeast with a dip of 45° NW. The "vein" has an irregular easterly strike with a dip varying from 45° to 80° N., cutting across the country rock with a sinuous course. The pegmatite ranges from 2 to 8 feet in thickness and is composed largely of quartz with smaller amounts of feldspar and mica. A small amount of pyrite and pyrrhotite is scattered through the rock. The mica has a clear "rum" color and is of good quality.

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 at different levels, the greater part of which have fallen in. One 30-foot tunnel was driven in on a 5-foot "vein," which had a north-south strike and a dip of 30° W. This pegmatite is irregularly conformable with the inclosing mica gneiss country rock. It has a 2½-foot quartz streak in the middle with mostly 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 (now stoped out between). One of these levels was driven back about 100 feet. The pegmatite had a strike of about N. 20° E. and a dip of 35° NW. in this tunnel. It had pinched down to about 18 inches in thickness with small scattering quartz lenses in it at the end of the tunnel. The mica from the Reed mine has a dark color and in part is "specked" with magnetite.

HAYWOOD COUNTY.

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 was obtained over a rough trail and several sets of ladders. The workings consist of an open cut nearly 200 feet long in a north-south direction along the side of the mountain and up to 25 feet deep. The country rock is very hard garnet gneiss, which has a northerly strike with nearly vertical dip. The pegmatite is conformable with this and pinches and swells from a few inches to several feet in thickness, with streaks branching out from it. The pegmatite contains quartz masses and streaks. 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-sized 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. The quality of these sheets was very good.

BUNCOMBE COUNTY.

New Balsam Gap mine.—The New Balsam Gap mine is near the head of North Fork of Swannanoa River, about 1 mile southeast of Balsam Gap. The mine is on the face of a cliff about 70 feet high and a few feet to one side of a waterfall over the cliff. It was worked by an open cut at the foot of the cliff, about 60 feet long, extending into the cliff. A tunnel or stope 15 or 20 feet high was then driven back under the cliff on the "vein" a distance of 70 feet. The full width of the pegmatite, 6 to 8 feet, was removed in the tunnel, and the waste was left to accumulate in the bottom as a floor for stoping out the "vein" above. The country rock is much-folded biotite mica gneiss striking north and south, with a high irregular dip 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 in one portion exposed in the roof of the tunnel it pinches down to about 1 foot in width but abruptly elbows out again to several feet, as shown in figure 65 (*a*). The irregularity of the pegmatite is further shown by the exposure in the end of the tunnel, of which figure 65 (*b*) is a vertical cross section. The pegmatite pinches down in the upper part, is large in the middle, and smaller again at the bottom. On the west side there is an elbow in the "vein" with a small arm of pegmatite branching off into the mica gneiss. An irregular-shaped horse of gneiss was included in the "vein." The pegmatite is composed of the usual minerals segregated out into coarse masses in places. The quartz and feldspar occur in masses 2 or 3 feet thick, and the mica is richer in some portions than in others. One place in the roof where the pegmatite pinched down to a width of 2 feet carries abundant mica. The mica is good and has some biotite associated with it.

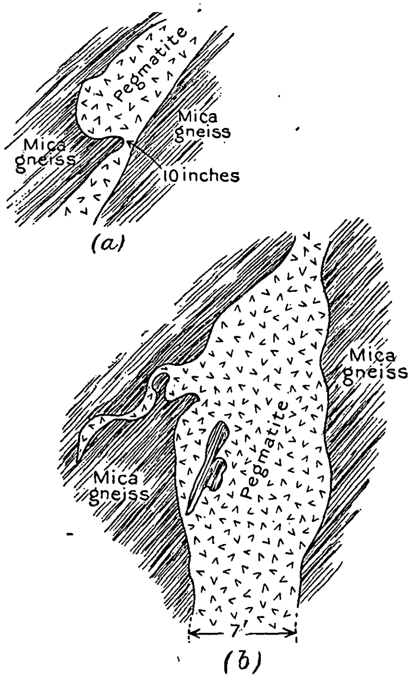


FIGURE 65.—New Balsam Gap mine, Buncombe County, N. C. (*a*) Section showing pegmatite pinched down to 10 inches and elbowing out abruptly; (*b*) irregularity of pegmatite exposed in end of tunnel; lenticular-shaped cross section with small side stringer and horse of mica gneiss.

Connally mine.—The Connally mine is 4 miles west of north of Black Mountain station, on the east side of North Fork of Swannanoa River. The country rock is diorite or hornblende gneiss, carrying mica gneiss bands. The mine was formerly opened by 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 massive quartz. A new shaft had been sunk near the old workings and pegmatite was encountered. The new tunnel was driven in a northerly direction for nearly 200 feet. Side tunnels were run near the end, as shown in figure 66, *A*. Irregularities in the formation were encountered at several places. At 1, figure 66, *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 this contact is shown in figure 66, *B*, which represents the section (*a*) exposed on the east wall. The feldspathic 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*) there is another large irregular mass of quartz included in or a part of the pegmatite. It is shown in cross section in figure 66, *C*, as it appears in the north wall of the tunnel.

The feldspar of the pegmatite is badly kaolinized, and it was the intention of Colonel Connally to test the deposit for kaolin. The mica occurs chiefly in the kaolin along the quartz masses and is much crushed in many places. The quantity of mica found in the new

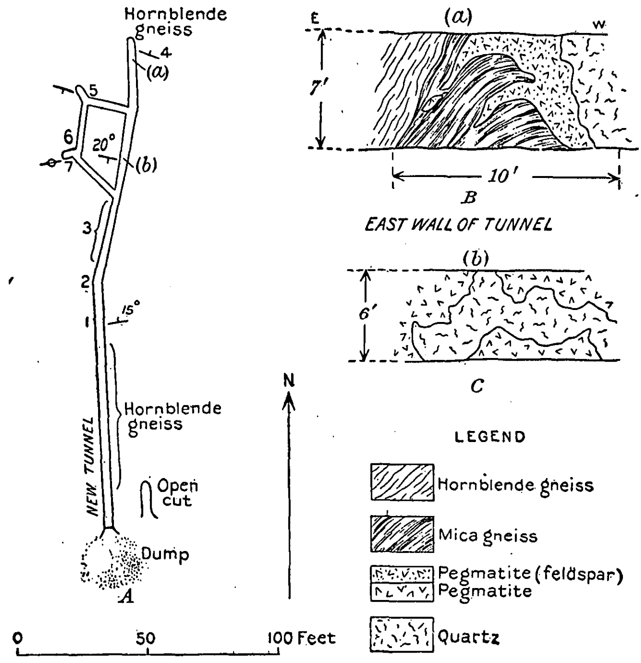


FIGURE 66.—*A*, Plan of Connally mine, Buncombe County, N. C.; reference figures described in text. *B*, Section in east wall of tunnel at (*a*) in *A*. *C*, Section in east wall of tunnel at (*b*) in *A*.

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.

YANCEY COUNTY.

Poll Hill mine.—The Poll Hill mine is 1¾ miles west of south 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 Company, and that higher up on the hill by Hall Brothers & Burleson. The part near the river was being cleaned out at the time of visit 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 to the 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 varies from 10 to 15 feet in thickness. It contains numerous small horses or streaks of mica gneiss or schist included parallel with its walls.

The upper part of the mine has been worked at a number of 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 of visit and the nature of the work is shown in figure 67, *A*. A 70-foot tunnel was driven in a N. 75° E. direction on a mica "vein." From this an incline was run in a southwesterly direction 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

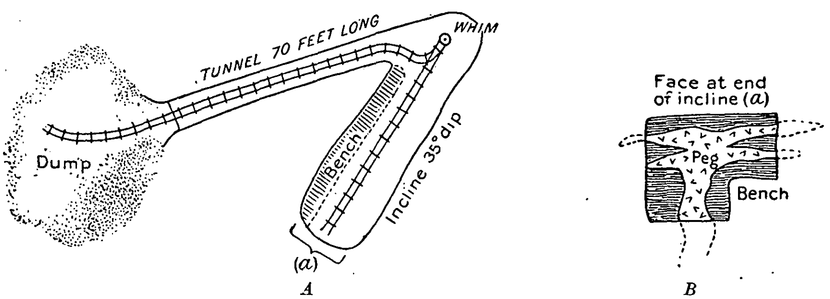


FIGURE 67.—*A*, Plan of Poll Hill mine, Yancey County, N. C. *B*, Cross section of pegmatite at end of incline at (*a*) in *A*.

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 67, *B*, represents 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 Company in 1904. The "vein" strikes N. 15° E., with a high easterly dip. It has been opened along its strike for a distance of nearly 100 yards up and down the slope of the mountain. The lowest opening is an old tunnel run in on the "vein" for drainage and development purposes. A shaft started higher up the hill to meet this old tunnel was never completed. At the time of visit 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. The latter material may have been drift from the outcrop of the "vein" above, though it probably belonged to 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" to "rum" red color and is of excellent quality for stove purposes.

Hensley mine.—The Hensley mine is on Pigpen Creek about 2 miles west of south of Green Mountain. It is said that there were ancient workings at this mine. It was operated by the Hampton Mining Company in 1906, when the accompanying notes were taken. The mine was also worked at earlier dates by white people. The country rock is mica gneiss, with north-south strike and a nearly vertical dip. The pegmatite is conformable, or nearly so, 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 one evidently having 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. 68.) 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. Some blocks of mica many pounds in weight have been found. Part is clay and iron stained near the surface and is used for electrical purposes, and part has a clear amber color and is suitable for stove use.

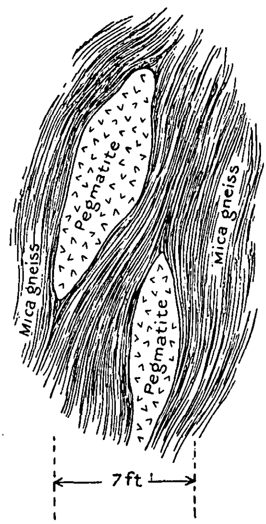


FIGURE 68.—Vertical cross section of pegmatite at Hensley mine, Yancey County, N. C.

Young mine.—The Young mine is about 2 miles west of Booneford and 100 yards west of South Toe River. The mine has been opened by cuts, pits, tunnels, and shafts covering a width of more than 50 feet and for a distance of more than 200 feet. The workings extend from the south side over the top to the north side of a ridge about 100 feet high. The mine has been operated at several different times, the last time by the J. E. Burleson Company in 1904–5. 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 75° SE. Streaks or horses of mica schist are included in the strike of the pegmatite and are parallel with it. The mica occurs in streaks parallel with these bands of schist, and the latter are left as walls to the workings in places. There is much small-sized mica in the "veins" and some sheets of large size are reported to have been found. The quality is good and the mica is said to be especially fitted for electrical purposes.

MITCHELL COUNTY.

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

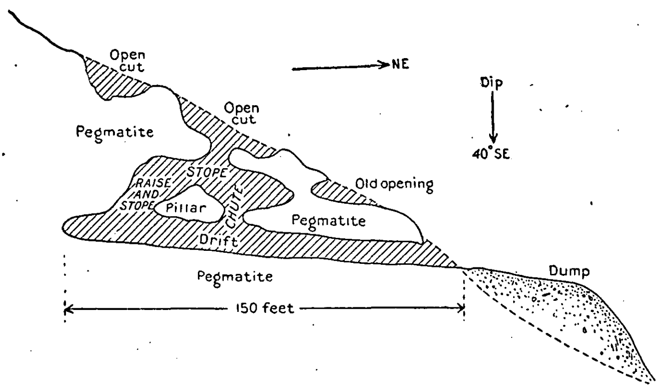


FIGURE 69.—Section in plane of pegmatite at Knob mine, Mitchell County, N. C.

coarse granite on the lower side. Only the coarse pegmatite, called the "vein," is mined; this pinches and swells between 1 and 4 feet in thickness. The mine was first worked by open cuts on the outcrop and shallow inclines. Later a drift was run about 150 feet from the outcrop lower down on the hillside, and portions of the "vein" were stoped out to the open cut above. Figure 69 is a section in the plane of the "vein" and shows the nature of the work at the time of visit. The mica has a dark-green color and is "specked," some abundantly, with dendritic spots of magnetite. Some crystals of large size are found, and one weighing 165 pounds was obtained at the time of visit in 1904. This block measured roughly 12 by 20 inches and was 30 inches thick. The mica was split and graded at the mine and shipped to electrical manufacturers. The splitting and rough trimming were done chiefly by women.

W. W. Wiseman mine.—The Wiseman mine is 2 miles northeast of Spruce Pine, on Beaver Creek. According to Mr. Mart Wiseman it was opened by James Wiseman and John Pendley in 1875. These men removed $2,000 or $3,000 worth of mica 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 went into the hands of the Southern Mica Company. The early workings consisted of a shaft carried down 30 feet and a tunnel 40 feet long along the vein.

At the time of visit (1904) the old workings had caved in badly, leaving a pit resembling an old open cut. The more recent workings of the Southern Mica Company were still open, however. A crosscut tunnel some 250 feet long had been driven into the "vein," along which drifts with extensive stoping were run. The country rock is highly schistose mica gneiss which has a varied dip and strike where it is cut by the tunnel. Several feet before the "vein" was reached the tunnel encountered coarse granite or fine-grained pegmatite, which grades into coarse pegmatite near the "vein." The coarse granite cuts across the schistosity of the gneiss, which trends N. 15° W. and has a 25° W. dip at the contact, whereas the granite has a strike more nearly east and west. Figure 70 shows the position of the workings and the relations of the rock formations. The crystallization of the pegmatite as exposed in the walls of the drift is very coarse. Crystals of orthoclase feldspar 2 and 3 feet square had been cut through and the candle light reflected from the cleavage faces exposed outlined their shapes well. This mine is reported to have yielded large blocks of mica, one weighing about 2,000 pounds. Samarskite is said to have been found in masses of many pounds weight and broken up and lost before its nature was known.

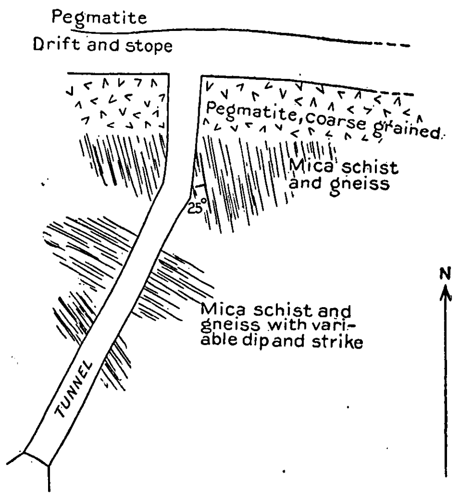


FIGURE 70.—Plan of later workings at the W. W. Wiseman mine, Mitchell County, N. C.

Charlies Ridge mine.—The Charlies Ridge mine is 1½ miles south of west of Plumtree and one-half mile west of Spear, about 200 yards southeast of the Justice mine. It was discovered about 1882 or 1883 by Ben Aldrich and worked by him for about six months. It has been operated at different times by Samuel Landers, Colonel Irby, and W. W. Irby. During 1905 and 1906 it was being 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 of visit. This tunnel was expensive, being run through very hard rock at the rate of about 3 feet a week and not being driven in a straight course. A plan of the workings and position of the pegmatite is shown in figure 71. The elevation 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, thus losing much of the advantage gained through the position of its starting point. From measurements taken for the benefit of the miners it was found that the tunnel would have to be driven about 80 feet farther, if on a level, and in a direction S. 40° E., to strike the "vein."

The country rock is biotite gneiss, whose dip and strike vary, though in general the strike is northeasterly and the dip southeasterly. The pegmatite is large and is richer in mica near its walls than in the

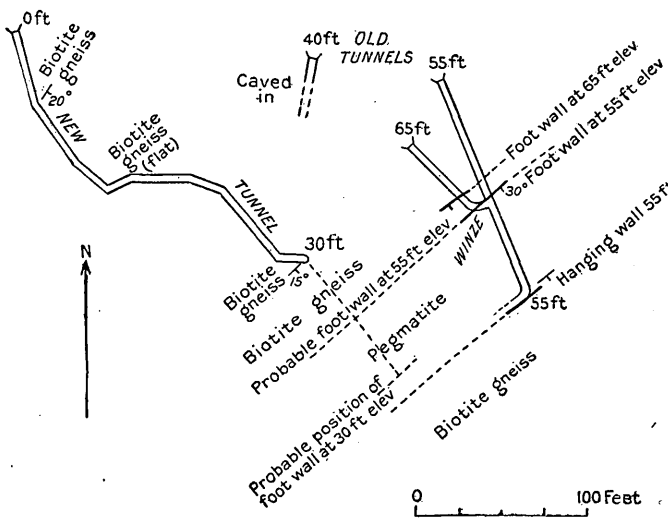


FIGURE 71.—Plan of Charlies Ridge mine, Mitchell County, N. C.; figures give elevations above mouth of new tunnel. The position of the pegmatite is shown on the 55 and 65 foot levels; also the probable position at the level of the end of the new tunnel.

interior. There is a streak of highly foliated biotite schist 3 to 6 inches thick along the walls.

Plumtree mine.—The Plumtree mine is one-half mile east of Plumtree, on Plumtree Creek. It was discovered by C. W. Burleson about 1870 and worked by him for about six months. It was later worked by Colonel English, Colonel Rorison, W. W. Avery, and others, and after a period of idleness was reopened again by the Burleson Brothers in 1906. The mine was operated by an open cut on the outcrop with a 30-foot incline and a tunnel or drift on the "vein" from a lower level. The country rock is mica gneiss interbedded with hornblende gneiss, and the wall rock is mica gneiss. The pegmatite is conformable, or approximately so, with the inclosing formations and strikes about N. 25° W., with a dip of 10° to 25° NE. It is from 18 inches to 4 feet thick. The mica streak lies near the hanging wall and in places is separated from the wall by a quartz vein 3 to 5 inches thick. The crystals of mica are reported to be of good size, running up to 40 and 50 pounds in weight. Some of them are badly crushed and crumpled and suitable for grinding purposes only. 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 conformable, or nearly so, with the inclosing gneiss, which lies nearly flat in places and has gentle rolling folds in other places. The pegmatite varies from a few inches to 7 feet in thickness and is reported by the miners to be richest in mica where it is between 2½ to 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 2 feet. For the last 30 feet of this tunnel the pegmatite is 7 feet thick and carries but little mica. Other tunnels have been run in different positions, following the directions in which the best mica was found. 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, with a rich "rum" color. One block is reported to have been found worth over $100.

WATAUGA COUNTY.

Dobbins mine.—The Dobbins mica mine is about 2 miles north of west of Elk Crossroads. It was operated extensively about 1890 and on a smaller scale about ten years later by the Blue Ridge Mica Company. There are two sets of workings about 250 yards apart, one at the foot of the hill and the other on the top of the ridge to the northeast. The work near the road consists of five tunnels, with two shafts and other openings of "groundhog" nature. The tunnels have been run in at different levels on the hillside, in a space about 70 feet wide, showing a large pegmatite formation. These tunnels have directions varying from N. 25° to 45° E. and roughly show the trend of the pegmatite. The country rock is biotite gneiss and strikes between N. 30° and 40° E., with a nearly vertical dip. The pegmatite is conformable, or approximately so, with the inclosing gneiss. Portions of pegmatite rich in small mica were exposed in some of the workings, but in others there was little or no mica. The openings on the ridge consisted of three shafts and tunnels on each side of the summit. The openings were confined to a belt about 100 yards long in a direction N. 35° E. and about 40 feet wide. One deep shaft has been well timbered and was in a good state of preservation. The other openings had caved badly. But little mica had been left around these workings. The mica seen at the openings along the road was mostly of a dark-brown to greenish-brown color. 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.

ASHE COUNTY.

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 Company 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 of 6 by 8 or 8 by 10 inches, but the principal production 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.

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 is usual for mica 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 over 100 yards and shown the thickness to vary from 3 to 8 feet. The country rock of the region is hornblende gneiss, but the mica deposit occurs in a smaller belt of biotite (probably granite) gneiss. The strike of the pegmatite is about N. 20° E. and the dip 75° to 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 72 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 by 2 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 over 10 inches thick and a foot wide were seen in the "vein," embedded in feldspar. 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. This mine was first opened by small pits, trenches, and a tunnel along the "vein." The surface workings were at the summit of the hill and the tunnel 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 about 75 feet long and 10 to 20 feet deep on the "vein."

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 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 like coarse

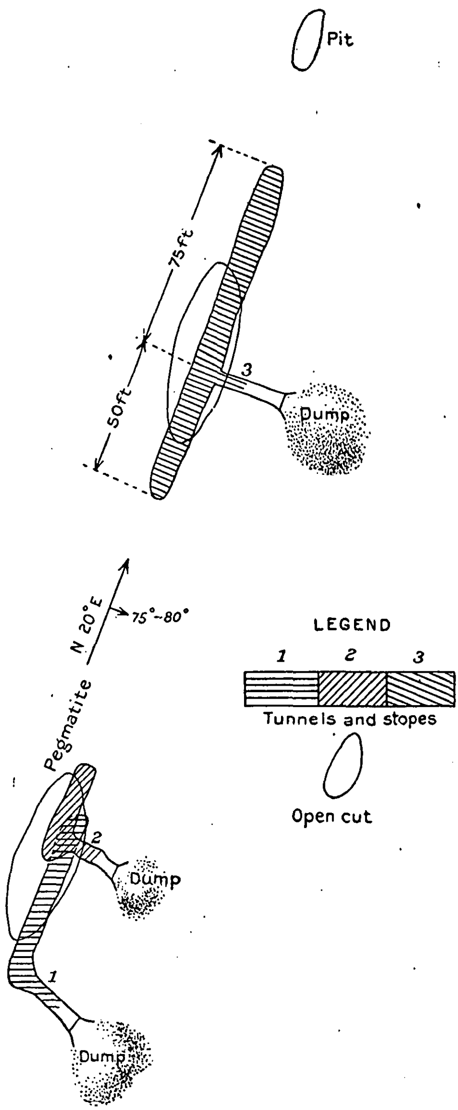


FIGURE 72.—Plan of North Hardin mine, Ashe County, N. C.

granite, whereas along the walls the crystallization is much coarser. The principal mica yield is reported to have come from the foot wall, along which massive quartz streaks up to 2 feet thick were found. It is said that the crystallization of the pegmatite was coarser below a depth of 15 feet and the quantity of mica in it larger than near the surface. The color of the mica obtained was a clear "rum" and the quality the best.

The quartz streaks along the foot wall of the pegmatite contained beryl crystals from less than an inch to 6 or 8 inches in diameter. These crystals were of good golden and aquamarine color, though cloudy and only translucent. It was found they made very pretty gems for scarf pins, cuff buttons, etc., when cut en cabachon.

WILKES COUNTY.

Joel Triplett mine.—The Triplett mica mine is near Hendricks on Stony Fork, 16 miles from Wilkesboro. There are three mica prospects on this property, one of which was opened several years ago by a tunnel 40 feet long. A pegmatite about 8 feet thick had been exposed approximately conformable with the mica gneiss country rock. The latter had a strike of N. 30° E. and a dip of 35° SE. and contained numerous small lenses and masses of quartz and pegmatite throughout. Mica was segregated in various small-sized blocks along the walls of the pegmatite. Some 50 pounds of sheeted and cut mica were seen. The sheets ranged in size from 2 by 2 to 4 by 4 inches. In quality 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.

RUTHERFORD COUNTY.

Isinglass Hill mine.—The Isinglass Hill mine is on the Southern Railway about 3½ miles north of Rutherfordton. A pegmatite formation over 30 yards thick has been found to carry mica in certain parts. The country rock is hornblende gneiss, badly folded and contorted, and the pegmatite is roughly conformable with it. The strike is east of north and the dip in general nearly vertical. The pegmatite near the mica workings is many yards thick and in a railroad cut 200 yards to the north shows only as small streaks, probably stringers from the main mass after it had forked into smaller branches. The pegmatite has been traced over 200 yards to the south by prospect shafts, but it is not known how thick it is at these points. Mica was found most plentifully in the portion where the open cuts are shown in figure 73. It is principally associated with a massive quartz streak in this place. The depth to which the mica workings were carried could not be ascertained because they had caved in badly, owing to the soft, decomposed nature of the rocks. The mica is in large part badly "specked" with magnetic iron. To judge from the large quantity of sheets 2 to 5 inches in diameter left on the dump, mica must have been very plentiful where found. Much of this waste mica was either "A" or "wedge," however.

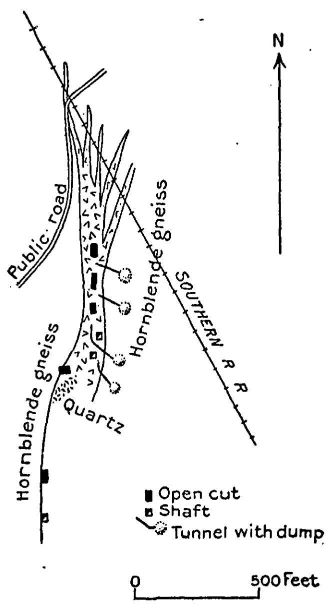


FIGURE 73.—Plan of workings and probable shape of the pegmatite in Isinglass Hill mine, Rutherford County, N. C.

Since the operations for mica were suspended the deposit has been examined for its value as a kaolin mine, and for this purpose 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 of visit. The following analysis of the kaolin, made by T. W. Smith, commercial chemist, Indianapolis, Ind., was furnished by Mr. Olive, owner of the mine:

Analysis 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

CLEVELAND COUNTY.

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 over thirty-five years ago and has not been worked within twenty years. The country rock is much crumpled mica schist-gneiss with 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 quartz band 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. The mica streak was all removed on the west side of the quartz ledge in the bottom of the open cut and only partly so on the east side. The mica is of fine quality, with 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. The mine was opened in the seventies and operated again at later dates. The workings have fallen in badly and but few notes were obtained. The country rock is mica schist-gneiss striking north with a dip of 70° W. The vein strikes about N. 70° E., as shown by the position of eight or ten shafts and pits with tunnels. These workings are all within a distance of about 60 yards of one another. Streaks of massive quartz up to 3 feet thick were encountered in the pegmatite in the workings. In one of the workings the mica was obtained from the north wall of one of the quartz ledges. The pegmatite is rich in feldspar, 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 in the north end of Cleveland County, 3 miles north of east of Casar and on the southeast side of Casar, respectively. There is so much similarity in the occurrence in each group of mines and so little to see of the formation at any one of the separate mines that a general description will answer for all. The Indian Town mines cover an area of over a square mile and consist of a dozen or so 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 with mica, cyanite, and garnet as constituent minerals. The gneiss has been much folded and crumpled over the whole region and has been intruded by granite masses in places. The pegmatite bodies, opened for mica, appear to cut across the schistosity of the gneiss as a general rule, though in some places they lie conformably 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 within the pegmatite. The occurrence of large bodies of feldspar or its alteration product, kaolin, with the mica is not common. 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 from the portion between the "A" lines.

LINCOLN COUNTY.

Thomas Baxter mine.—The Baxter mica mine is about three-fourths of a mile from the southwest corner of Lincoln County, on the old Rutherfordton road. It is probably the oldest mine in the county and is reported to have been opened before 1870. The workings have nearly all fallen in, and little could be determined of the formation. There were six to eight shafts and cuts with tunnels. One shaft is said to have been 65 feet deep, with good mica in the bottom. The ground-water level in a well near the mine was about 35 feet below the surface. The workings fall within an area about 50 yards wide and 75 yards long in a direction north of east. The country rock is much-folded mica schist-gneiss. A large quartz vein or ledge outcrops in a direction N. 70° E. through the workings. The mica is of the best quality, splitting well, and has a beautiful clear "rum" color. Large quantities of weathered small sheet mica 1 to 2 or 3 inches in diameter are scattered around the mine. It is said that the mine was a large producer, including many pounds of large sheets, as 8 by 10 and 10 by 12 inches.

M. M. Hull mine.—The Hull mine is about 2½ miles northeast of Hulls Crossroads. This mine, which was opened about 1891, is sometimes called the Rock Cut mine. The work consists of a cut 40 feet long, 20 feet deep, and 5 feet wide. The pegmatite strikes N. 70° E. and is nearly vertical. It cuts across the cyanitic mica gneiss country rock, which strikes N. 10° E. and dips 50° SE. Bunches of small mica are still left in the walls. The color and quality of the mica are of the best, and some sheets 10 by 14 inches are reported to have been found.

John Dillinger mines.—The Dillinger mines, of which No. 1 is 2 miles south of Henry on the roadside and No. 2 is on a branch one-fourth mile west of the same road, were worked in 1905 and 1906 by the Cawood Mica Company. At each mine the country rock is much folded cyanitic mica gneiss. The pegmatite streak in each is irregular and has an east-west strike. Each mine was opened by a cut from 18 to 20 feet deep. In the No. 1 mine much of the mica found was "A," but of good color and with some clear portions. In the No. 2 mine the pegmatite had quartz ledges in it and the most mica was found alongside of these. Beryl was also reported as found in this mine.

STOKES COUNTY.

Joe Hawkins mine.—The Hawkins mica mine was first opened about 1890 by people living in the county and during 1903 was again operated by the Empire Mica Company, 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 massive pegmatite formation, in which feldspar and quartz form large separate masses. The pegmatite varies from 6 to 12 feet in thickness, as exposed in the workings, and is approximately conformable to the inclosing mica gneiss country rock. The latter 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 in thickness, 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" nature, with good portions between the "A" structure lines. Some of this wedge and distorted mica included rough garnets, either in crystals or flattened between the laminæ. The workings consist of two open cuts, with an incline on the pegmatite from one, and three shafts 20 to 30 feet deep with tunnels connecting them. In all there are nearly 150 feet of tunnels and incline. Figure 74 gives a general plan of the workings.

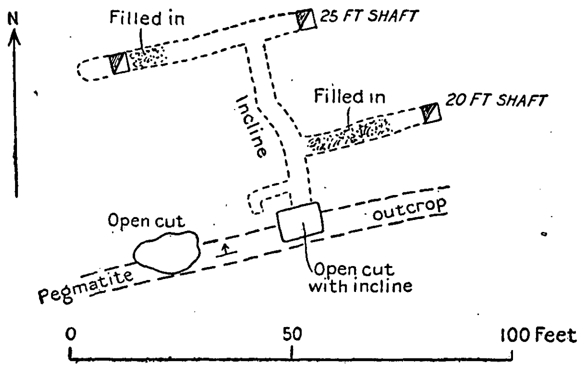


FIGURE 74.—Plan of Joe Hawkins mine, Stokes County, N. C.

Hole mine.—The Hole mica mine is on the ridge between Dan River and Big Creek, near the mouth of the latter, and near Tulip post-office. There are two separate mica-bearing pegmatites at this mine, opened at points about a third of a mile apart in an east west direction. The principal deposit consists of a large pegmatite over 20 feet thick, striking nearly east and west with a dip of 30° N. As exposed in the open work on the outcrop and small inclines, the pegmatite is composed of three bands or veins of massive quartz from 4 to 6 feet thick, with two beds of feldspar 4 to 7 feet thick between them. It is said that another feldspar band was developed beneath the lower quartz vein exposed at the time of visit, but this was covered with rubbish and could not be examined. The quartz and feldspar bands or veins are parallel and dip with the pegmatite to the north. The feldspar has kaolinized to a large extent and has been removed from the two veins exposed in inclines 10 and 20 feet deep. There were smaller masses and streaks of quartz 1 to 10 inches thick in the large feldspar streaks. Figure 75 is an ideal cross section of the pegmatite. The pegmatite can be traced a number of yards along the outcrop by massive white quartz bowlders. Mica occurs through the feldspar masses and along the contact with the quartz streaks. The mica is partly of the "A" variety, and a 20-pound block of such mica was seen in the face of one of the veins. The mica has a brownish or smoky color.

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 pegmatite here is conformable with the mica gneiss

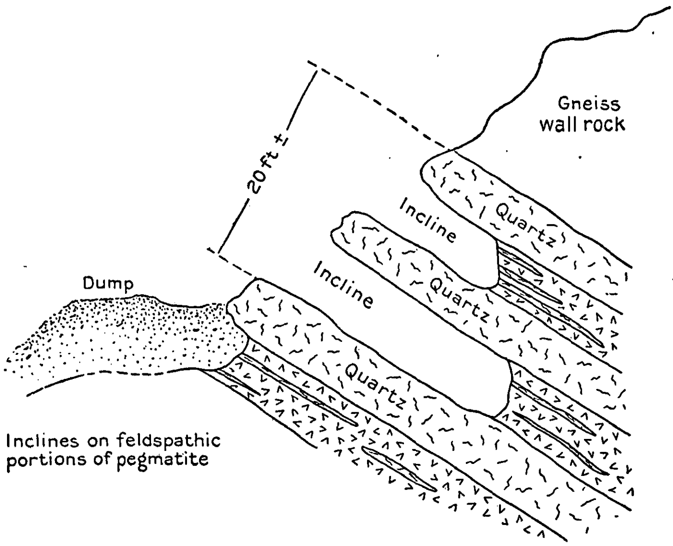


FIGURE 75.—Ideal cross section at Hole mine, Stokes County, N. C.

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 mica blocks were seen in the hard rock, and this mica was of clear dark-green color, considerably ruled.

ORIGIN.

Mica of commercial size in North Carolina occurs only in pegmatite. There has been considerable difference of opinion concerning the origin of this rock in different regions, some writers arguing for intrusion as an igneous magma, others for deposition from solution. One group maintains that pegmatite formed as dikes, the other that it formed as veins. Still other authors consider pegmatite to be the product of aqueo-igneous processes in which there are all gradations between the conditions of a magma and those of a solution. Accordingly, it would be impossible to draw a sharp line between pegmatites formed as dikes and those formed as veins. In some places the nature of the pegmatite and its relation to the accompanying rock are such that it may be stated with a fair degree of certainty to which class the deposit belongs.

In the mica-bearing pegmatites of North Carolina there are features that may be interpreted as showing an intrusive origin in one place and a solution deposit in another place. On the other hand, a large number of the deposits possess features characteristic of both dikes and veins, so that it is not possible to assign one method of formation or the other. It is probable that the greater number of the pegmatites opened for mica in North Carolina approach conditions of vein formation more closely than they do those of dike formation. This is in contrast with the mica-bearing pegmatites of South Dakota,[a] which, in the greater number of places, are thought to possess features characteristic of dikes rather than of veins.

Features observed in pegmatites that may indicate vein origin are the presence of quartz veins or sheets oriented parallel to the walls; the similarity of these quartz veins or sheets to ordinary quartz veins in the mica region; horses of wall rock in sheetlike bodies lying parallel to the walls (by intrusion such sheets would tend to be turned or bent at an angle to the walls); the occurrence of pegmatite in small lens-shaped bodies; balls, veinlets, and other replacement deposits, some of them entirely disconnected with other pegmatite masses. The following conditions are possible evidence of intrusion: The occurrence of irregular-shaped horses and distorted sheetlike horses without parallelism to the walls; a typical coarse granite texture and its persistence through a considerable distance; a bending of the schistosity of the inclosing rock around pegmatite bodies without evidence of replacement (this may also take place around deposits from solution in which the force of crystal growth has distended the wall rock).

[a] Mica deposits of South Dakota: Bull. U. S. Geol. Survey No. 380, 1909, pp. 382-397.

SUPPOSED DEPOSITS OF GRAPHITE NEAR BRIGHAM, UTAH.

By Hoyt S. Gale.

Reported deposits of graphite near Brigham, Utah, have recently been the subject of considerable interest in a more or less local way. Prospects situated on Threemile Creek, between the settlements of Brigham and Perry, Boxelder County, Utah, were visited by the author in October, 1909, and several samples representative of the material that had then been exposed were collected. These samples have been analyzed by Dr. Chase Palmer in the Geological Survey laboratory.

The deposits near Brigham form a part of a series of metamorphosed sediments, presumably of pre-Cambrian age. The associated rocks consist of slates and schists, graywackes, conglomerates, and quartzites, all more or less sheared and contorted. Some beds of black, somewhat foliated schist are included in this series, and these beds are apparently derived through metamorphism from strata containing carbon, probably originally in the form of organic remains, if organic material may be assumed to have existed in rocks of pre-Cambrian age. The carbonaceous schists outcrop near the channel of Threemile Creek, having a general east-west strike and showing at intervals for at least three-fourths of a mile. The carbonaceous beds exposed in the shallow prospects appear to be at least 15 or 20 feet in thickness, and as they evidently represent an original stratum of the sedimentary series, it is quite probable that they may prove fairly persistent both horizontally and in depth throughout the area in which the outcrops occur. The carbonaceous schist shows a black lustrous polish resembling that of graphite, especially in joints or on the foliation of the rock. When pulverized, however, the substance lacks the smooth, greasy feeling of pure graphite, but much of the material selected as most promising for commercial use appears to be free from coarse sand or grit.

An average sample representing 7 feet 4 inches of the beds exposed in the main prospect was analyzed, giving the following results:

Analysis of average sample of supposed graphite from deposits near Brigham, Utah.

Moisture and volatile matter	3.34
Fixed carbon (by difference)	3.48
Ash	93.18
	100.00

Another sample collected at random from a more foliated or schistose bed associated with a large vein of quartz about three-fourths of a mile farther up the canyon gave the following test:

Analysis of supposed graphite from deposits near Brigham, Utah.

Moisture	1.24
Volatile matter	9.97
Fixed carbon (by difference)	5.48
Ash	83.31
	100.00

As these analyses ran unexpectedly low, test was made of a selected piece of the richest-looking material. The result of this test is essentially similar to the others:

Analysis of selected sample of supposed graphite from deposits near Brigham, Utah.

Moisture and volatile matter	5.03
Fixed carbon (by difference)	5.59
Ash	89.38
	100.00

In all these tests the carbon burned off in the flame of an ordinary Bunsen lamp without the use of the blast, apparently indicating that the substance is more of the nature of an impure coal than of graphite. The ash derived from the combustion of these samples is essentially clay of a light-gray color, showing it to be free from whatever carbon it originally held.

Material resembling the deposits near Brigham in appearance is used in the manufacture of paint and also for foundry facings. This usually contains, however, over 20 per cent of carbon in the form of true graphite. The Brigham material, although containing little or no graphite, may possibly prove of value as a paint pigment. Its value for fire-resisting purposes is questionable.

SURVEY PUBLICATIONS ON MISCELLANEOUS NONMETALLIC PRODUCTS—ASBESTOS, BARITE, FELDSPAR, FLUORSPAR, GRAPHITE, MICA, QUARTZ, ETC.

The following list includes a number of papers, published by the United States Geological Survey or by members of its staff, dealing with various nonmetallic mineral products. The government publications, except those to which a price is affixed, may be obtained free by applying to the Director, U. S. Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

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STERRETT, D. B. Mica deposits of western North Carolina. In Bulletin 315, pp. 400-422. 1907.

——— Meerschaum in New Mexico. In Bulletin 340, pp. 466-473. 1908.

——— Mica deposits of South Dakota. In Bulletin 380, pp. 382-397. 1909.

——— Mica. In Mineral Resources U. S. for 1908, pt. 2, pp. 743-754. 1909.

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ULRICH, E. O., and SMITH, W. S. T. Lead, zinc, and fluorspar deposits of western Kentucky. In Bulletin 213, pp. 205-213. 1903. 25c.

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