

# SOME DEPOSITS OF MICA IN THE UNITED STATES.

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## INTRODUCTION.

This paper is intended to present descriptions of a number of mica deposits examined in various parts of the United States during the summer of 1913. It has not been prepared with any idea of attaining completeness, either for the whole United States or for any of the States in which mines were examined, but describes only those deposits which could be reached in the time available. General information on the production, value, uses, and nature of mica is given only very briefly.

Much assistance was kindly rendered by many persons during the examination of different mines and is here acknowledged. Aid was given in New Hampshire by Samuel Cordick, superintendent of the General Electric Co.'s mine; Andrew T. Orr, of the Mica Products Co.; C. W. Bryant, of the Standard mine; L. R. Brown, of Canaan; G. N. Ricker, of Canaan, who furnished general information on a number of mines in Grafton County and extended other kindnesses; M. M. Kilton, of Grafton Center; L. L. Howard, of the Keene Mica Products Co.; W. A. French, of the American Insulator & Mica Co.; Leon Allen, of Keene; and Edward Howard, of East Alstead; in Virginia by P. Lippert and Capt. McCray, of the Ridgeway Mica Co., and several persons owning mica prospects near Axton; in North Carolina by George H. Hauser, of Winston-Salem; in South Carolina by Earle Sloan, formerly State geologist; R. C. Willimon, of Greenville; and J. J. Fretwell, of Anderson; in Texas by George Kirtley and Mr. Elerding, of the Texas Mica Co.; and in Colorado by J. D. Endicott, of Canon City; B. H. Bigger, of Morrison; and Messrs. Kitchens, of Masonville. Other persons helped with many little kindnesses.

The production of partly trimmed sheet mica in the United States in 1912 amounted to 845,483 pounds, valued at \$282,823, and the production of scrap mica amounted to 3,226 short tons, valued at \$49,073, a total value of \$331,896. In 1913 the value of the production exceeded \$400,000. The price of mica varies greatly according to the quality and the uses to which the mica is to be put. It is also subject to considerable variations due to market conditions.

Very little of the mica mined can not be used in some way, but some of it, known as scrap and suitable only for grinding, may bring as low as \$10 to \$15 a ton. From these figures the price ranges to more than \$1,000 a ton for large sheet mica. The average price paid for run of mine mica, not split or sorted, ranges from \$50 to \$200 a ton. During part of 1913 a prominent mica company offered the following prices per pound for rough trimmed sheet mica of good quality guaranteed to cut into plates of the sizes indicated:

To punch disks 1½ inches in diameter.....	\$0.03½
To cut sheets 1½ by 2 inches.....	.12
2 by 2 inches.....	.30
2 by 3 inches.....	.70
3 by 4 inches.....	1.35
4 by 6 inches.....	2.25
6 by 8 inches.....	4.00

Specked and clay-stained mica may bring less than half these prices, and mica of exceptionally good grade would command higher prices.

Mica is used in various industries, such as the manufacture of electric machinery, stoves, certain forms of lamp chimneys, fireproof materials, wall papers, and lubricants. The perfect insulating qualities of mica and the adaptability of its sheets to various forms of manufacture render it unsurpassed for use in electric apparatus. By fitting together and cementing with shellac many small thin sheets, mica is built up into large sheets of "micanite," or "mica board," which are suitable for many forms of electric 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. Ground mica is used to impart a silvery luster to wall paper and for other decorative effects. It is also mixed with oils and grease for lubricating. Ground mica mixed with shellac, called "molded mica," is used in electric insulators of various types.

#### CHARACTERISTICS OF MICA.

Of the several varieties of mica only two, muscovite and phlogopite, have extensive application in the industrial world. Only muscovite is mined in the United States.

Muscovite, like all the other micas, belongs to the monoclinic system of crystallization but has a symmetry approximating the hexagonal. This symmetry is indicated by nearly hexagonal outlines observed in the prisms, by the percussion figures, and by "ruled" and "A" mica.

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 com-

plete the simplest crystal, 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. Fairly well developed hexagonal or rhombic prisms are occasionally 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 partly crushed mica has been removed. This is accomplished by rough splitting or cleaving the large book into sheets one-sixteenth 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.

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  $60^\circ$  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.

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. Most of these characteristics are well known to users of mica or can be readily recognized when first encountered.

Muscovite is sometimes called white mica, in allusion to its high transparency when split into thin sheets. In such sheets very little if any color is visible, but the same mica may show a strong color in sheets one-sixteenth of an inch or more thick, and it is to these thicker sheets that reference is made in describing the color of mica in the following pages.

Mica from different deposits, either in the same or in different States, may show wide variations in quality. It is not possible to assign certain constant qualities to mica from any one State which has a number of mines in intermittent operation. Accordingly accurate comparisons can not generally be made between the output from the several producing States. Mica of variable quality is found in nearly every region where more than one deposit is worked.

## GENERAL GEOLOGY.

Most of the mica deposits of the United States occur in regions of highly metamorphic gneisses and schists. A few have been found in less altered granites or other igneous rocks. The highly metamorphic gneisses and schists are considered to be of pre-Cambrian age in most places, but in others the age has not been determined.

Deposits of muscovite mica of commercial value are confined to pegmatite. This rock is variable in composition, but in its more normal phases is composed of feldspar and quartz, with or without mica and other minerals. It is therefore allied to granite in composition and has been called giant granite. Its texture grades from that of ordinary granite to that in which the individual grains or minerals measure a number of feet across, and both these extremes may be found in the same deposit.

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 which may be several feet thick.

Quartz occurs in several ways in pegmatite—either intermixed with feldspar and mica in granitic texture, or graphically intergrown with feldspar, or segregated out into large separate masses. The segregated quartz may form sheets or veins in the interior or along the walls, or it may occur in irregularly shaped bodies through the pegmatite. It is massive and generally granular, though locally showing rough crystallization.

The mica is found in various positions in the pegmatite and no definite rule can be laid down for guidance in finding it in different deposits. In the pegmatites in which quartz segregations are prominent the mica is generally richest near the quartz. In some deposits the mica follows one or the other wall, and in others it may be either regularly or irregularly distributed through the pegmatite. The mica occurs in rough crystals and blocks, which range in diameter from a small fraction of an inch to several feet. The rough blocks, as obtained from the mines, generally yield only a small percentage of trimmed sheet mica, a yield of 10 per cent being unusually high. The remaining mica is suitable only for grinding.

Pegmatites occur in irregular masses, sheets, and lenses, which range in size from small deposits to those many yards in thickness and length. These masses cut the country rock, either conformably with its bedding or at various angles to it. Some pegmatites are conformable with the bedding of the inclosing gneisses or schists through part of their extent and cut across it in other places. The irregularities in the shape of pegmatite deposits render their mining difficult.

**NEW HAMPSHIRE.**  
**HISTORY OF MICA MINING.**

Mica mining in the United States began with the opening of the Ruggles mine in Grafton County, N. H., about 1803. Later other mines were opened in New Hampshire, which for many years furnished practically all the mica used in the United States. Mining was carried on in a desultory way until about 1840, and then operations became extensive until 1860. After 1868, when mica mining commenced in North Carolina, the production in New Hampshire declined, and in the last 40 or 50 years it has only intermittently formed a considerable part of the total production in the United States. Large imports and large outputs of mica from other States have several times so reduced the price of mica as to nearly make its mining unprofitable in New Hampshire. During the last three years there has been a revival in mica mining in this State, and the production for 1913 was larger than for a number of preceding years.

Most of the New Hampshire mica mines have been worked intermittently, and some of them have been operated on a large scale. New mines of value are still being discovered and some of the old mines are opened at intervals with varying results. The dumps of some of the old mines have been worked over for the smaller sizes of sheet mica and the scrap mica thrown away during earlier mining. The yield of mica from such operations has been large.

The mines described below are only those examined during part of June, 1913. A number of large and well-known mica mines of New Hampshire are not included simply because it was not possible to visit them in the time available. The descriptions include several mines not in operation as well as those being worked at the time of examination. Some of the descriptions are very incomplete, as the mines were in such a condition that details could not be learned, or sufficient time was not available for complete study.

Mica deposits have been mined in Grafton, Cheshire, Sullivan, Merrimack, Strafford, and Coos counties. The best deposits lie in a belt (probably a broken belt) extending from Keene through the middle of Cheshire County northward into Sullivan County and the northwestern part of Merrimack County and east of north to about the center of Grafton County. The principal mining districts in this belt are in the towns of Rumney, Groton, Alexandria, Orange, and Grafton. There are also a few mines in Dorchester and Canaan, Grafton County; Danbury and Wilmot, Merrimack County; Springfield and Acworth, Sullivan County; and Alstead, Gilsum, and Sullivan, Cheshire County. The shipping points have been Rumney, West Rumney (now Swainsboro railway station), Bristol, Canaan, Grafton Center (now Cardigan railway station), Grafton, Danbury, and Keene.

**GENERAL FEATURES OF OCCURRENCE.**

The mica deposits of this region lie in broken mountain country at elevations ranging from less than 1,000 to over 3,000 feet above sea level. Swampy areas, ponds, and lakes, characteristic of glaciated regions, occur in unexpected places among the hills. Much of the country is rather thickly covered with second-growth timber and brush. The roads away from the main lines of travel are bad or indifferent, so that some of the mines are not easily accessible. The abandonment of many of the farms in the mica region is responsible for the poor condition of the roads and for the heavy growth of brush now mantling large areas of the country. This desertion of the farms also works another hardship on the mica industry, making it difficult for the miners to find boarding places or for the companies to purchase food and forage for the camps.

The rocks of the mica region of New Hampshire are complex and consist of a series of metamorphic schists and gneisses with intruded granite and pegmatite. The mica deposits are not confined to any one definite type of rock. Hitchcock<sup>1</sup> states that mica deposits of value are to be found chiefly in an area of fibrolite-mica schist, a subdivision of the "Montalban group" as mapped in his "Geologic atlas of New Hampshire." Many of the largest mines are located in areas of this rock, but some valuable mines are included in areas of rock mapped under different names.

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

**GRAFTON COUNTY.**

*General Electric Co.'s mine.*—A new deposit of mica half a mile west of Swainsboro (formerly called West Rumney) was opened two years ago by the General Electric Co., of Schenectady, N. Y. This deposit is on the Burley estate and had been known for several years. The pegmatite is exposed through a short distance only, so that there had been much hesitancy by prospective buyers about purchasing the property until it was finally taken up by the General Electric Co. This company set up a shop and storage house near the mine and has equipped a building near by with the best modern power machinery for the first steps in manufacturing the mica on a large scale. The plant can also be utilized in preparing mica that may be obtained from other mines in the region owned by the company or from other producers.

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<sup>1</sup>Hitchcock, C. H., *Geology of New Hampshire*, vol. 3, pt. 5, pp. 89-91, 1878.

The mine is located near the top of a small hill about 60 feet above the valley on the south side. The position of the workings and surrounding features is shown in the rough sketch forming figure 12. The work consists of an open cut or stope 50 feet long in a N. 60° E. direction, 55 feet deep on an average incline of about 60° NW., and of varying width. The mine is about 50 feet higher than the terrace ground below.

The country rock is mica gneiss. Near the pegmatite it consists of a highly foliated quartz-biotite-muscovite gneiss. Fibrolite, if present, is not conspicuous. The gneiss has been strongly folded near the mine and strikes from N. 60° E. with high northwest dip to north with 70° E. dip. The pegmatite is in part conformable with the inclosing gneiss, having an average strike of N. 60° E. and dip

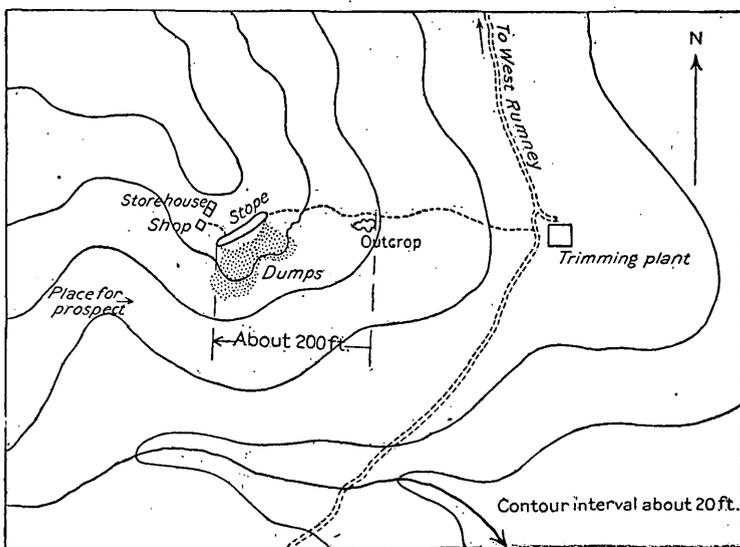


FIGURE 12.—Rough sketch of General Electric Co.'s mica mine near Swainsboro, Grafton County, N. H.

of 60° NW. through the 100 feet where it has been exposed by stripping of the hillside soil. If the pegmatite holds this strike to the southwest for more than 100 feet it could be opened at a level nearly 50 feet lower. A prospect trench in the position shown in the sketch would determine this point. The width of the vein exposed in the working averages about 8 feet but varies from 18 feet at the surface to 4 feet in the bottom at the northeast end. Variations in thickness occur where there are rolls or pinches in the wall rock. About 150 feet due east of the mine a mass of pegmatite several feet thick outcrops on the hillside. This might be the same vein warped from the strike shown in the workings, or it may be another body of rock.

The pegmatite has a varied texture, some being very coarse grained and some resembling coarse granite. In places along the contacts

where the texture is not coarse there is a partial banding of mica-rich streaks with mixed quartz and feldspar. The vein is richest in mica along the hanging wall for a thickness of 1 to 3 feet, but bunches or pockets of good mica also occur scattered through the mass of the pegmatite. The mica crystals range from small ones to some 2 feet or more in diameter. Much of the mica is in clean crystals with good, flat cleavage. It has a clear light rum color, and the best sheets make an excellent stove mica. Fragments of beryl crystals 2 to 6 inches in diameter were observed on the dump. These crystals are reported to range from 6 to 12 inches in length.

The pegmatite in the outcrop between the mine and trimming plant is coarse grained. It contains large masses of quartz with some mica and should be prospected.

*Palermo mine.*—The Palermo mica mine (formerly called Hartford) is about  $1\frac{1}{2}$  miles southwest of North Groton, in one of the ridges on the northeast side of Bald Head Mountain. This mine is one of those noted large producers of mica of which several have been worked extensively in New Hampshire. It is now said to be owned by the General Electric Co. No work was in progress at the time of examination and many of the workings were filled with water. The following description has been prepared from a study of the dumps and workings still open and from information kindly furnished by Mr. L. R. Brown, of Canaan. Mr. Brown was superintendent for nearly 20 years when the mine was in operation.

The workings available for examination are described below: An open cut (1, fig. 13) 100 feet long, 40 feet deep in the end, and 20 to 30 feet wide, is driven N.  $10^{\circ}$  W. into a steep hillside. (See fig. 13.) At the end of the cut there is a large tunnel or room (2, fig. 13) 50 feet long with deep inclined stopes from it; an upraise (3) connects with workings about 30 feet higher and to the west, where an open cut (4) 30 feet long has been made, with drifts and stopes carried underground on the pegmatite. Another open cut (5) 20 to 30 feet wide and 40 feet long had been made to the northeast of the main working, and about 50 feet higher than the main cut. From this an inclined shaft (6) was sunk, and according to Mr. Brown this shaft connected with one of the main stopes of the mine at considerable depth. Water filled the workings to the level of the main open cut. Several large dumps have been built up to the south and west of the mine and cover more than 2 acres of ground. Iron rail tracks lead to the later dumps from the deep stopes at the end of the open cut. Several of the buildings have collapsed, and all are in a bad state of repair. A thick growth of brush and saplings conceals much of the dumps and the area around the mine. Parts of the dumps have been worked over for small sheet and scrap mica thrown away during earlier opera-

tions. These dumps are probably not more than half worked over and will still yield a quantity of small sheet and scrap mica.

The following information was supplied by Mr. Brown, who states that the inclines with stopes sunk from the room at the end of the main cut are very extensive. Three inclines were sunk in about the position shown in figure 13 to depths of more than 300 feet. The vein (7, fig. 13) between these inclines was stoped out in large masses, pillars being left where necessary. The inclines were steep, probably at least  $45^\circ$ , and were equipped with tracks and mine cars raised by the hoisting engine in the end of the main open cut. The mine did

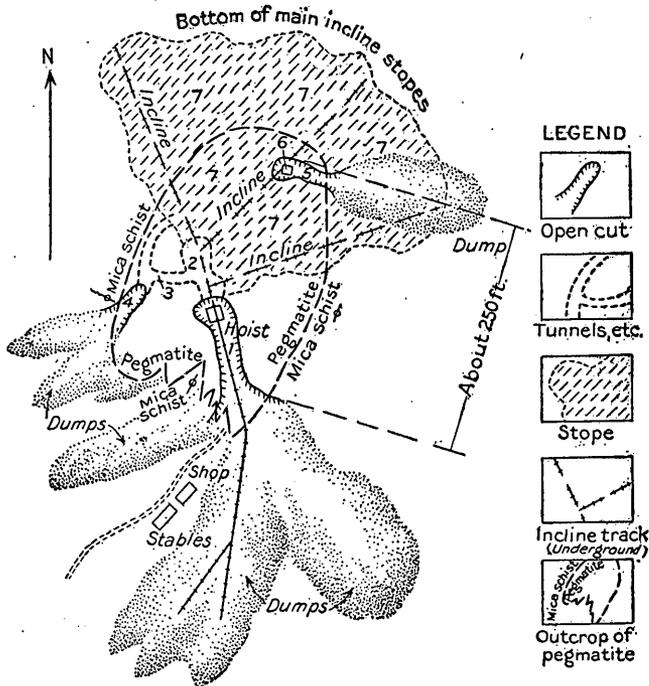


FIGURE 13.—Plan of Palermo mica mine, near North Groton, Grafton County, N. H. See text for explanation of numbers.

not require a great amount of pumping when the quantity of ground opened is taken into consideration. One stope was nearly 30 feet high and 60 feet long, representing a huge pocket of almost solid mica. Most of the work was done by single-hand drills. At one time 85 miners were employed and 25 to 30 girls were kept busy sorting and trimming mica.

The country rock is a lumpy or porphyritic biotite schist or gneiss, in which the lumps appear to be composed almost entirely of bunches of muscovite mica. The strike of this rock, measured near the mine, varies through wide limits, owing to distortion during intrusion of the pegmatite. The pegmatite cut across the country rock in a

large, irregularly shaped mass, whose approximate outcrop is shown in figure 13. This outcrop indicates an oval or pipe-shaped deposit, but from the information furnished by Mr. Brown and incorporated in the sketch the pegmatite appears to spread out as either a curved sheet or a conical mass underground. Owing to the resistant qualities of the rock the outcrop forms a small knob on the end of a ridge. The texture of the pegmatite is diverse, and in places extremely coarse. Feldspar occurs in crystals and masses several feet across, and some of the irregular quartz segregations are large. In places the rock carries much small mica mixed with feldspar and quartz. Large mica is reported to have been found proportionally rich in pockets through the vein. Mr. Brown tells of one mica crystal found which measured 4 feet 2 inches long and 28 inches wide, and of another fine crystal with sharp edges and fairly smooth faces 2 feet square and 2 feet thick. The mica left in the dumps shows that the mine yielded a clear, rum-colored mica of good quality.

Among interesting specimens found on the dump were beryl and zinnwaldite mica. The beryl ranged from small greenish translucent crystals to opaque crystals 3 inches across. One rough crystal of mica less than an inch across, found on the dump, was determined to be zinnwaldite by W. T. Schaller, of the Geological Survey. The sheets of this mica show a clear brown core and an exterior of bluish green, about the color of indicolite tourmaline. These colors are arranged parallel to lines of crystallization and the blue contains thin zonal growths of the brown. Both parts give the reactions of zinnwaldite.

*Mica Products Co.'s mine.*—Two new mica deposits 1 mile west of North Groton were opened during 1913 by the Mica Products Co., of Philadelphia. At one of these an open cut was being made extending southwestward into a steep hillside for a height of about 45 feet. The cut was carried back into the hillside by benches, the waste rock being rolled to the bottom and carried off in mine cars to the dump.

The country rock is mica gneiss, in places carrying fibrolite. It is cut by pegmatite, striking N. 48° E. and dipping about 80° NW. The pegmatite ranges from 8 to 16 feet in thickness, with an average of over 12 feet. The mica is richest near the middle of the vein, but some is scattered through other parts. Much of the mica is rather small but of fine stove quality. It is of a beautiful clear rum color in sheets one-tenth of an inch thick. One crystal was found that weighed 24½ pounds and would cut into sheets over 6 inches square.

The other deposit lies a couple of hundred yards north, and was being prospected by small cuts in an outcrop of hard pegmatite about 50 feet wide. The pegmatite is inclosed in mica gneiss or schist, and has a strike of N. 45° E. and a vertical dip. The mica obtained here has been exposed to the weather and is not as sound as that from

the other working. It might be found to improve with depth, if present in sufficient quantity to pay for development. Pale-green beryl crystals were found, parts of which were clear enough for gems.

*India Mica Co.'s mine.*—The India Mica Co.'s mine is in the southeast corner of the town of Dorchester, near Bryant Pond, about  $5\frac{1}{2}$  miles N.  $40^{\circ}$  E. of Canaan. The mine was closed in 1906, after several years of active operation. It had good equipment in the way of camp, engines, and machinery. Two principal openings were made, an open cut 70 feet long and 20 feet deep north of the engine house and a cut 50 feet long opening into a stope 50 feet deep south of the engine house. (See fig. 14.) Pillars were left in this stope and five tiers of floors were built, with stulls and lagging. An inclined track extended from the engine house down into the stope for the removal of mica and waste rock.

The country rock is quartz-biotite schist which strikes N.  $20^{\circ}$ – $35^{\circ}$  E. and has a steep west to vertical dip. Near the pegmatite the schist contains much black tourmaline in small crystals. The pegmatite is approximately conformable with the inclosing schist. In the north working the formations have been kinked or folded, as shown by the shape of the open cut (fig. 14). The pegmatite is in the main from 6 to 10 feet thick, and the entire thickness was removed in mining at the southwest end of the mine. At the surface the pegmatite bulges to 12 feet in thickness, but is poor in mica. At 50 feet below the surface the

vein, it is reported, pinches down to 12 inches in thickness. The texture of the pegmatite appears to be rather even. The feldspar is mostly oligoclase and was not found in very coarse crystals. The mica has a clear light rum color and some of it is of good quality. It occurs in crystals, some of which weigh 50 pounds. In the folded part of the pegmatite many of the mica crystals are twisted and of poor quality.

Two hundred yards west of north of the mine a prospect was opened on an outcrop of pegmatite 15 feet thick. Mica, mostly small, was found associated with large segregations of quartz. Black tourmaline is also present in the pegmatite.

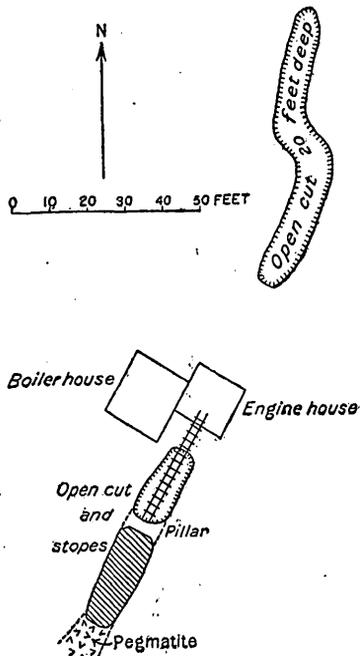


FIGURE 14.—Plan of India Mica Co.'s mine, in the southeast corner of the town of Dorchester, Grafton County, N. H.

During the earlier days of mining by the India Mica Co. the mica as it came from the mine was hauled to Canaan and there graded for shipment. Later a plant was set up in Canaan and the mica was rough trimmed for the market.

*Keyes mine.*—The Keyes mica mine is  $4\frac{1}{2}$  miles N.  $50^\circ$  E. of Canaan, in the town of Orange, on the east side of the north end of Tugg Mountain. The principal working was an open cut of about the shape shown in the rough plan in figure 15, and 5 to 18 feet deep. Most of the open cut was in pegmatite, but streaks or horses of the biotite mica gneiss country rock were encountered at the places shown. The full thickness of the pegmatite was not exposed, but is probably at least 50 feet with the mica gneiss inclusions. One large horse of

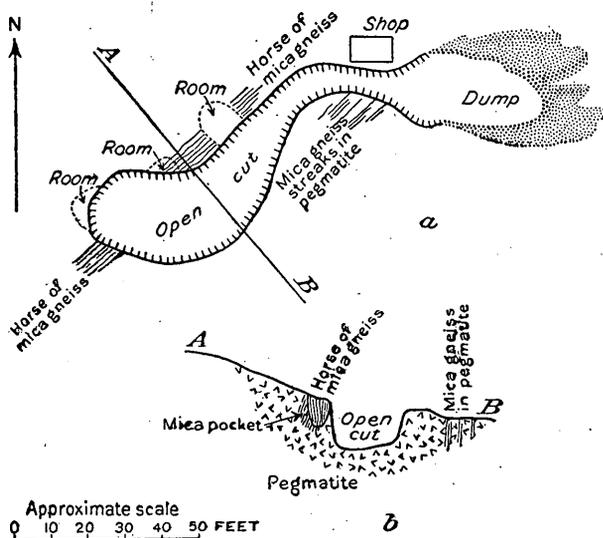


FIGURE 15.—Plan and cross section of Keyes mica mine,  $4\frac{1}{2}$  miles northeast of Canaan, Grafton County, N. H., showing workings and part of geology.

gneiss is 10 feet thick, but does not extend far into the pegmatite, as shown in the cross section (fig. 15). The inclusions all strike northeast, which is probably also the trend of the pegmatite. The texture of the pegmatite is coarse in places, the feldspar crystals measuring a foot or two across. The mica is somewhat pocketed and appears to be richest near the contact with the mica gneiss. At the bottom and on the west side of the large horse of mica gneiss good mica has been left in the pegmatite. The mica has a clear light-rum color and some of it is of good quality. The pegmatite carries beryl, pieces of which were seen on the dump, and one crystal 8 inches across had been left in the rock. A few rough quartz crystals were removed during mining, but most of the quartz is massive.

*Sanborn mine.*—The Sanborn mica mine is on Tugg Mountain, about  $3\frac{1}{2}$  miles N.  $70^{\circ}$  E. of Canaan. It has not been operated for three years. The developments consist of an open cut of the shape shown in figure 16. This cut is about 100 feet long, with an enlargement at the south end, and is 10 to 20 feet deep. The country rock is a highly foliated mica gneiss with quartzose and micaceous layers. Both biotite and muscovite are present. The gneiss strikes N.  $10^{\circ}$ – $20^{\circ}$  E. and has a high dip to the east. Several beds of pegmatite, whose surfaces have been rounded by glacial erosion, outcrop on the summit of the hill. These pegmatites are in part conformable with the inclosing gneiss, but in places cut across its bedding. The mica has been obtained from a small bed of pegmatite about 10 feet thick, which has branched out

from a large mass of pegmatite into the surrounding gneiss and from around the end of the body of mica gneiss included between the fork and the main mass of the pegmatite. The inclosed body of gneiss is about 60 feet thick and at the south end the contact has a pitch to the north of about  $35^{\circ}$ . The cross section in figure 16 shows the relations between the pegmatite and gneiss. The pegmatite has an uneven texture and in places contains quartz segregations. More mica is exposed in the outcrop south of the open cut near the contact of the pegmatite at a place where the mica gneiss has been crumpled by folding. The mica seen around the mine was of fair quality, some having a clear rum color and some a slightly greenish cast.

*Belden or Standard mine.*—The Belden or Standard mine is on the south end of Tugg Mountain, 3 miles N.  $75^{\circ}$  E. of Canaan. It has been operated by several persons and companies, and worked by the Standard Mica Co. on an extensive scale. The last work was done by C. W. Bryant, of Lebanon, in June, 1913. At this time the mine consisted of an irregular-shaped open cut or quarry about 250 feet long in a north-south direction, about 200 feet wide, and from 10 to 45 feet deep. Another smaller open cut had been made to the

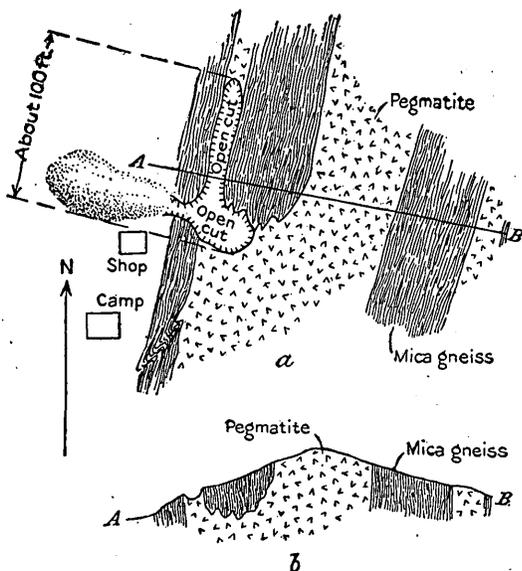


FIGURE 16.—Plan and cross section of Sanborn mica mine,  $3\frac{1}{2}$  miles N.  $70^{\circ}$  E. of Canaan, Grafton County, N. H., showing geology and workings.

south of the main quarry. The approximate position of the openings, mine buildings, tracks, dumps, etc., is shown in the rough sketch in figure 17. The quarry was worked to different levels in benches, as shown in the figure. At the south end of the main quarry two short tunnels were made.

The country rock is mica gneiss composed of quartzose layers and layers rich in biotite and muscovite. The pegmatite is a very large mass whose relation to the country rock is not exposed. The impression gained by examination of the workings is that of a thick bed

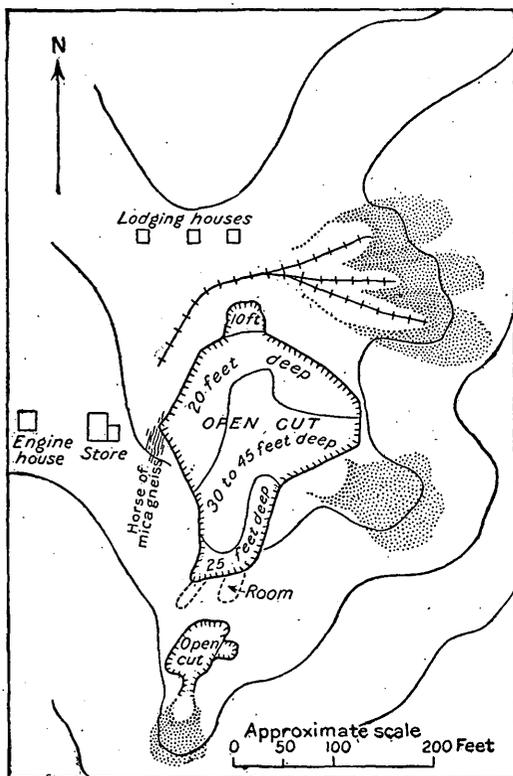


FIGURE 17.—Plan of workings at Belden or Standard mica mine, 3 miles N. 75° E. of Canaan, Grafton County, N. H.

with a northerly strike and a dip of 20°–30° E., but it is possible that the dip is more nearly vertical. The open cut is wholly in pegmatite except for a small horse of mica gneiss on the west side. This gneiss has been strongly metamorphosed and contains a quantity of black tourmaline. It appears to merge into the pegmatite. The pegmatite varies in texture and in places is very coarse. Feldspar crystals 1 to 3 feet thick were seen, and quartz occurs in irregular segregations and veins, in one place 7 feet thick. Beryl crystals are rather common, and the mica and beryl are most plentiful around the quartz masses. In general the mica is rather pockety, but a few crystals occur scattered through the pegmatite, and to insure the recovery of all this mica the whole of the pegmatite was mined by the Standard Mica Co. This proved to be an extravagant method. The later work by Mr. Bryant was directed only toward those parts of the pegmatite found to be richest in mica.

The pegmatite is composed of two kinds of feldspar, microcline and albite. In places the microcline has formed a rough graphic intergrowth with quartz. Some of the albite occurs in rough crystals,

and beryl are most plentiful around the quartz masses.

almost of the clevelandite type. Black tourmaline is scattered through the pegmatite with small quantities of bluish-green apatite and opaque garnets. The beryl crystals range from small ones to some 10 inches in diameter and 12 inches long. Probably several tons of rough opaque crystals could be gathered up around the mine. Most of the mica is small, under 4 by 6 inches, but sheets 8 by 10 inches are reported to have been cut from the largest crystals. The mica is of fair quality; showing shades of both rum and green colors.

Other mica prospects have been tested on the same property, one 150 yards southwest, another about 300 yards southwest, and another 250 yards north-northwest of the main mine. At the first of these the pegmatite is at least 40 feet across and carries a quantity of small mica. Along the west contact of the pegmatite the gneissic wall rock merges into the pegmatite as if by a fusion contact. At the second place an open cut 50 feet long was made on a pegmatite vein  $2\frac{1}{2}$  to 6 feet thick, and another cut 45 feet long on another vein 1 to 4 feet thick, lying 60 feet to the west. These pegmatites are in part conformable with the inclosing gneiss, but one of them has a branch or fork cutting across the foliation.

*Hoyt Hill mine.*—The Hoyt Hill mine is 3 miles S.  $75^{\circ}$  E. of Canaan, near the summit on the west side of Hoyt Hill. The working consists of an open cut or shaft 20 feet across and reported to be about 50 feet deep, inclined to the north. It was filled with water at the time of examination, and only surface conditions could be studied. The country rock is mica gneiss composed of biotite and muscovite schists with quartzose layers. Black tourmaline is present in some of the layers. The schist layers of the gneiss are in places strongly folded and crumpled and inclose lenses and streaks of quartz, pegmatite, and granite. The strike is N.  $30^{\circ}$ – $40^{\circ}$  E. and the dip is rather variable. The pegmatite cuts through the gneiss in the form of a stock or pipe. The plan of the open cut in figure 18 shows the approximate shape of the deposit. On the northeast side the pegmatite forks out into the gneiss. On the east side the gneiss has been crumpled by the intrusion of the pegmatite. Among the minerals observed on the dump were pinkish plagioclase feldspar, black tourmaline, and green apatite. The mica has a clear rum color, and crystals of good size are said to have been obtained.

*Prospect near Orange.*—A mica deposit was worked on the road from Orange to Alexandria, about  $3\frac{1}{2}$  miles east of Canaan and half a

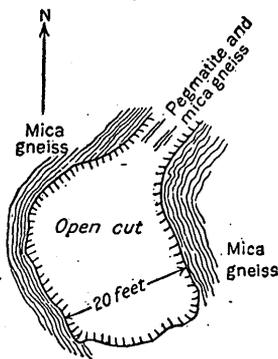


FIGURE 18.—Plan of Hoyt Hill mica mine, 3 miles S.  $75^{\circ}$  E. of Canaan, Grafton County, N. H.

mile southeast of Orange. Two open cuts and a short tunnel were made in the position shown in figure 19. The cut near the road is reported to have been 30 feet deep, but is now filled up. The one to the north is about 15 feet deep, but is at present filled with water. The country rock is mica gneiss containing streaks of fine biotite schist. It strikes N. 10° E., and stands vertical.

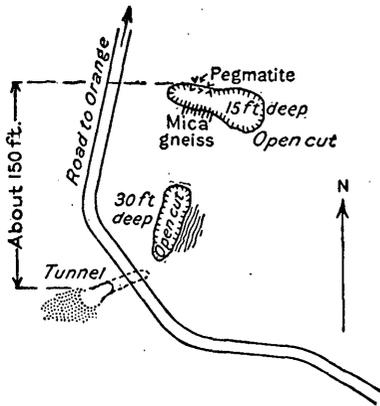


FIGURE 19.—Plan of workings at mica prospect half a mile southeast of Orange, Grafton County, N. H.

The country rock is mica gneiss containing streaks of fine biotite schist. It strikes N. 10° E., and stands vertical. The pegmatite is irregular in shape and was not found in the northern open cut in line with the strike shown by the work near the road. Black tourmaline is plentiful in the pegmatite and occurs in crystals 4 inches in diameter. Very little mica had been left around the mine.

*Ruggles mine.*—The Ruggles mine is in Isinglass Mountain, 1½ to 1¾ miles northwest of Grafton Center (Cardigan railway station). Several sets of openings have been made, but only one set at the south end of the mountain was examined.

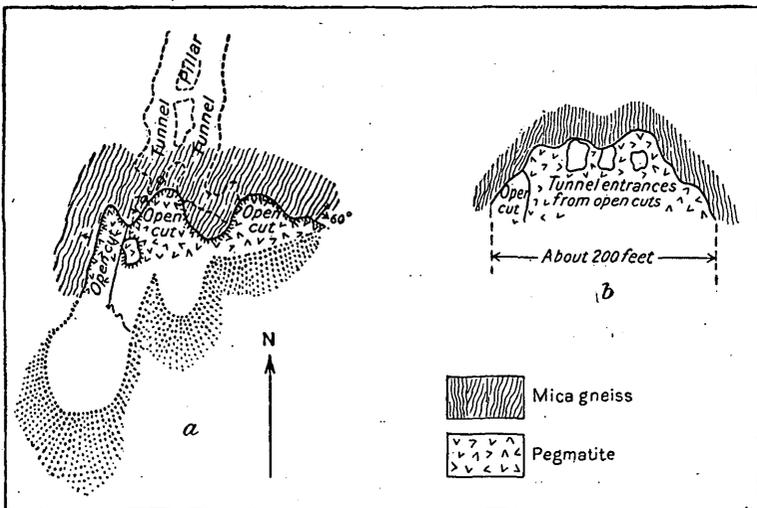


FIGURE 20.—Plan and cross section of part of Ruggles mica mine, near Grafton Center, Grafton County, N. H., showing workings and geology.

Other workings are reported to have been made below this on the mountain side half a mile farther north. The workings are on the steep south slope of the mountain and consist of three partly connected open cuts with tunnels driven back into the mountain from them. (See fig. 20.) These tunnels are large and irregular, opening

into rooms and down stopes on the sides. Light was not available to examine them for more than 100 feet back, but they appear to be long and large. The open cut on the west is at a lower level than the other two cuts.

The country rock is mica gneiss in which biotite schist is prominent. Its banding is due to other layers, especially those rich in quartz. Near the pegmatite the gneiss is contorted and contains much tourmaline. The country rock strikes N.  $10^{\circ}$ - $20^{\circ}$  E., and dips from  $60^{\circ}$  E. to  $70^{\circ}$  W. The pegmatite is large and at the place opened forms a dome-shaped mass cutting across the gneiss, as shown in the cross section (fig. 20). On the sides the dip of the pegmatite is steep and is approximately conformable with the schistosity of the inclosing rock. The contact of the dome-shaped mass of pegmatite is irregular and pitches  $20^{\circ}$  S. in the workings on the surface. Back in the tunnel the pitch is more nearly horizontal. Horseshoes of tourmalinated biotite schist are inclosed in the pegmatite. Evidently large masses of the pegmatite were found to be rich in mica, and in a few places good mica has been left in sight in pillars and some smaller mica that would pay to mine remains in the walls. The dumps are large and contain much mica, some that would yield sheets measuring from 3 by 4 inches down to punch size and scrap mica. During part of 1912 and 1913 the dumps around a few of the openings were worked over with good results. The mica from the Ruggles mine has a clear rum color and good cleavage, and is suitable for glazing and electric uses.

*Kilton mine.*—The M. M. Kilton mine is 1 mile N.  $50^{\circ}$  W. of Grafton Center (Cardigan railway station). It has been in operation in a small way for a number of years, and at the time of examination the prospects for opening a good deposit of mica were bright. The mine is in a steep hillside at the south end of Isinglass Mountain, about a third of a mile south of the south end of the Ruggles mine. The workings consist of an irregular open cut about 25 feet deep with rooms from its sides and a stripped area with surface excavations on the hill above. The relations are shown in the rough sketch in figure 21.

The country rock is mica gneiss composed of beds of schist containing variable quantities of biotite, muscovite, and quartz as principal constituents, with accessory minerals. The gneiss strikes east of north and has a nearly vertical dip. The pegmatite body is large and varies from coarse-grained rock in the deeper workings to fine pegmatitic granite carrying black tourmaline southwest of the mine. The excavations have developed a mass or roof of mica gneiss covering a part of the pegmatite on the east side of the mine. The lower contact between the pegmatite and the gneiss is approximately hori-

zontal, with small rolls, but it is not conformable with the foliation of the gneiss. A small normal fault trending N. 10° E. and dipping

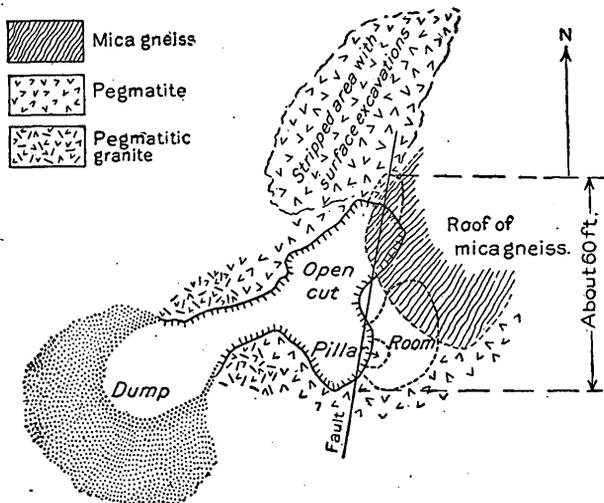


FIGURE 21.—Plan of Kilton mica mine, near Grafton Center, Grafton County, N. H., showing workings and geology.

80° W., with a 3-foot downthrow to the west, cuts through the workings, as shown in the sketch. The mica occurs in streaks and pockets, and in the room at the north end of the open cut a large pocket or bunch of crystals was being removed at the time of examination. These crystals were 2 feet or less in diameter but were rather thin, some measuring only 2 or 3 inches. The quality of the sheet mica is good. Among the associated minerals of the pegmatite are black tourmaline, in crystals up to 4 inches in diameter, massive yellow beryl, and garnets.

*De Mott mine.*—The De Mott mine is 2½ miles south of east of Grafton, near the crossroads on Prescott Hill. It has been worked by an irregular-shaped open cut 30 feet across and 3 to 15 feet deep. The country rock is highly foliated mica gneiss which strikes west of north and has a variable easterly dip. At the place where the work has been done the pegmatite cuts across the foliation of the gneiss, but north of the mine the pegmatite ledge is more nearly conformable with the

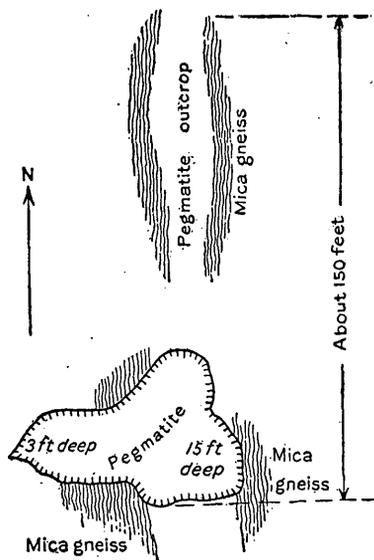


FIGURE 22.—Plan of De Mott mica mine, on Prescott Hill, Grafton County, N. H., showing workings and geology.

pegmatite cuts across the foliation of the gneiss, but north of the mine the pegmatite ledge is more nearly conformable with the

inclosing gneiss, as seen in the prominent exposure extending up the hill. The relations between the country rock and pegmatite and the shape of the open cut are shown in the rough sketch in figure 22. The whole open cut is in pegmatite. Quartz occurs in irregular masses or segregations several feet thick in the pegmatite, and feldspar occurs in rough crystals 1 to 3 feet across. The mica is pockety or in bunches near the quartz. Beryl crystals, the largest 1 foot thick, are plentiful and a ton or more of them have been laid out near the dump. Only scrap mica was left around the mine.

*United Mica Co.'s mine.*—The mine of the United Mica Co. is on the southwest side of Prescott Hill,  $2\frac{1}{2}$  miles S.  $50^{\circ}$  W. of Grafton Center (Cardigan railway station). The company has a trimming

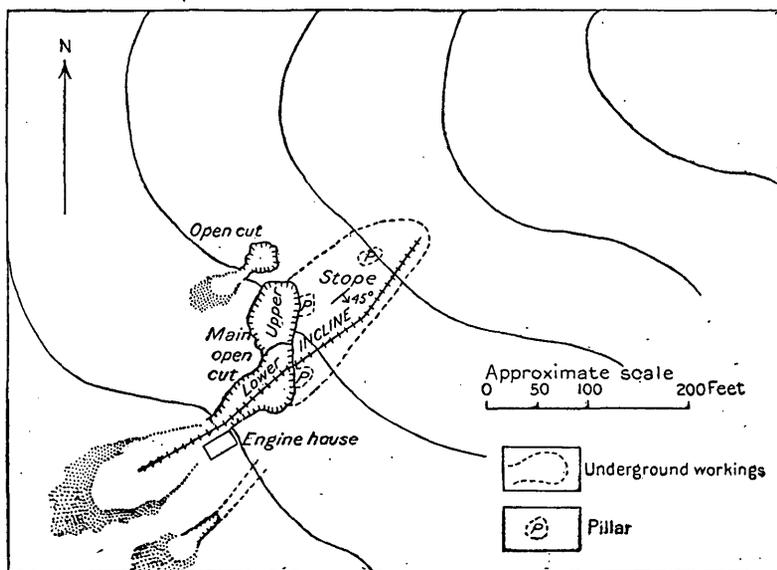


FIGURE 23.—Plan of United Mica Co.'s mine, on the southwest side of Prescott Hill, Grafton County, N. H. The stope is on a dip of  $45^{\circ}$  SE.

house and plant with good equipment at Grafton Center. The mine has been worked by open cuts and tunnels with stopes driven northeastward into the hillside, as shown in figure 23. The main open cut is divided into upper and lower parts, the upper part being 15 to 20 feet higher than the lower. A large stope has been opened from it 200 feet to the northeast, with a few pillars left for the support of the roof. An inclined track extends from the open cut into the stope to a depth of about 30 feet in a distance of 100 feet, and the track is then run on a level 100 feet farther, to the end of the stope. From the head of the incline the track leads to the dump, a distance of about 150 feet. Another small cut was made above the main open cut to the north, and still another with a tunnel and stope to the southwest. The vein has been opened to a depth of about 60 feet from

the outcrop in the highest cut, on an incline of about  $45^{\circ}$  SE. There are local variations in the incline where the vein rolled.

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

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

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

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

*Reynolds beryl mine.*—Mica of good quality with a clear rum color was found at the Reynolds beryl mine, on Sanders Hill,  $2\frac{1}{4}$  miles S.  $25^{\circ}$  W. of Grafton. This deposit is 400 feet higher than the valley on the north and has been worked for gem beryl. A quantity of mica was laid out during this work and would have helped defray the mining costs if it had been sold. The pegmatite crops out along the hillside and has been opened at two places. Massive translucent gray and smoky quartz, large crystals of potash feldspar, muscovite, biotite mica, black tourmaline, red garnets, green apatite, and green and golden beryl were the minerals observed on the dumps.

*Wild Meadows mine.*—The Wild Meadows mine is  $2\frac{1}{2}$  miles N.  $75^{\circ}$  E. of Grafton. It is not now in operation but has been worked by an

open cut nearly 175 feet long and in places 20 feet deep, driven south-westward into a hillside, with a shaft, and two pits to the southwest, as shown in figure 24. The country rock is a rather coarse porphyritic biotite gneiss with interbedded mica schist striking N. 20°-40° E. and having a vertical dip. The pegmatite ranges from 8 to 12 feet in thickness and has a slightly sinuous course, approximately conformable with the inclosing gneiss. All the pegmatite was not removed during mining, masses of it being left in the sides of the open cut where it was folded or bulged out into the country rock. The texture of the pegmatite varies from medium to coarse grained, some of the feldspar crystals being 1 foot thick. Both potash feldspar and albite, or soda feldspar, are present. The mica left exposed in the walls of the cut was in small bunches of crystals. The mine yielded a clear light-colored mica with a fine cleavage. Crystals of black tourmaline, beryl, and red garnets are scattered through the pegmatite.

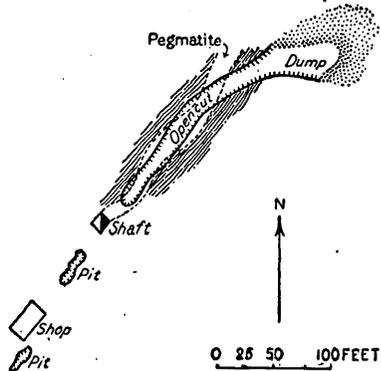


FIGURE 24.—Plan of Wild Meadows mica mine, 2½ miles east-northeast of Grafton, Grafton County, N. H., showing workings and geology.

*Mud mine.*—The Mud mine is 2 miles S. 80° W. of Alexandria, in a steep hillside. It is now owned by the General Electric Co. but has not been operated for several years. It has been opened by a cut 150 feet long, 35 feet in greatest depth, and 30 feet wide

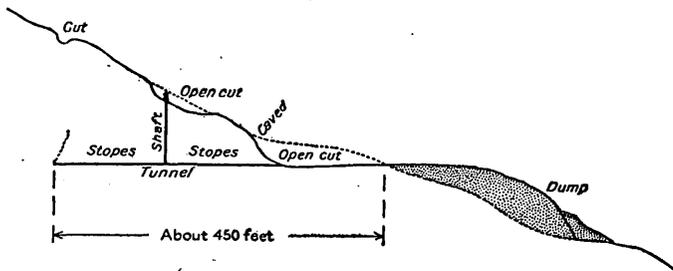


FIGURE 25.—Longitudinal section of workings at Mud mica mine, near Alexandria, Grafton County, N. H.

and by a tunnel driven some 300 feet farther into the hill. Another open cut was made in the hillside at a higher level, and a shaft 70 feet deep sunk from it to the tunnel. The underground workings had caved badly and could not be examined, but some stoping is reported to have been done. The workings are shown in profile in figure 25. Down stopes 10 to 15 feet deep are reported to have been made in the floor of the tunnel, where good mica was found. The country rock is coarse porphyritic biotite gneiss. The pegmatite

strikes about N. 35° E. and has a vertical dip. A prospect crosscut trench shows it to be at least 50 feet thick near the end of the open cut. Both plagioclase and potash feldspar are present in the pegmatite, and the mica apparently occurs in a streak 4 to 6 feet thick along the northwest wall. Some of the mica is partly specked.

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

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

#### CHESHIRE COUNTY.

*Brooks prospect.*—A new mica prospect was opened in the spring of 1913 on the land of Charles Brooks, 1½ miles west of East Sullivan.

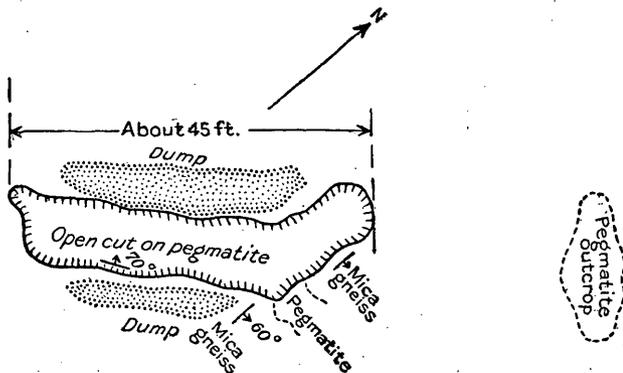


FIGURE 26.—Plan of Brooks mica prospect, near East Sullivan, Cheshire County, N. H.

The prospect lies in gently sloping ground and consists of an open cut 45 feet long, 8 to 10 feet wide, and 4 to 10 feet deep, of the shape

shown in figure 26. The country rock is grayish muscovite-biotite gneiss striking north and dipping east. The pegmatite has a north-east strike in part of the open cut, but forks, one branch going north and the other (not developed) east. The contact of the pegmatite and gneiss on the southeast side of the cut dips  $70^{\circ}$  NW. More pegmatite crops out about 30 feet northeast of the open cut. Much of the pegmatite is only medium grained, but in places the texture is coarse. It is composed of a rather even mixture of potash feldspar, quartz, and mica (including a little biotite), with variable quantities of black tourmaline. The mica has been found in crystals measuring as much as 10 inches across. Some of the crystals show "wedge," "A," or "hair-lined" structure, and others split smoothly. The color is light rum. Sheets 3 by 4 inches could be cut from some of the rough crystals seen. Over 3 tons of rough run of mine mica is reported to have been taken from the open cut.

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

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

About 200 yards farther south much mica has been found in a deposit of loose material consisting of fragments of pegmatite, feldspar, quartz, and earth. The mica is of good quality, and some fair-sized plates are reported to have been found. This deposit probably represents a bank of glacial drift consisting of material scooped out of a pegmatite mass not far distant. Two other possibilities exist—either that this loose material represents a pegmatite

deposit decomposed in place, or that it is waste from older workings which have been covered over or filled up.

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

The texture of the pegmatite is very coarse, some of the crystals of potash feldspar measuring 4 feet across, all clean feldspar. Gray and smoky quartz occurs in irregular masses. The mica was scattered irregularly through the pegmatite, but in one place a streak or pocket of light-green "wedge," "A," and "fishbone" mica was encountered. About 5 tons of mica is reported to have been taken out, some of which would yield good sheets. Among the associated minerals in the pegmatite, observed chiefly on the dump, were triphylite, beryl, black tourmaline, and pyrite. The triphylite occurs in grayish masses several inches across, with blue streaks, due to alteration products, along the cleavage faces. The beryl crystals are opaque, are yellowish or greenish gray, and measure as much as 12 inches in diameter. Several hundred pounds could easily be gathered from the dumps.

*Keene Mica Products Co.'s mine.*—The mine of the Keene Mica Products Co. is 1 mile N. 40° W. of Gilsum. It has been worked by an irregular-shaped open cut 65 feet long and 15 to 25 feet wide, shown in plan view in figure 27. This cut is about 25 feet deep along the east side, where there is a slight overhanging wall, and 15 feet deep on the west side at the north end. The country rock is biotite gneiss carrying considerable tourmaline near the pegmatite. The gneiss strikes N. 15° W. and has a high but variable dip to the east. The pegmatite mass is large and irregular in shape. In part it is conformable with the foliation of the inclosing gneiss and in part it cuts the foliation. The relation between the gneiss and pegmatite exposed in the north end of the cut is shown in the cross section in figure 27. From the south side of the northern part of the open cut a trough-shaped horse of tourmaline-biotite gneiss, 12 to 15 feet thick, with pegmatite on each side of and below it, extends southward for more than 70 feet. Apparently this horse did not connect with the deeper roll of the gneiss on the north end of the cut shown in the cross section. The pitch of the pegmatite and gneiss contact along

this side of the cut is about  $15^{\circ}$  N. This would mean that the surface relation restored would give the approximate contacts shown by the dotted lines in the plan, and such were the original conditions as reported by the miners.

The pegmatite is of diverse texture, some parts showing a very coarse crystallization with feldspar crystals 2 to 3 feet across and large quartz segregations. A little graphic granite was observed. The mica is richest near the hanging wall of the pegmatite, in streaks 3 to 7 feet thick. A thickness of 6 to 7 feet has been removed in mining, and in places the work has been extended to other parts of the pegmatite where pockets of mica were found. A mica streak, part of which has been worked, occurs along the west side of the horse of biotite gneiss. The face left on the pegmatite at this point

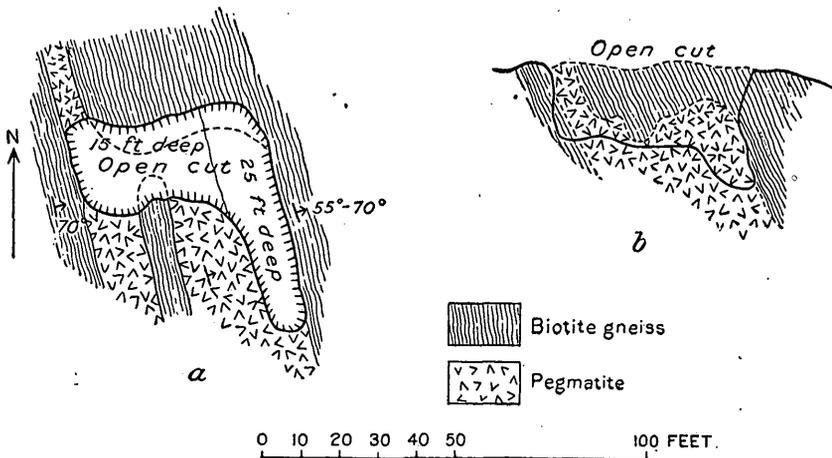


FIGURE 27.—Plan (a) and cross section (b) of Keene Mica Products Co.'s mine, 1 mile northwest of Gilsum, Cheshire County, N. H., showing geology.

shows a quantity of smaller sheet mica which will pay to remove. The mica obtained from this mine has a clear light rum color and is of good quality. A little biotite is associated with the muscovite.

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

*French mine.*—The French mine of the American Insulator & Mica Co. is  $1\frac{1}{2}$  miles N.  $25^{\circ}$  W. of Gilsum, in the town of Alstead. It is an old mine, opened over 50 years ago and worked successively by the discoverer, a man named Mitchell, by a Mr. Bowers, and during the last 13 years by W. A. & C. H. French. The workings consist of a large open cut 60 yards long, 30 to 40 yards wide, and 20 to 60 feet deep, with smaller openings at the north end and a shaft or pit 20 feet

deeper than the bottom of the cut, or 80 feet from the surface. Two steam drills are used in mining, and derrick hoists and an inclined track are used to remove waste and mica from the pit.

The country rock is mica gneiss with highly schistose layers. The gneiss strikes north to N. 30° E. and dips 60°–80° SE. The pegmatite occurs in a large irregular mass cutting the gneiss. Streaks or horses of gneiss and schist are inclosed in the pegmatite, retaining about the same strike and dip as the country rock. Two prominent horses of schist, extending nearly across the pit, were left standing above the level of the adjoining floor. The relations between the pegmatite and gneiss walls and horses are shown in figure 28. The area of the

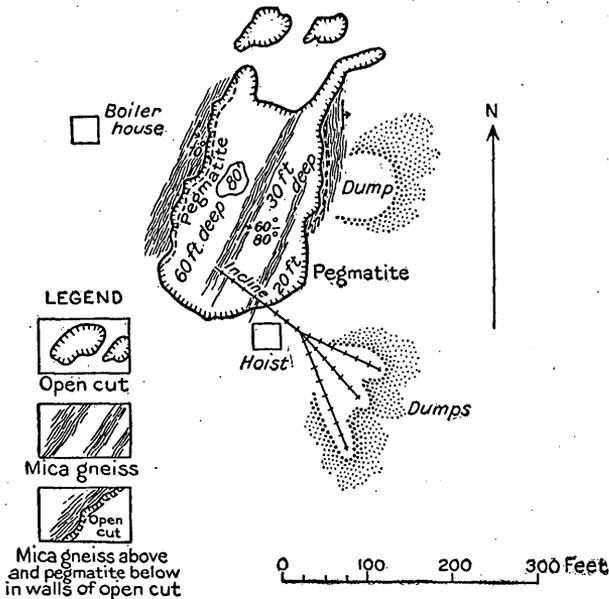


FIGURE 28.—Plan of French mica mine of American Insulator & Mica Co.,  $1\frac{3}{4}$  miles northwest of Gilsum, Cheshire County, N. H., showing workings and geology.

pegmatite is larger below ground than at the surface, so that the walls of the cut show pegmatite below with mica schist or gneiss above. Both the gneiss and pegmatite are somewhat altered by weathering, but in places the pegmatite is fresh and hard. The feldspar of the pegmatite is mostly the potash variety, with perthitic texture. Quartz does not occur in large segregations, and only a few small masses were observed. Black tourmaline is abundant in places and, near the bottom at the south end of the open cut, crystals 8 inches or less in diameter are associated with the mica. The mica is scattered irregularly through the pegmatite, there being some richer places, chiefly along the mica schist inclusions or walls. Mica crystals of

various sizes, some 18 inches or more in diameter, were abundant in the working face at the south end of the cut, below and south of the end of the incline. The mica has a good cleavage with very elastic sheets. Some of it is slightly smoked or dusted with minute particles between the laminæ.

*Island mine.*—The Island mica mine, 2 miles N. 20° W. of Gilsum, has not been operated for several years. The workings consisted of three open cuts and a short tunnel. Two of the open cuts were at the east foot of a small knoll (roches moutonnées) standing about 25 feet above the surrounding swampy ground. These open cuts were 20 and 25 feet deep, but are now filled with water. The third cut was made back into the knoll at a level a few feet above the lower cuts, but still 18 or 20 feet lower than the summit of the knoll. (See fig. 29.)

The country rock is biotite gneiss, which contains much black tourmaline near the pegmatite. The gneiss has a highly varied strike and dip adjoining the pegmatite, as shown by symbols in figure 29. It has been badly folded and crinkled in places by the intrusion of the pegmatite. The pegmatite is very irregular in shape, but has a generally westerly trend across the knoll. It incloses streaks of mica gneiss, and small stringers and bodies of it are intruded into the surrounding gneiss. Where the rock has been stripped bare by glacial action, north of the shop, a number of small curved lenses or bulblike masses of pegmatite are exposed in the crinkled gneiss. Along the contact of the main pegmatite these small masses appear to have been forced out into the gneiss, which has curved around them. A tongue or streak of mica gneiss included in the pegmatite extends in between the two lower cuts and may have connected with a body of gneiss exposed in the bottom of the upper open cut.

The pegmatite contains large segregations of gray and smoky quartz, some graphic granite, pockets or bunches of mica (both mus-

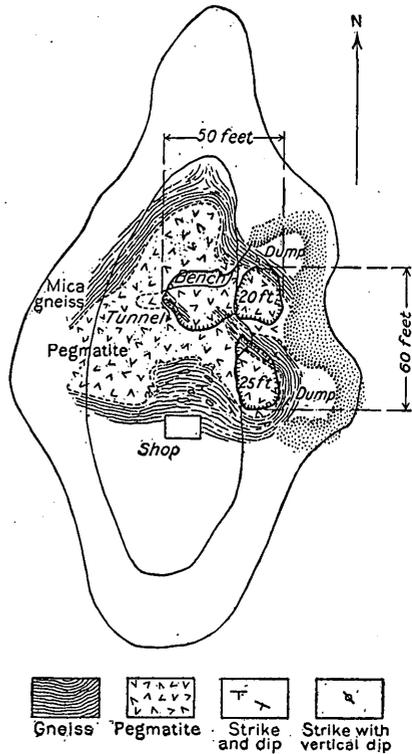


FIGURE 29.—Plan of Island mica mine, 2 miles N. 20° W. of Gilsum, Cheshire County, N. H., showing workings and geology.

covite and biotite), black tourmaline, green apatite, a few red garnets, and numerous beryl crystals. The mica seen was mostly "bunchy," but, of course, the best had been removed in the last mining. It has a clear rum color and is of good quality. A few biotite crystals are intergrown with the muscovite. The beryl crystals are as much as a foot in diameter and are varicolored—blue, blue-green, yellow-green, and rich and pale golden yellow. Good gem beryl has been found, but most of the beryl is translucent or opaque. Small golden beryl gems of exceptional beauty have been cut from clear portions of large crystals.

*Tripp mine No. 1.*—The Tripp mica mine No. 1 is about a quarter of a mile west of north of the Island mine, or  $2\frac{1}{2}$  miles N.  $20^\circ$  W. of Gilsum. It has not been operated for several years, and at the time of visit the workings were filled with water and badly overgrown with brush. The workings consist of an open cut over 125 feet long in a north-south direction and 20 to 30 feet wide. The waste and ore were removed by an inclined track at the north end. Some of the pegmatite was coarse grained with large quartz segregations and crystals of potash feldspar over a foot thick. At the north end of the open cut a tree had been recently uprooted, exposing a deposit of mica several feet across in the pegmatite. Some of these mica crystals were 12 inches in diameter and sheets were seen that would cut 4 by 6 inches. The mica has a clear rum color and is of fair quality.

*Davis Mica Co.'s mine.*—The mine of the Davis Mica Co. is  $2\frac{1}{2}$  miles N.  $15^\circ$  W. of Gilsum, on the southwest side of the road leading to East Alstead. It has been worked by long open cuts on the outcrop and shafts with drifts and stopes. One shaft is reported to have been 125 feet deep. Good mine houses and shops were supplied and both aerial tram and track were used to facilitate mining. The workings are chiefly along the side of a low hill above swampy ground. From the mine houses the open cuts extend south about 100 yards and northeast about 100 yards to the road. (See fig. 30.) The mine was not in operation at the time of examination and many of the workings were filled with water.

The country rock is mica gneiss containing prominent layers of biotite schist with more or less tourmaline. The rocks have a variable north to northeast strike and a high east or southeast dip. The pegmatite is conformable with the inclosing gneiss through part of its course, and at the most productive part of the mine it forks, as shown by the outline of the workings in figure 30. A second pegmatite outcrops a few feet to the east of the mine and has been opened for mica near the road. The pegmatite of the main vein varies greatly in texture and composition. In the southern part of the workings biotite is extremely plentiful in the pegmatite, and some of it is inter-

grown with muscovite. In one part of the mine crushed biotite crystals from a quarter of an inch to 1 inch thick and as much as several inches across are so abundant as to make the pegmatite very dark gray. A little beryl, green apatite, and black tourmaline were also observed. The muscovite mica has a clear light rum color and is of good quality.

*Tripp mine No. 2.*—The Tripp mine No. 2 is a continuation, across the road to the northeast, of the Davis mine and has been opened by a series of open cuts along the outcrop. (See fig. 30.) The open cuts are more like stopes and are from 4 to 7 feet wide, according to the thickness of the vein. The depth could not be learned, as they were filled with water within 15 to 25 feet of the surface. The cuts or stopes showed a dip of  $60^\circ$  or more to the northwest, different from that of the southern part of the Davis mine. The small mica seen around the dumps indicates that a good grade was obtained.

*Parson mine.*—The Parson mine, worked by the Fitzgibbon Mica Co., is  $1\frac{1}{4}$  miles N.  $5^\circ$  E. of East Alstead, on the west side of the public road. The workings consist of several open cuts and pits within a distance of about 175 yards in a N.  $30^\circ$  E. direction, as shown in figure 31. These pits range from small size to 50 feet across and 200 feet long and from 10 to 40 feet deep. They were worked as open quarries, and derricks were used to remove waste and ore. The last work was done in 1906 or 1907 and was extensive.

The country rock is mica gneiss containing layers of highly foliated muscovite-biotite schist. The pegmatite is probably at least 100 feet thick but incloses streaks of schist. Large quartz segregations or veins are also inclosed in the pegmatite, and near these the mica is richest. Much black tourmaline, some in close association with the mica, was observed. The mica has a clear light rum color, and small pieces seen on the dumps possessed good cleavage. At the north end of the mine the pegmatite forks, part extending northeast

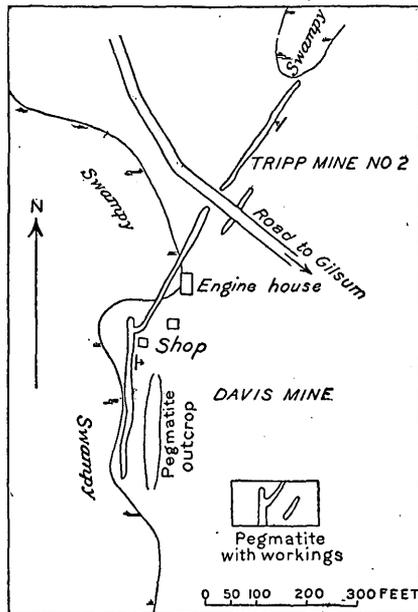


FIGURE 30.—Plan of workings at the Davis Mica Co.'s mine and Tripp mica mine No. 2,  $2\frac{1}{2}$  miles north-northwest of Gilsum, Cheshire County, N. H.

along the west side of the road and part evidently crossing the road and forming the vein of the Granite State Mica Co.'s mine.

*Granite State Mica Co.'s mine.*—The mine of the Granite State Mica Co. was in operation during 1913. It was worked by an open cut 250 feet long in a northeast-southwest direction, as shown in figure 31. This cut is 35 feet deep in the southwest end, 45 feet deep in the middle, and 10 to 15 feet deep in the northeast end. An inclined track and a derrick have been used to remove waste and ore. At the time of examination the track had been abandoned and the derrick hoisted from a large pit below the position previously occupied by the track. A quantity of wall rock has been removed during mining.

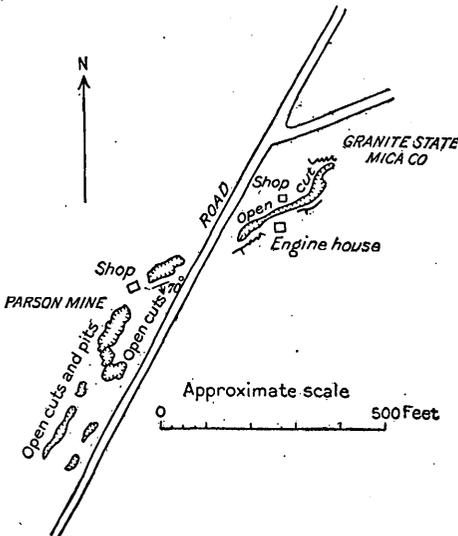


FIGURE 31.—Plan of the Parson mine and the mine of the Granite State Mica Co.,  $1\frac{1}{2}$  miles north of East Alstead, Cheshire County, N. H.

The pegmatite cuts the mica gneiss country rock about conformably with its average attitude—that is, it trends northeast and has a high southeast dip. It was from 3 to 8 feet thick through much of the open cut and nearly 20 feet in the middle, though here it was thickest near the surface, pinching in depth. Much of the pegmatite is rather fine grained, but some has a coarse texture with large quartz segregations. The mica is most plentiful near the hanging wall, but some is scattered through the pegmatite or occurs along the footwall. Large crystals of

mica, measuring over 2 feet across, are reported to have been found. The mica has a clear light rum color and is of good quality.

*Lakin prospect.*—A small mica prospect on the George A. Lakin place,  $1\frac{1}{2}$  miles N.  $25^{\circ}$  E. of East Alstead, was being tested during 1913 by E. Howard. Only a small amount of work had been done at the time of examination, consisting of a little digging and some blasting into an outcrop of pegmatite along a hillside. The pegmatite contains smoky-gray quartz segregations and in places grades into pegmatitic granite. Only small crystals of mica were seen, but 4 by 5 inch plates are reported to have been found. The better mica has a clear rum color, but part has been badly crushed.

## VIRGINIA.

## HENRY COUNTY.

Mica has been mined and prospected for at a number of localities near Ridgeway, in Henry County, Va. Attention was drawn to these mica deposits some years ago by Capt. McCray, now of Ridgeway. Capt. McCray opened many of the prospects and was instrumental in interesting persons from Pittsburgh, Pa., by whom most of the mining has been done.

Ridgeway is situated in a rather strongly dissected portion of the Piedmont Plateau. Some of the hills have moderate slopes, but in places the valleys have steep walls. The elevation at a United States Geological Survey bench mark near the Norfolk & Western Railway station is 834 feet above sea level. Some of the ridges in the vicinity, such as that on which the town of Ridgeway is situated, rise at least 100 feet higher.

The country rock in the Ridgeway region along the mica belt is chiefly diorite, more or less schistose, and in places cut by fine aplitic granite and pegmatite. Streaks of mica schist and garnet schist and a belt of soapstone were observed inclosed in the diorite country rock near the mica belt. The strike of the formations is in general northeast, with variations measured between N. 20° E. and N. 60° E. The dip of the bedding is generally high to the west or nearly vertical, but a few exceptions were noted.

*Ridgeway Mica Co.'s mine.*—The Ridgeway Mica Co., of Ridgeway, is an outgrowth of the former Pittsburgh Mica Co. The new company was formed by P. Lippert, of Pittsburgh, Pa., and associates after a period of idleness following rather extensive operations by the Pittsburgh Mica Co. The Ridgeway Mica Co. owns a large area of land around Ridgeway on which both mica and feldspar have been mined or prospected for. During 1913 the principal mine, about a quarter of a mile northwest of the railway station, was operated for mica, and prospecting was carried on at some of the other deposits.

The mine has been worked by open cuts, shafts, and stopes through a distance of about 160 feet horizontally in a N. 25° E. direction, and to a depth of about 120 feet, as shown in the generalized sections of figure 32. The workings are irregular in shape, corresponding to irregularities in the vein. Mining has been carried on from different openings, beginning with the cut at the north end and working successively southward and deeper to the present shaft and down stope from its bottom. Large stopes have been made, and these elbow out in places where there were bulges in the vein.

The country rock is schistose diorite which strikes about N. 25° E. and dips to the west at a high angle. There are local variations of

dip and strike, especially around the irregularities of the pegmatite. In places the wall rock has been metamorphosed to quartz-biotite schist by contact with the pegmatite. The pegmatite as a whole is approximately conformable with the inclosing schistose diorite. It does not all lie between two plane parallel walls, but elbows out to the west by a series of bulges so that the average dip is about  $75^{\circ}$  W.

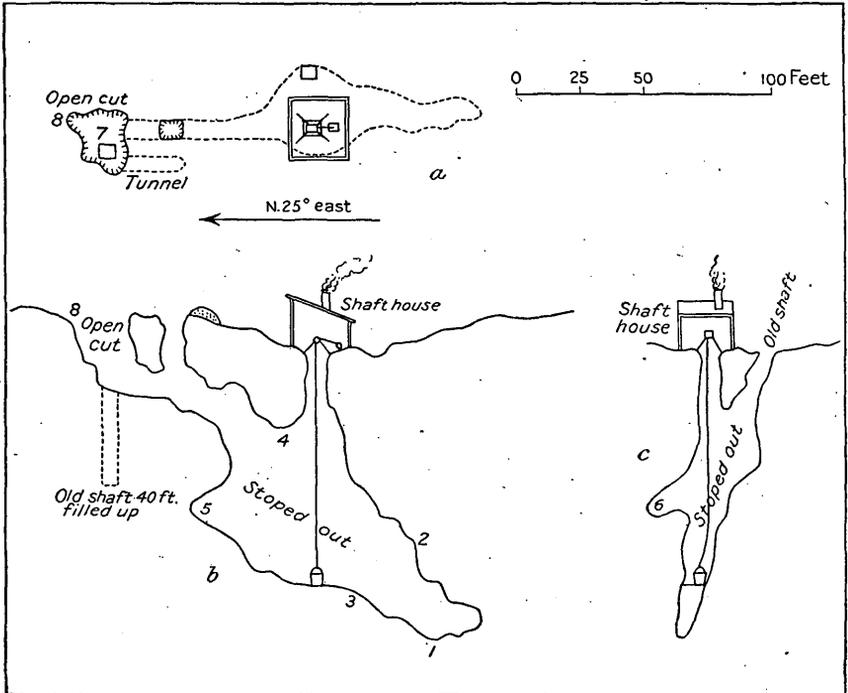


FIGURE 32.—Plan and sections of Ridgeway Mica Co.'s mine at Ridgeway, Henry County, Va. *a*, Plan; *b*, longitudinal section looking S.  $65^{\circ}$  E.; *c*, cross section looking N.  $25^{\circ}$  E.

Notes on the pegmatite at the different places numbered in figure 32 are given below:

1. Pegmatite 6 feet thick; contains fine mica, some in crystals weighing several hundred pounds.
2. Pegmatite 4 feet thick, becoming thicker above; contains good mica.
3. Pegmatite 1 foot thick.
4. Pegmatite 30 feet thick; yielded much mica.
- 5 and 6. Bulges in pegmatite. Schist roof over 5.
7. Pegmatite 30 feet thick, pinching to 4 feet at 8.

Mining has revealed a pay shoot of mica pitching about  $35^{\circ}$ – $40^{\circ}$  S.  $25^{\circ}$  W. in the body of the pegmatite. On the surface the pegmatite was traced about 250 feet S.  $25^{\circ}$  W. by prospect pits in which a little mica was found. Two pits 15 feet deep, about 400 feet south of the mine, opened mica-bearing pegmatite, but it is possible that these were not on the same vein.

The pegmatite consists of a fairly even mixture of feldspar, quartz, and mica. The feldspar is white albite and rarely occurs in crystals over a foot thick. The quartz is the light smoky-gray variety and occurs chiefly in irregular masses few of which are over 2 feet thick. Mica occurs in crystals ranging from those of small size to some over 2 feet in diameter. Large crystals are not rare, but many of them have the "A" structure strongly developed. A portion of a mica crystal measuring 18 by 20 inches and weighing about 42 pounds was recently presented to the United States National Museum by the Ridgeway Mica Co. This specimen has the "A" structure strongly developed on one side, but has a perfect cleavage over the full width of the crystal on the other side. Such a crystal would yield a quantity of good sheet mica between the "A" lines in those portions where the "A" structure occurs. There is necessarily a large percentage of scrap in "A" mica, but some good sheet mica can be cut between many of the "A" lines. Crystals that would yield plates 12 by 20 inches were obtained during the summer of 1913. The mica has a light smoky or brownish-green color and is classed as No. 1.

At the time of visit 10 men were employed at the mine, 5 below ground and 5 above, including two expert mica trimmers from Mitchell County, N. C. The equipment consists of a storage and trimming house, a boiler house, an engine and shaft house, a hoisting engine with bucket hoist, a steam drill, a mine car, etc. The Pittsburgh Mica Co. had a grinding mill near the site of the present trimming house, but this mill was burned down several years ago and the scrap mica is now shipped to mills in other places.

Another mica deposit was worked by the Pittsburgh Mica Co. about 250 feet S. 25° E. of the main mine. The workings were on a fairly large scale but are now rather inaccessible. The pegmatite body was large, at least 30 feet thick in one part, and was approximately conformable with the schistose diorite country rock. The feldspar of the pegmatite was considerably decomposed. The country rock was metamorphosed to biotite schist along the contact with the pegmatite. This mine is reported to have yielded a quantity of good mica.

Several other mica prospects and mines have been opened on either side of the road along the ridge to the northeast of the principal mine, on land belonging to the company. Most of these were discovered by Capt. McCray. The different deposits will be described in their order of location northeastward from the main mine.

Good mica was found in some pits a few hundred yards north of the mine on the west side of the ridge.

Across the road and about 100 yards north of east of the mine two test pits had been made for feldspar in a semidecomposed pegmatite. Fairly fresh potash feldspar had been found at a depth of several

feet. About 600 yards northeast another prospect had been opened for feldspar on semidecomposed pegmatite.

Two-thirds of a mile northeast of the mine a pit had been opened on mica-bearing pegmatite near and on the southeast side of the road. Only small mica crystals had been left around the prospect, and the sheets had a greenish cast. About 200 yards north of this prospect, on the northwest side of the road, a shaft had been sunk 27 feet on a promising vein and good mica is reported to have been found. About 60 feet southwest a pegmatite mass, inclosing a 2-foot quartz vein, crops out in a plantation road. Mica in sheets as much as 4 inches across occurs in the decomposed feldspar along the southeast side of the quartz streak.

About 1 mile northeast of the main mine and 100 yards northwest of the road a trenchlike open cut 60 feet long in a N. 60° E. direction and a 25-foot shaft had been made on a mica-bearing pegmatite. This work was done by Capt. McCray a number of years ago and is said to have yielded about \$1,500 worth of mica. The pegmatite body is 6 feet thick in the end of the cut and is inclosed in schistose diorite. The feldspar of this pegmatite is chiefly albite. About a quarter of a mile to the northeast, 150 yards northwest of the road, Capt. McCray sank another shaft about 30 feet deep on a promising mica deposit.

About a quarter of a mile southeast of the prospect last mentioned, or  $1\frac{1}{4}$  miles northeast of the main mine, several shafts with short drifts had been made. These shafts were from 18 to 30 feet deep and cut decomposed pegmatite in schistose diorite. A quantity of small mica crystals with fine smooth cleavage were found. This mica is somewhat "specked" and may be classed part as No. 2 stove and part as good electric mica.

Capt. McCray has opened several other prospects in this region, in some of which he reports fairly promising mica veins.

The Ridgeway Mica Co. owns a feldspar quarry, from which several carloads of feldspar have been shipped, and other mica prospects on the same property about 2 miles south of Ridgeway.

*Knight prospects.*—Several mica prospects, none over 12 feet deep, have been opened on land now owned by H. A. Knight, 250 yards east of the railway station. These prospects are several years old, with the exception of one made within a year. They fall within an area about 150 feet long in a N. 25° E. direction and 100 feet wide. The country rock is diorite cut by aplite and inclosing several bodies of pegmatite. In the last prospect opened the pegmatite was 12 feet thick at the surface and 6 feet thick at a depth of 7 feet. The southeast wall of the pegmatite strikes N. 25° E. and has a vertical dip, and the northwest wall dips about 45° SE. Rough crystals of clear mica 6 or 8 inches across were found during prospecting.

## HENRY AND PITTSYLVANIA COUNTIES.

Mica has been prospected and mined on a small scale at several places in the vicinity of Axton, Va., near the border of Henry and Pittsylvania counties. This region forms a part of the dissected Piedmont Plateau of Virginia and is similar in aspect to the Ridge-way country, already described. Elevations range from 700 feet above sea level in the valleys to over 900 feet on the ridges.

The country rock of the Axton region consists of mica and garnet schist and gneiss with included beds of hornblende schist, all cut by granite and pegmatite. The strikes of the schists and gneisses measured were chiefly between north and N. 30° E., but wide variations from these directions were noted. The dips are diverse.

*Turner mine.*—The C. S. Turner mine is on the summit of a hill about one-third of a mile N. 70° E. of Axton. It has been opened for a distance of about 100 yards in a N. 25° E. direction by several shafts and pits and a trench at the southwest end. One shaft is reported to have been 40 feet deep. The pits ranged from a few feet to 15 feet in depth. The country rock is decomposed mica schist cut by granite. The schist has an average strike of about N. 25° E. and a high dip to the east. The pegmatite occurs in overlapping lenslike masses approximately conformable with the inclosing schist. The mica is mostly clear and rather dark green in sheets over one-sixteenth of an inch thick. Some of it is a little specked. A quantity of "wedge" and "A" mica crystals are obtained along with the good mica. Mr. Turner states that about 10,000 pounds of mica was removed from the trench and yielded about 500 pounds of sheet mica and 9,500 pounds of scrap. The largest mica would have cut into sheets measuring 6 by 8 inches, but was sold for \$2.50 a pound in the rough.

*Harston mine.*—The David W. Harston mine is about 3½ miles north of Axton, near the foot of a hill with a slope of about 15° WSW. The workings consist of a shaft about 20 feet deep, a tunnel extending 35 feet irregularly N. 60° E. from the shaft, and two small tunnels or gouges of about 6 feet each on the north and south sides of the shaft at about the same level as the main tunnel. A prospect pit had also been made about 30 feet north of the shaft. The position of the workings is shown in figure 33.

The country rock is mica schist cut by granite and pegmatite, partly decomposed to the depth of the workings. The schist near the mine strikes N. 60° E. and dips 35° SE. The pegmatite is very irregular in shape and the workings expose a mass about 15 feet thick in the bottom of the shaft with two branches forking out from it, one about parallel with the schistosity of the inclosing rock and the other cutting across it. These relations are shown in the cross section in

figure 33. One arm of the pegmatite was opened by the prospect pit and the other was followed down by the shaft. Mica occurs in irregular-shaped bunches or pockets in the pegmatite, ranging from a few inches to over 3 feet across, but a few crystals are scattered through the mass of the rock. Mica was rather plentiful in the 2-foot streak of pegmatite exposed in the shaft. The largest yield came from the tunnel. Minerals associated with the mica are partly decomposed potash feldspar, gray smoky quartz, and a little black tourmaline. One crystal of beryl 2 inches in diameter was observed on the dump.

It is reported that about 11,000 pounds of mica was shipped from this mine, from which possibly 2,000 pounds of sheet mica could have been obtained. The largest crystal weighed several hundred pounds. The mica is brownish green and rather heavily "specked." Some of the crystals have been badly cracked and would yield only small plates, but others have a good smooth cleavage in large sheets.

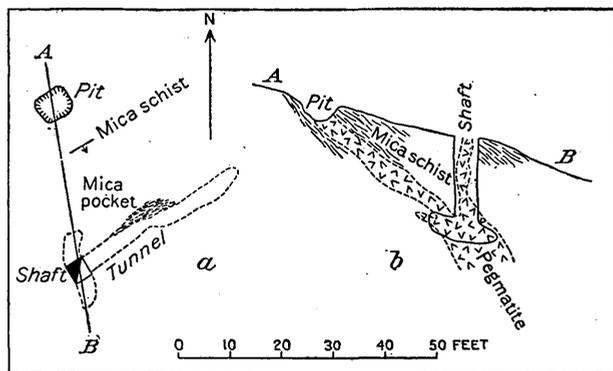


FIGURE 33.—Plan and section of Harston mica mine,  $3\frac{1}{2}$  miles north of Axton, Henry County, Va.  
a, Plan showing workings; b, cross section showing workings and geology.

About 250 feet S.  $70^{\circ}$  W. of the mine a mass of decomposed pegmatite 25 feet wide crops out in a road. Sheets of mica 3 inches in diameter were split from crystals found loose in the soil here. About 150 yards S.  $80^{\circ}$  W. a quantity of small sheet mica was plowed up in the light sandy soil of a cultivated field.

*Willis mine.*—A mica deposit has been prospected on the land of L. C. Willis, 3 miles north of Axton, by an 18-foot shaft, a short tunnel, and three pits in a northeast direction. The workings fall within an area 75 feet long and 20 feet wide. The country rock is mica and garnet schist. The pegmatite contains potash feldspar, which is partly decomposed, also a large streak of white quartz ranging from 2 feet thick in the shaft to about 6 feet thick a hundred feet to the southwest.

Only small mica was seen around the prospect, but larger and better material is said to have been carried away. Some of the small pieces

examined have a good cleavage, but larger rough sheets several inches across were less perfect. The mica has a dark-green color in thick sheets and some is a little "specked." An interesting specimen of sharply folded or crumpled mica was found at this prospect.

*Holland mine.*—Mica was mined or prospected at two places on the land of D. S. Holland, 2 miles north of Axton. Only one of these was examined. This consisted of a small open cut with a shaft 20 feet deep filled with water. The country rock is schistose diorite and interbedded mica schist. The pegmatite is irregular in composition and grades into granitic pegmatite or coarse granite. Only small mica was seen at the mine, but about 2,000 pounds of better quality has been stored away. This mica is clear but rather dark green in thick sheets. Rectangular plates measuring 4 by 5 inches were seen at Mr. Holland's house.

#### FRANKLIN COUNTY.

*Chestnut Mountain mines.*—Mica has been mined and prospected at several places in the Chestnut Mountain region about 12 miles

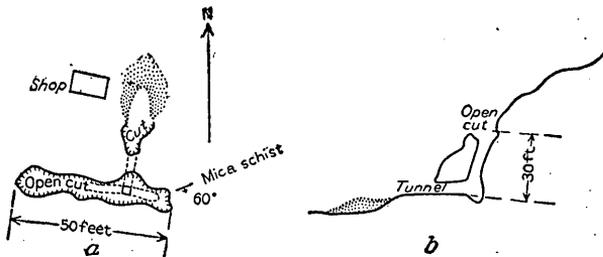


FIGURE 34.—Plan (a) and cross section (b) of Chestnut Mountain Mica Co.'s mine, on Chestnut Mountain, Franklin County, Va.

southeast of Rocky Mount, in Franklin County. The principal work was done by the Chestnut Mountain Mica Co., on the east side of the mountain, and consisted of an open cut 50 feet long and 5 to 12 feet deep along a steep hillside on the outcrop, with a shaft connecting with drifts and a crosscut tunnel about 20 feet lower at the foot of the hill, as shown in figure 34.

The country rock is mica and kyanite schist and gneiss. The strike of the inclosing schist as measured varied from N. 40° E. to N. 70° E. and the dip from 40° to 60° SE. The pegmatite cuts the country rock with a strike of N. 80° W. to nearly west and a variable dip of about 60° N. The pegmatite ranges from 2 feet in thickness in the east end of the cut to over 8 feet in the west end. The feldspar content has been strongly kaolinized and the inclosing schist has been badly decomposed. Mica seemed to be rather plentiful but was chiefly in small and "ruled" crystals, so that the yield of sheet mica would not be large. Under favorable conditions of transporta-

tion, it might pay to work the mine for scrap mica alone. A rotary screen had been set up to dry-clean the scrap mica from dirt and would not need much improvement to meet ordinary requirements. Several tons of scrap mica could be cleaned up from waste now lying around the mine.

A small open cut had been made about 200 feet west of the mine and about 50 feet higher up the hill. It may be on the same body of pegmatite as the lower working, but at this place the pegmatite contains more quartz with a quantity of "mica capping" or quartz mixed with small mica crystals.

About a quarter of a mile north of the mine a 15-foot shaft or pit had been sunk on a pegmatite near the main road to Rocky Mount. The pegmatite exposed in this opening was 10 feet thick. It was badly decomposed and the inclosed mica had been strongly broken and "ruled" into small sheets. A mica crystal 18 inches across was seen, but it was so badly crushed that only small sheets could be cut from it. Plates nearly 1 foot in diameter are reported to have been found. The mica is rather plentiful, but most of it is partly "specked." Large black tourmaline crystals were found in the pegmatite.

About  $1\frac{1}{2}$  miles northwest of the main mine there is an old prospect for mica consisting of a shaft about 20 feet deep. The country rock here is mica schist, which strikes N.  $35^{\circ}$  E. and dips  $70^{\circ}$  SE. The pegmatite is approximately conformable with the inclosing rock and is about  $2\frac{1}{2}$  feet thick near the surface. Hard blocks of mica capping 2 feet thick had been removed from the shaft. Only small mica crystals about 2 inches across were left on the dump. The pegmatite contains black tourmaline and opaque red garnets.

#### BEDFORD COUNTY.

*American Asbestos Co.'s mine.*—Mica was mined several years ago by the American Asbestos Co. on property now owned by Frank Mosher and associates 9 miles south of east of Bedford City, Bedford County. The deposit was worked by an open cut 40 feet long and 20 feet in greatest depth, with a shaft, now filled with water, reported to be 30 feet deep, in the end of the cut. The open cut was driven northwestward into a hillside about 30 feet above a creek. A hoist was arranged over the shaft, and a tram extends from it to the shop and storehouse about 40 feet to the northwest. The position of the workings, shop, etc., is shown in figure 35.

The country rock is hornblende schist or schistose diorite, badly weathered to a reddish-brown earth. The pegmatite is approximately conformable with the inclosing schist, striking N.  $30^{\circ}$  E. and having a nearly vertical dip. Where exposed in the open cut, it is nearly 20 feet thick. The east half is highly feldspathic and the west

half contains more quartz and is richer in mica. The quartz occurs in irregular masses and in small sheets or lenses parallel with the walls of the pegmatite. A horse or sheet of hornblende schist 1 foot thick is also included in the pegmatite. Opaque reddish garnets are abundant, and some flattened garnet crystals are inclosed between the sheets of mica. Much of the mica has the "A" structure but would yield good sheets from the part between the "A" lines. Mica crystals 8 or 10 inches across were seen in the shop, where several tons of rough mica is stored.

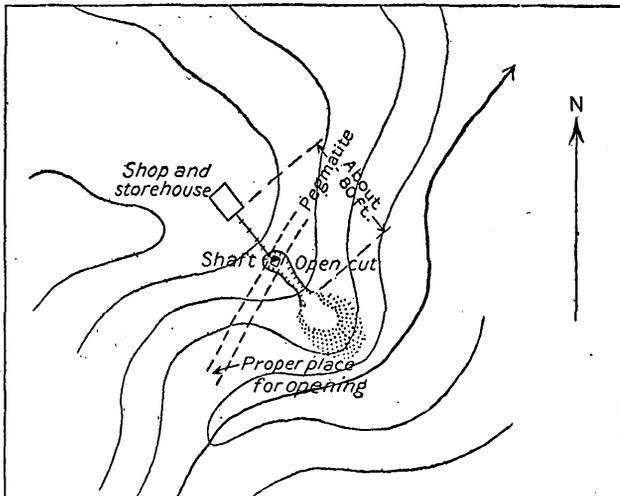


FIGURE 35.—Plan of the mica mine of the American Asbestos Co., 9 miles east-southeast of Bedford City, Bedford County, Va.

The mine could have been worked to better advantage from a lower level on the hillside about 75 feet to the southwest, as indicated in figure 35. A crosscut prospect trench would have located the pegmatite at this point, if continuous, as indicated in the figure, and mining could have been carried on by open work or drift with stopes to the northeast.

## NORTH CAROLINA.

### YADKIN COUNTY.

*Hauser mine.*—A new locality for mica in North Carolina was brought to the attention of the writer during 1913 by Mr. George H. Hauser, of Winston-Salem. It is in Yadkin County about 6 miles east of Yadkinville, and the prospects that have been opened are mostly on land owned by Mr. Hauser. An itinerant miner located the prospects several years ago and, after "groundhog" mining at a number of them, abandoned the work. The country is a roughly dissected part of the Piedmont Plateau and much of it is covered with timber. The country rock is diorite, in places strongly schistose.

The best deposit tested is about half a mile south of the main road leading west into Yadkinville. It was worked by numerous pits, trenches, and cuts and one shaft 40 feet deep within an area 250 yards long northwest to southeast and 200 feet wide; as shown in the rough sketch map (fig. 36). Outcrops of pegmatite carrying mica and another pit lie outside of this area. The exposures were not so good as to permit the working out of the relations between the pegmatite and the inclosing schistose diorite. In a pit across a branch on the northeast side of the mine the country rock is cut by a pegmatite body having a northeast strike and a vertical dip. The country rock strikes northwest with a vertical to high northeast dip. The position of the workings indicates either an irregular body of pegmatite with arms branching out, several veins, or a large blanket

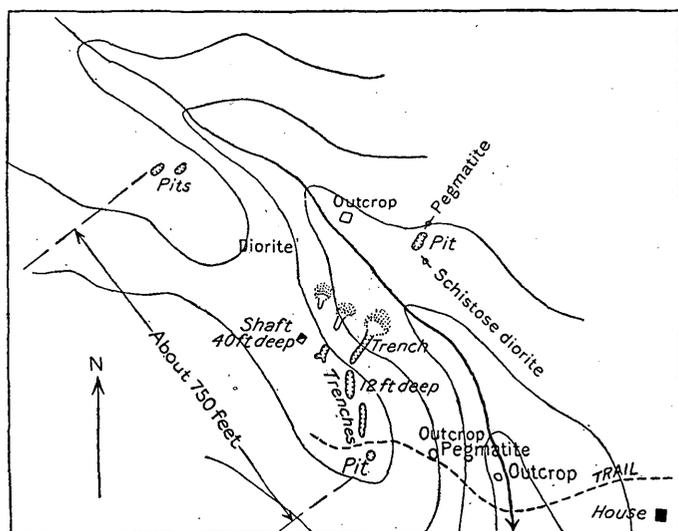


FIGURE 36.—Plan of Hauser mica mine, 6 miles east of Yadkinville, Yadkin County, N. C.

ledge (or ledges) with offshoots of smaller veins. The appearances suggest one or more beds of pegmatite cropping out on the hillside with a low dip to the northeast. If such prove to be the conditions, mining could be very effectively carried on by open cuts and drifts from this hillside.

Large blocks of white, gray, and smoky quartz, some translucent and some nearly clear, were removed during mining. Some of this quartz shows imprints of numerous mica crystals. Semikaolinized feldspar was encountered in many of the workings, and an outcrop of pegmatite along the branch contains solid crystals of microcline 18 inches across, with small mica. In the principal workings mica seems to have been fairly plentiful. Only small crystals had been left around, but these were mostly of good quality, having a clear brownish-green color and very good cleavage. Some was slightly

"specked." Some of the blocks have good crystal outline with fairly sharp faces, especially the crystals adjoining massive quartz. A few larger crystals of mica, measuring 4 to 6 inches across, found on the dumps, were badly crushed and had a very imperfect cleavage. Some of these included numerous small crystals of mica penetrating the laminæ at various angles. In the two pits at the northwest end of the workings much "A," "wedge," and "fishbone" mica was found. Masses of tangled blocks of this mica, measuring several inches across, had been left around the pits, but such material would be suitable only for grinding.

Another prospect was opened near a branch on the point of a low ridge a quarter of a mile southeast of this mine. A cut 6 feet deep and 20 feet long in a N. 70° W. direction was made on the north side of the ridge, exposing a pegmatite dike about 10 feet thick with a strike of N. 70° W. and a high dip to the south cutting schistose diorite. Most of the mica seen was in bunched masses of "wedge" and "A" crystals. Some slightly specked small sheet mica was also seen. The pegmatite contains feldspar crystals a foot thick, but most of the rock is very uneven grained.

Another mass of pegmatite crops out on the hillside about 100 feet to the north, across the branch. This pegmatite is coarse grained and from it crystals of mica 2 to 3 inches across have weathered out.

## SOUTH CAROLINA.

### LOCATION AND GENERAL GEOLOGY.

Earle Sloan<sup>1</sup> has described several mica deposits and mentioned the location of others in South Carolina. These deposits lie chiefly in the Piedmont Plateau in Oconee, Anderson, and Greenville counties. Some of them have been operated on a fairly large scale and yielded a quantity of good mica. A brief examination of those described below was made in October, 1913.

The rocks observed in the region around the mica mines consist largely of mica schist and gneiss with some kyanitic and garnetiferous phases, diorite, hornblende schist, and granite gneiss. The mica and garnet schists and gneisses are probably parts of the Carolina gneiss, as described by Keith in the geologic folios of western North Carolina. In this portion of the Piedmont Plateau weathering has been extensive, and in places the rocks are decomposed to depths of many feet.

### GREENVILLE COUNTY.

*Willimon mine.*—One of the largest mica mines in South Carolina is that of R. C. Willimon, 9 miles southeast of Greenville. This mine has been operated intermittently for many years and has recently

<sup>1</sup> Catalogue of the mineral localities of South Carolina: South Carolina Geol. Survey Bull. 2, 4th ser., pp. 142-149, 1908.

been leased by the J. E. Burleson Mica Co., of Sprucepine, N. C. Operations have been fairly extensive, but none of the underground workings were accessible at the time of examination. Openings have been made through a distance of 200 yards in a N. 60° E. direction, and a few prospect pits are not in the same line. The position of the numerous openings is shown in figure 37. According to reports, considerable drifting and stoping have been done and the deepest shaft is more than 100 feet deep. The rocks are soft, so that many

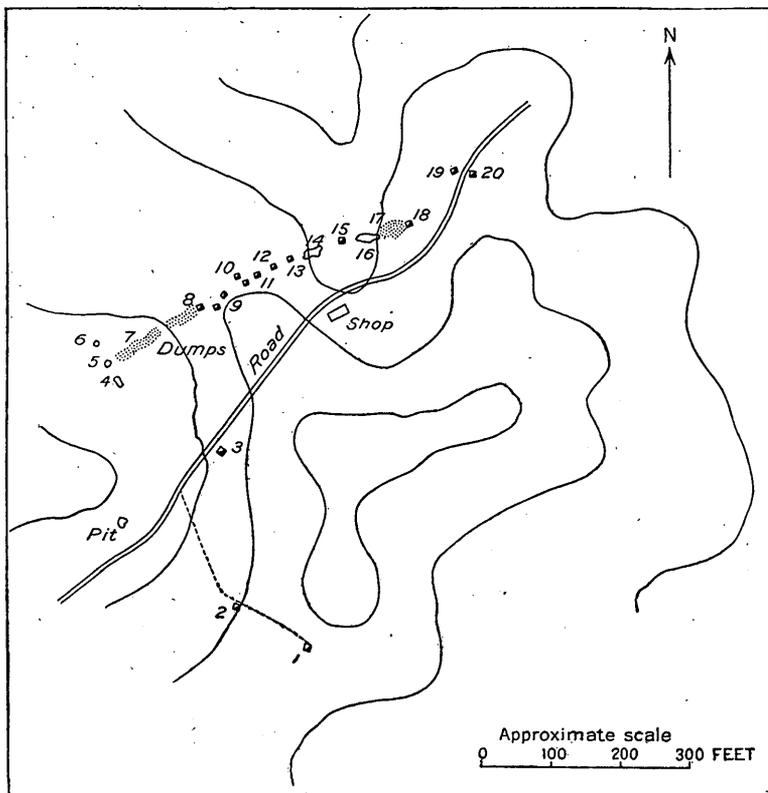


FIGURE 37.—Plan of workings at Willimon mica mine, 9 miles southeast of Greenville, Greenville County, S. C.

of the workings have caved in, and it has been in the endeavor to find new ground and avoid old workings that so many shafts have been made. The following observations were made at the openings shown by numbers in figure 37:

1. A shaft 25 feet deep in decomposed mica gneiss and pegmatite. The pegmatite is about 3 feet thick, strikes N. 60° E., and dips 75° NW. Mica in sheets 2 to 3 inches across.

2. Shaft 30 feet deep, partly caved in. Pegmatite 5 feet thick in decomposed kyanite-mica gneiss, both striking N. 60° E. and dipping 80° NW. Considerable small mica in dump.

3. Shaft 40 feet deep in decomposed mica and kyanite gneiss inclosing pegmatite.
4. Prospect trench; did not cut the vein.
- 5 and 6. Old shafts partly filled by caving. Only small mica left on the dumps.
7. Rather large dumps of waste removed from 8; contains some decomposed porphyritic granite.
- 8 and 9. Extensive underground workings, now mostly caved in. Pegmatite inclosed in decomposed mica gneiss.
10. Two new shafts, 10 and 30 feet deep, in mica gneiss on northwest side of the pegmatite.
11. Shaft more than 30 feet deep. Red clay near surface; decomposed pegmatite below. Small mica blocks of pegmatite and massive quartz on dump.
12. Old shaft in pegmatite.
13. New shaft 30 feet deep with water in bottom.
14. Old workings badly caved in. Much small mica on dumps.
15. Old shaft 20 feet or more deep, badly caved in. Small mica on dump.
16. Large pit or open cut on vein.
17. Large dumps of waste removed from 18.
18. Deep shaft, drifts, and stopes; badly caved in. Was equipped with steam pump, hoist, etc. Much mica obtained from these workings.
19. Prospect pit; no pegmatite found in the decomposed mica gneiss.
20. Prospect pit in pegmatite. Small mica found.

General information gained by a study of the dumps and accessible openings and the surrounding country may be summarized thus: The country rock is composed of mica schist and gneiss, kyanitic in places, cut by porphyritic granite and pegmatite. All these rocks have been weathered to soft earth to a depth of at least 30 feet. Four pegmatite veins have been tested, one of which has proved large and continuous. This vein is over 10 feet thick in places and contains segregations or masses of quartz. The pegmatite veins are approximately conformable with the inclosing rock, striking about N. 60°–65° E. and having vertical to high northwest dips.

Little could be learned of the quantity of mica the mine has produced or of the size of the better sheets. Possibly 25 tons of small sheet and scrap mica was lying around the workings. This mica could be screened and used for grinding. The small sheet mica seen had a clear amber to rum color and good cleavage. Some of it was considerably "ruled."

#### ANDERSON COUNTY.

*Gailliard mine.*—A deposit of mica has been worked extensively on the Warren Gailliard place (formerly J. J. Fretwell place) about 6 miles S. 75° W. of Starr. The mine has been worked at two different periods, but was idle at the time of examination. The principal workings fall within a distance of about 900 feet in a N. 20° E. direction, as shown in figure 38. Eight shafts, ranging from 15 to 40 feet in depth, and several pits have been made. Drifts were run from the shafts and stopes made wherever rich vein material was

found. Many of the workings have caved in and could not be examined.

The country rock as exposed in the branch south of the mine is strongly folded biotite gneiss injected with granite and pegmatite. The strike and dip are variable, the strike averaging northeast and the dip southeast. The gneiss and included pegmatite exposed in the workings are both deeply weathered. Masses of white quartz

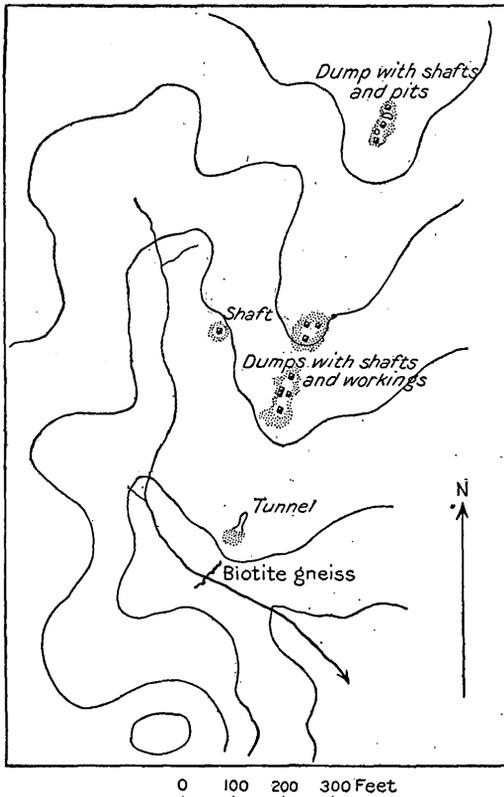


FIGURE 38.—Plan of workings at Gaillard mica mine, 6 miles S. 75° W. of Starr, Anderson County, S. C. Approximate contour interval 15 feet.

In the middle group the quartz is still exposed as an irregular vein 2 to 3 feet thick inclosed in the decomposed pegmatite and lying about 3 feet from the west wall of the vein. In places the quartz is gray, and some of it is smoky. The pegmatite varies in thickness, being at least 18 feet thick in the middle workings and probably ranging from about 8 to 25 feet, including streaks or horses of micagneiss. Whether the three main groups of shafts and the tunnel to the south are all on the same pegmatite body could not be determined. From the nature of the work done it is evident that the mica is pockety and irregularly scattered through the pegmatite.

It is most plentiful in decomposed feldspar next to quartz veins and masses. Some is partly intergrown with quartz. Most of the mica seen was small, occurring either in small crystals or in larger crystals cut by ruling into ribbons and small plates. Crystals yielding sheets 10 inches square are reported to have been obtained when mining was in progress. The mica is clear and of good quality, splitting well.

Several tons of scrap mica could be obtained by screening and washing the waste mixed with kaolin on the dumps, and if such ma-

terial had been saved during the first operations it would have gone far toward defraying the cost of mining.

A shaft had been sunk about 150 feet west of the main line of workings. A body of pegmatite similar in composition to that in the main workings was encountered and a quantity of small mica had been removed.

*Fretwell prospects.*—A small amount of prospecting has been done on the old Hall place, now owned by J. J. Fretwell, about  $1\frac{1}{2}$  miles west of Barnes, where a mica belt has been traced for nearly a mile in a northeasterly direction. Three deposits cropping out on small knolls about 200 yards apart were examined. The pegmatite crops out as white gravelly quartz soil, with blocks of white quartz and mica plates scattered through it. This soil can be traced rather plainly over the fields because it contrasts with the darker earth and red clay soil formed by the decomposition of the inclosing schists. Each

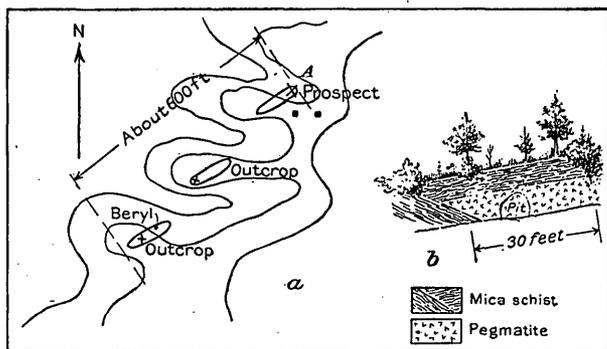


FIGURE 39.—Outcrops at Fretwell mica prospect,  $1\frac{1}{2}$  miles west of Barnes, Anderson County, S. C. *a*, Sketch plan; *b*, cross section at prospect marked *A*.

outcrop has a trend of about  $N. 60^{\circ} E.$ , as shown in figure 39. It is probable that they are separate bodies of pegmatite and do not represent one continuous mass. The country rock is mica gneiss composed of many schist layers. Both the mica gneiss and the pegmatite have been deeply weathered.

Practically no work has been done on the middle and southwest pegmatite masses, but weathered sheets of mica are abundant at the prospects marked "X" in figure 39. An opaque yellowish beryl crystal was found at the place indicated in the sketch map. At the northeast end of the area examined two prospect pits had been opened on each side of a small gully. Nothing could be seen of the pegmatite in the pit on the south side, but the later work on the north side, at the place marked "A" in figure 39, yielded promising mica. A cross section of the formations encountered at this place is shown in the figure. The pegmatite appears to be a nearly horizontal bed inclosed in mica schist, but it may have an easterly strike and a north-

erly dip. The mica schist on the west wall strikes east of north and dips about  $25^{\circ}$  E. Fifty feet west of the prospect the schist strikes N.  $40^{\circ}$  E. and dips  $35^{\circ}$  SE. Massive white quartz boulders crop out east of the prospect. The mica occurs in pockets or bunches of crystals and irregularly scattered through the pegmatite. Crystals of mica as much as 8 inches across have been found, and specimens were seen which would cut to 2 by 3 inches. The mica obtained near the surface is rather badly clay stained, but the better pieces are of a clear light rum color and have a good cleavage.

The pegmatite is decomposed and soft and can be easily excavated. The deposit should be prospected by a face cut back into the north side of the gully, extending east as far as mica is found, and further work should be carried on at the best showings of mica.

Another mica prospect has been opened on land owned by Mr. Fretwell, on the northeast bank of Savannah River about a quarter of a mile above the mouth of Big Generostee River. This prospect is about a mile south of the Gailliard mine, or 7 miles S.  $65^{\circ}$  W. of Starr. An open cut was made some years ago around a quartz outcrop on the hillside, revealing pegmatite with mica crystals of promising size and crystals of potash feldspar 18 inches across. Bluish-green and yellowish beryl crystals were found, one of which was over 4 inches in diameter. A 30-foot tunnel was driven in under the the open cut, but without encouraging results. The country rock is fine biotite gneiss cut irregularly by the pegmatite.

*Wharton mine.*—Mica was mined on the Sam Wharton place,  $6\frac{1}{2}$  miles N.  $82^{\circ}$  W. of Iva, several years ago. The workings consisted of an open cut 40 feet long in a N.  $60^{\circ}$  E. direction along the northwest side of a small branch, with two crosscuts from the hillside, and a crosscut tunnel with a room at the end a few feet northeast of the open cut. The country rock is decomposed mica schist inclosing streaks of hornblende schist striking northeast and having a variable dip. The pegmatite cuts the country rock irregularly and pinches from a thickness of 15 feet in the open cut down to a few inches in the tunnel at the northeast end of the workings. The formations are weathered and easily excavated. Rough sheets of mica 8 inches across were seen on the dump, with a few pieces that would cut 2 by 3 inch plates. This mica has greenish cast and splits well.

Another prospect pit was made 200 feet west-southwest of the main workings. Blocks of hard pegmatite containing small mica were left on the dump, but little could be seen of the formation.

*Sherard mine.*—Mining has been carried on intermittently on the old Vandiver Sherard place,  $6\frac{1}{2}$  miles N.  $80^{\circ}$  W. of Iva, about a quarter of a mile southwest of the Sam Wharton mine on the same belt of mica deposits. The first working was a 30-foot shaft with drifts. Later a 25-foot shaft was sunk about 100 feet N.  $20^{\circ}$  E. of

the first shaft, and drifts were run out to the north and south. A crosscut tunnel 140 feet long was next driven in from the hillside below on the east, and the mine was worked through it. At about halfway in this tunnel cut another vein, on which drifts were run. After this crosscut tunnel caved in, a new shaft was sunk west of the vein to a depth of 35 feet, and a crosscut was made to the vein. These workings are very irregular and include some unnecessary work. Their position is shown in figure 40.

The country rock is diorite or hornblende gneiss, with streaks of mica schist. The pegmatites cut the inclosing rocks irregularly. The main vein is as much as 15 feet thick and has a N. 20° E. strike and a west dip. It contains quartz segregations, two veins of which are exposed in the first shaft made. The pegmatite cut in the crosscut tunnel is about 10 feet thick, and includes horses or streaks of mica schist. Only small mica was found in this vein. The mica obtained from the main vein has a slightly smoky color and part is "specked." It has a good cleavage, and some of the small crystals seen were clean and sound. Good-sized sheets are reported to have been obtained during mining.

*Terry prospect.*—A mica prospect was opened on the old Terry place, about 6 miles west of Iva, by an open cut 35 feet long in the side of a knoll, but at present little can be seen of the formations. Massive white quartz is abundant on the summit of the knoll and much very small mica has been left around the pit.

*McConnell prospect.*—A prospect opened on the place of J. N. S. McConnell, 3¼ miles north of Anderson, yielded promising specimens of mica with beryl crystals of good color, reported to be nearly emeralds. When examined the workings consisted of a trench 45 feet long in a N. 70° E. direction, 15 feet wide, and 5 feet deep, and a crosscut trench entering at the west end. The country rock is weathered to a dark reddish-brown sandy soil, and no outcrops were seen near the prospect. The soil has probably been formed by the weathering of a biotite or hornblende granite and carries small blocks of diorite. The pegmatite is not now exposed, but the dump contains kaolinized feldspar, blocks of massive white quartz, smoky and colorless quartz in rough crystals, weathered plates of mica 8 inches or less across, large dark-red garnets, black tourmaline, limonite

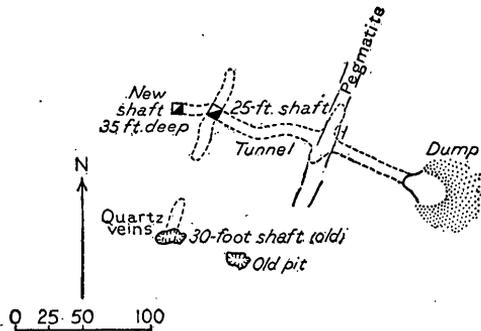


FIGURE 40.—Plan of workings at Sherard mica mine, 6¼ miles N. 80° W. of Iva, Anderson County, S. C.

pseudomorphs after pyrite, and black stains of manganese oxide. The mica remaining after the weathered parts are trimmed off is clear and of good quality. The principal workings are along the summit of a ridge extending west of north down to Little River. The deposits have been tested by pits for a distance of 75 yards in a S. 15° E. direction up the ridge. The deepest pit was probably not more than 15 feet deep, and most of the openings are partly filled. The country rock is mica gneiss, but its relations to the pegmatite were not visible. The pegmatite is at least 20 feet thick, as shown by the position of the prospect pits. Massive ledges or veins of white quartz form part of the pegmatite. Only small mica sheets were seen around the mine, but large crystals are reported to have been found. The mica is of a clear light rum color and of good quality.

*Welborn prospect.*—A prospect reported to be about 10 feet deep was opened on the land of W. C. Welborn, about 6 miles east-southeast of Pendleton, a number of years ago, but this has now been filled up. The country rock at this place is mica gneiss which has been badly weathered. The gneiss strikes N. 60° E. and dips 55° SE., and small beds of pegmatite exposed in the roadside cut the bedding nearly perpendicularly. Blocks of white quartz were left on the surface. So much scrap mica is mixed through the soil around the prospect as to indicate that the deposit is rich. It may have been abandoned because the mica is rather heavily "specked," as at one time that variety was not in strong demand. Some of the mica has the "A" structure but would yield good sheets from the portion between the "A" markings. A few rough sheets 8 inches in diameter were seen.

#### OCONEE COUNTY.

*Leroy prospects.*—Several deposits of mica have been prospected on the G. W. Leroy place, 5 miles northeast of Seneca. The mining or prospecting here was done by Thaddeus Leroy, who owns other mica prospects on land adjoining on the west. Some of the smaller prospects were tested by a few days' work, and the mica obtained is said to have paid wages of over \$3 a day for the work.

Other prospects for mica have been tested or are known on the places of John Dyer and J. F. Smith, one-half and three-fourths of a mile south of Leroy's.

#### TEXAS.

##### CULBERSON COUNTY.

*Texas Mica Co.'s mine.*—Outcrops of mica were discovered in the Van Horn Mountains, in Culberson County (formerly El Paso County), Tex., some 20 years ago by Ben Kraus, of Pecos. The deposits lay idle until 1910, when they were located by the Texas Mica Co., of

Pecos, and the inclosing two sections of land were purchased from the State. The prospects lie on the west side of the Van Horn Mountains about 15 miles S. 20° W. of Van Horn. Van Horn is on the Texas & Pacific Railway, but the nearest railroad station is Dalberg, on the Southern Pacific line, about 9 miles northwest of the mine. The dirt road to Van Horn crosses the railroad about 6 miles north of the mine.

The mining developments are not extensive and consist of two open cuts on the principal deposit and several smaller prospects at other places. Trails and roads have been built from the camp to some of the prospects. A small grinding mill was erected for experimental work with some of the products mined. The mill is operated by an 18-horsepower gasoline engine, which also furnishes power for an air compressor and drill. The company has been interested in the development of two products, mica and micaceous rock, suitable for giving a "micolithic" finish to cement and other structures.

The Van Horn Mountains consist of a main range over 15 miles long with a north-south scarp on the east, broken plateaus and ridges in the middle, and a less prominent range on the west. This smaller western range trends west of north, diverging from the main mass of the mountains, and sinks into the surrounding basin or plains a few miles north of the mica deposits. These deposits occur in the rough hills formed by valleys and eroded surfaces of the west range of the mountains. The most of the hill slopes are steep, in places breaking into rocky cliffs. Elevations near the deposits range from about 4,200 feet above sea level at the camp to over 5,000 feet at the north end of the property. The Van Horn Mountains attain greater elevations (5,622 feet) in the Van Horn Peaks, 2 miles east of the mica prospects, and along the crest of the eastern range, 5 miles east of the prospects.

The region is a typical desert and has the characteristic desert vegetation, composed of sagebrush, various species of cactus, etc. Water for general camp use is caught during rains in a natural cistern or reservoir in a draw about 200 yards east of the camp. Drinking water is hauled from a well about 1½ miles west of the camp.

The mica deposits occur in an area of pre-Cambrian crystalline rocks exposed by the erosion of overlying sedimentary formations. The adjacent sedimentary rock is chiefly rather heavy bedded gray limestone, cherty in places, with a little limy shale, and probably is of Carboniferous (Pennsylvanian) age. An area of such rock in about the proper position for correlation, in the south end of the Carrizo Mountains, 8 miles north of the mica prospects, has been mapped as the Hueco formation by G. B. Richardson.<sup>1</sup>

<sup>1</sup> Notes on northern border of the Chispa quadrangle, made during areal mapping of the Van Horn quadrangle.

The crystalline rocks consist of quartz-mica gneisses and schists, biotite schist, hornblende schist, and pegmatite. The quartz-mica gneisses and schists are composed chiefly of quartz, muscovite, and biotite, with variable quantities of feldspar. They are from fine to medium grained and are light to dark gray according to the proportion of biotite they contain. Some of the outcrops are red and reddish brown from the abundance of iron oxides present. The biotite schist is a black, strongly laminated rock composed of coarse lustrous scales of biotite mica with small quantities of quartz and feldspar. The hornblende schist is a medium-grained greenish-black foliated rock in which hornblende is a prominent constituent. In one place it is highly garnetiferous, containing garnet crystals as much as half an inch in diameter. The pegmatite is prevailingly reddish and exhibits many of the irregularities of texture common to that rock. In most of the outcrops it is composed chiefly of feldspar and quartz with small quantities of mica. Locally mica is abundant. Most of the feldspar is reddish orthoclase or microcline. It occurs as small grains mixed with quartz, with or without mica, in typical granite texture, as graphic granite, and in some places in crystals measuring over 2 feet in thickness. The quartz occurs also in irregular gray to white masses or segregations ranging from 1 inch to 5 feet thick. These masses of quartz are apparently scattered at random through the pegmatite. Most of the mica in the pegmatite is muscovite. It ranges from small scales to crystals 1 foot across. The mica crystals occupy no regular position in the rock and vary greatly in abundance in different bodies of pegmatite and in different parts of the same body.

The crystalline rocks outcrop in an irregular-shaped area about 2 miles long from north to south and a little over half a mile wide. They have been complexly folded, as shown by the dip and strike marks in figure 41. These pre-Cambrian gneisses and schists have been cut by pegmatite both parallel to and across their schistosity. The pegmatite, however, does not cut the surrounding limestones, which overlie the crystalline rocks unconformably and dip away from the area on all sides at varying angles. The structure is that of an elongated dome from which the overlying sedimentary beds have been eroded, exposing the core of underlying crystalline rocks.

The mica of value as sheet mica and for grinding into pure products is found in pegmatite, which is abundant in the area of crystalline rocks and occurs in ledges and streaks ranging from a few inches to over 100 feet thick. Sheet mica of promise has been found in only a few of these deposits. The principal working is on the east side of a draw about 150 yards from the camp. It consists of two open cuts in a steep hillside. The larger cut is about 65 feet long in a north-south direction and 5 to 20 feet deep. The other opening lies a few

feet to the northwest and is a crosscut trench about 35 feet long with a depth of 15 feet at the inner end. These workings are on a large pegmatite dike with a northerly strike. The west wall of the pegmatite is not exposed, but on the east there is a rather fine grained red gneiss composed of quartz, feldspar, biotite, and muscovite. The

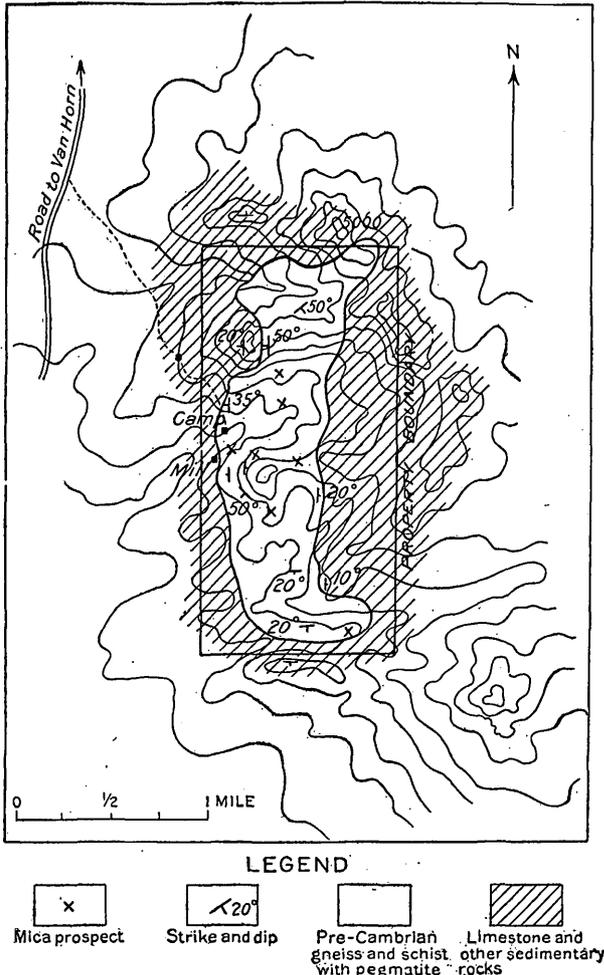


FIGURE 41.—Sketch of Texas Mica Co.'s holdings, 15 miles southwest of Van Horn, Culberson County, Tex., showing topography and geology.

pegmatite incloses horses or streaks of both hornblende and quartz-mica schists parallel with its own strike.

The mica was found richest in an irregular streak developed by the largest open cut. Several crystals are commonly found near together, and these bunches are scattered through nearly barren pegmatite at intervals of a few feet. From 4 to 5 tons of mica were taken from this cut. Much of the mica is small, but some was seen in the storage

house that would trim into sheets 4 by 6 inches. The better crystals are firm and split fairly well. Most of the sheet mica so far mined would be punched into washers and cut into small sheets. The mica has a greenish-brown color in sheets one-sixteenth of an inch thick. Most of it is slightly specked and some is rather strongly specked with magnetite. Some of the larger mica crystals seen had been badly crushed and "ruled." Others were wedge shaped or showed "A" markings.

In two of the other prospects good sound mica, but in small crystals only, was observed. Only a small amount of work had been done on these prospects, and their possibilities had not been determined.

At several places on the property the crystalline rocks have a composition which makes them useful, when ground and properly mixed with other ingredients, in giving a natural-rock finish ("micolithic" finish) to cement and other construction material. The special rock used in the different mixtures varies with the effect desired. Several phases of the quartz-biotite-muscovite schist and gneiss have been ground for this purpose. A large body of coarse biotite schist supplies an abundance of black mica with which to vary the tone of the "micolithic" finish. This biotite schist occurs as a bed in contact with pegmatite. Several feet from the contact it is even-grained, finely laminated schist composed largely of biotite in plates or scales as much as one-eighth of an inch across. Within 3 feet of the pegmatite the biotite scales are coarse, ranging from one-sixteenth to over half an inch in diameter. They are bunched at all angles, and the rock shows but little schistosity. This rock may be called massive biotite.

## COLORADO.

### FREMONT COUNTY.

*Location of mines.*—Mica was mined and prospected in Fremont County, Colo., by the United States Mica Co., of Chicago, and others from about 1904 to 1907. The mines are located on the east side of Mac Gulch, a tributary of Currant Creek, about 2 miles south of the Park County line and about 25 miles northwest of Canon City. The Micanite post office was formerly near the mines, but at present it is 3 miles east, on the West Fork of Wilson Creek. The deposits are in rough, mountainous country at elevations of 7,900 to 8,400 feet above sea level. The names and present ownership of all the claims could not be learned. The old Micanite post office and mica shops are in the gulch, and the position of the different workings examined can be described with respect to them. The most northerly working is about three-fourths of a mile north of the shops, in the steep east wall of the gulch, probably 300 feet above the bottom. This working

will be called the North mine in the following descriptions. Mine No. 8 of the United States Mica Co., at present claimed by Thomas Pennington and Luther Seymour under the name Climax, is about 250 yards east of south of the North mine in less broken country near the summit of the ridge. Another working, which will be called the East mine in the description below, is nearly a quarter of a mile east of the Climax or No. 8, on the west side of a small gulch tributary to Mac Gulch. Another deposit was opened by the United States Mica Co. on the summit of the narrow ridge east of the shops, about two-thirds of a mile south of the Climax working. This will be called the South mine. Two prospects have been opened by F. L. Rowe, of Micanite, one about 150 yards south of the South mine on the point of the ridge, and the other a quarter of a mile to the southeast, in the east side of the gulch. Still other prospects are reported to have been opened in the region by the United States Mica Co.

*North mine of United States Mica Co.*—The North mine was worked by an open cut and tunnels in a northerly direction along the steep mountain side. Crosscuts and pits were made on the west or lower side. The open cut is about 100 feet long and of irregular shape. It has a depth of 25 feet in places, but caving of the walls has filled parts of it. The dumps on the mountain side are large.

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

*Climax claim or mine No. 8.*—The Climax claim or working No. 8 of the United States Mica Co. was worked by three open cuts with connecting tunnels, some smaller cuts or pits, and a tunnel at a lower

level. The workings fall within an area about 100 feet long from north to south and 50 feet wide, and their positions are shown in the rough sketch (fig. 42).

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

The country rock is diorite gneiss with streaks of biotite schist and gneiss. The pegmatite dike is probably 25 feet thick and cuts the inclosing gneiss irregularly. In the open cuts it appears to dip  $15^{\circ}$ - $20^{\circ}$  E., but the lower contact exposed in the end of the tunnel

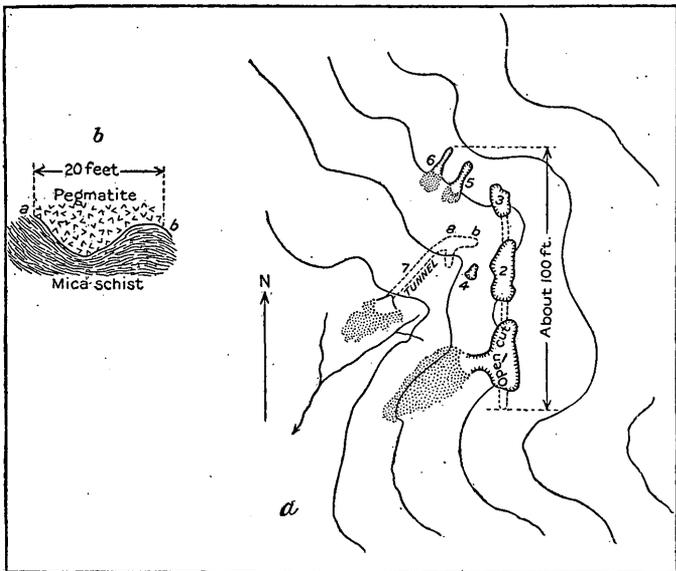


FIGURE 42.—Plan and section of Climax mica claim or working No. 8 of United States Mica Co., 25 miles northwest of Canon City, Fremont County, Colo. *a*, Plan of workings; *b*, cross section in end of tunnel; 1, 2, 3, open cuts; 4, 5, 6, small cuts or pits; 7, tunnel.

is irregular and rolling, as shown in figure 42. The pegmatite is coarse grained and has an irregular texture. Parts of it consist of the normal mixture of feldspar, quartz, and mica, but other parts contain large crystals and segregations of these and other minerals. Quartz occurs in masses 10 feet across, feldspar in crystals a yard through, and mica in blocks weighing 50 pounds or more. Imperfect crystals of mica 18 inches across and 6 to 8 inches thick and masses of wedge-shaped crystals 2 feet across had been left exposed in the face of the pegmatite in the open cuts. An unusual feature of this pegmatite, but without economic value, is the inclusion of cordierite crystals or masses, some nearly a yard across, in various stages of alteration. This cordierite occurs in contact with all three minerals

of the pegmatite—that is, the feldspar, quartz, and mica. Part of it is fresh and glassy and has a gray to dark violet-blue color in thin pieces. Much of the cordierite has altered to muscovite (often called pinite) and some has been only partly altered. Alteration has taken place along numerous parallel cleavage planes, and the surfaces of these planes are heavily coated with mica. The effect of these numerous cleavages with their reflection from mica-coated surfaces in the glassy cordierite is striking. In some places entire cordierite crystals have altered to masses of brownish-stained mica which still preserve the prominent cleavage planes of the cordierite as thin layers of mica schist with smaller crystals of mica developed between them. Green apatite was found in some of the pegmatite in crystals as much as 2 inches in diameter.

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

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

*South mine.*—The South mine was worked by an open cut with short tunnels near the summit and along the west side of a small knob on a ridge. The open cut is about 45 feet long in a north-northwest direction, 15 to 20 feet wide, and 10 to 25 feet deep. Cross-cut trenches were made at each end of the open cut to the hillside on the west for the removal of waste and ore, as shown in figure 43.

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

pegmatite and aplite 2 inches to over a foot thick extending from it into the granite below, as shown in the section in figure 43. The pegmatite apparently forms a large bulge or body cropping out at the present surface and surrounded by granite below and on the sides. There seem to be transitional phases between the pegmatite and aplite, and the streaks of these rocks may represent feed channels for the main body of pegmatite or may be offshoots from that mass.

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

*Rowe mine.*—At the north working of the F. L. Rowe mine an open cut was driven about 35 feet S. 80° E. into the side of the ridge, with a short tunnel and an 18-foot raise to a small open cut above. The biotite granite country rock is cut by two streaks of pegmatite,

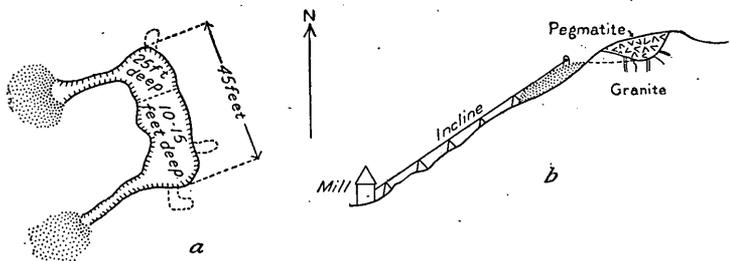


FIGURE 43.—Plan and section of South mine of United States Mica Co., 25 miles northwest of Canon City, Fremont County, Colo. *a*, Plan; *b*, cross section, looking north.

the upper one 10 feet thick and the lower about 25 feet thick. The west contact of the lower pegmatite strikes N. 25° W. and has an irregular east dip. The pegmatite masses have a very uneven texture and contain segregations of both quartz and dark-pink feldspar 3 to 4 feet across. The mica occurs chiefly in wedge-shaped and "ruled" crystals suitable only for grinding as scrap. Some of it is specked. Several tons of mica was left around the workings.

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

#### LARIMER COUNTY.

*Buckhorn mine.*—Considerable work was done several years ago by the Buckhorn Mica Mining & Milling Co., about 17 miles in an air line S. 75° W. of Fort Collins, on the North Fork of Buckhorn Creek. The mica deposit lies in an oval-shaped hill elongated in a N. 65° E. direction, about 200 feet higher than and a quarter of a mile south of the camp and mill in the valley below. The elevation of the camp is

about 8,000 feet above sea level. Fires have damaged much of the timber, but there is sufficient left on the mountains for mining purposes. A fair road was built from the mine to Masonville, about 12 miles to the southeast, but the bridges and some of the grades are now in bad repair.

The mine was worked by open cuts, two shafts, drifts, trenches, and pits in a N. 65° E. direction along the summit of the hill. The approximate position of the workings is shown in figure 44, in which 1 is a crosscut trench or open cut; 2 an open cut 90 feet long, 10 feet wide, and 2 to 15 feet deep; 3 an open cut 20 feet long and 8 feet deep; 4 a shaft (now boarded up) in the end of a crosscut tunnel; 5 a shaft filled with water within 25 feet of the surface; 6 a crosscut trench 20 feet long and 3 feet deep; and 7 two prospect pits. Drifts were made from the interior shaft 4 on the vein. It was not possible to see much of the underground workings, but the size of the dump indicates that they were rather extensive.

The country rock is chiefly quartz-biotite schist. The pegmatite is approximately conformable with the foliation of the schist, striking about N. 65° E. and having a nearly vertical dip. The contact between the two rocks is sharp. The

pegmatite varies in thickness from about 9 feet in the open cut marked 1 to 20 feet in the other open cuts, 2 and 3, and about 10 feet in the prospect pits, 7. It is a variable mixture of gray quartz, albite feldspar, pink orthoclase or microcline feldspar, mica, and a few accessory minerals such as beryl and black tourmaline. The mica occurs in bunches or pockets, some of them several feet thick, in which there is not much gangue mineral, and in separate crystals distributed irregularly through the pegmatite. The pockets are filled chiefly with "wedge," "A," "fishbone," and "ruled" mica in crystals ranging from those of small size to some several inches across. In some of the "A" mica thin plates of albite were observed between the laminae. Blocks of light-greenish compact massive mica have been thrown on the dumps. This is composed almost entirely of mica in scales of various sizes, some minute and some one-eighth of an inch in diameter, with but few impurities intermixed. Pale-greenish to white beryl crystals several

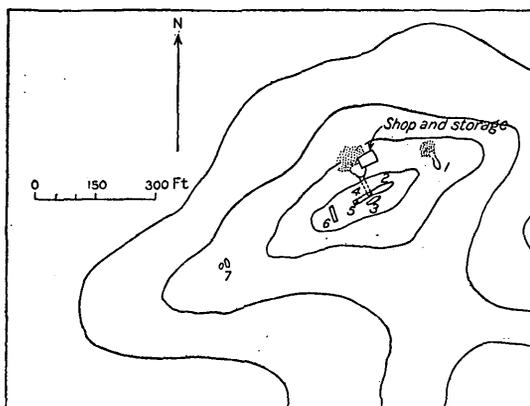


FIGURE 44.—Sketch plan of workings of Buckhorn Mica Mining & Milling Co., 17 miles S. 75° W. of Fort Collins, Larimer County, Colo.

inches across were observed in the pegmatite in the open cut. In places black stains of manganese oxide have penetrated into the seams in the pegmatite. The mica-quartz schist wall rock in one place has been strongly metamorphosed by the pegmatite and much small black tourmaline has been deposited in the bedding planes and through the layers of schist.

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

The mill erected on the property was operated by steam engine and was equipped with dry-grinding machinery. The mica was ground with a Raymond patent pulverizer No. 0 and conveyed to a Barnard & Leas bolter by air draft from a rotary blower. The capacity of the mill was limited by that of the bolter to  $1\frac{1}{2}$  tons a day. The pulverizer could have supplied two or more bolters.

Another mica prospect was opened by Parkson & Kitchen about a quarter of a mile west of the Buckhorn mine. The work consisted of an open cut on a bulge of pegmatite nearly 30 feet across. The pegmatite has a northwesterly strike and is inclosed in biotite gneiss. An irregular streak or pocket of mica, about 6 feet thick, extended across the pegmatite in a northeasterly direction. Green and yellow opaque beryl crystals up to  $2\frac{1}{2}$  inches in diameter were found. Orange-colored and yellow ocherous stains of uranium were found in a few pieces of pegmatite on the dump. These were reported to surround small cores of a heavy black mineral which might be pitchblende. The mica obtained resembles that of the Buckhorn mine and is practically all suitable only for grinding.

#### JEFFERSON COUNTY.

Mica has been mined or prospected at several localities in Jefferson County, and two deposits southwest of Morrison were examined. These were the Bigger Bros.' mine, about 9 miles southwest of Morrison, and the Thomas mine, about 12 miles west-southwest of Littleton. These mines are in rough mountain country a few miles west of the first foothills scarp of the Rocky Mountains.

*Bigger mine.*—The Bigger Bros.' mine is located on the south side of a tributary of Turkey Creek at the edge of a broken plateau about 7,100 feet above sea level. It is about half a mile from a good road along Turkey Creek to Morrison. A passable wagon road could be

made to the mine at small expense. The developments consist of a deep shaft with a tunnel from the hillside to an upper level, an open cut northwest of the shaft, and an irregular set of "groundhog" workings to the southeast of the shaft. The approximate positions of the different workings are shown in figure 45. The shaft is reported to be 80 feet deep and was sunk some 30 years ago in search of tin ore. It is filled with water within 30 feet of the surface. The tunnel from the hillside on the northeast is about 50 feet long and only about 15 feet below the surface. It has caved in badly. Other short tunnels were made from the shaft at this level. The open cut to the northwest is about 35 feet long and 10 feet deep. The "groundhog" workings are about 100 feet southeast of the shaft and consist of an irregular-shaped open cut about 20 feet deep with short drifts and rooms.

The country rock is chiefly diorite cut by reddish granite. The pegmatite crops out in a large bed that is nearly horizontal or has a light south dip, forming a small scarp along the edge of the valley, and is therefore in a very favorable position for development by open work or tunnels. The lower contact of the pegmatite is concealed by soil and vegetation, but the bed must be at least 25 feet thick. The shaft cut through pegmatite into the underlying diorite, but at what depth could not be determined. The pegmatite has an exceedingly variable texture, and in places the segregations of the different component minerals are large. Masses of pink orthoclase or microcline feldspar, 8 feet thick, composed of several large crystals, and irregular segregations of quartz, some with a pale rose tint, of similar size, were encountered in the workings. Mica occurs in large aggregations or deposits of "wedge," "A," "ruled," and "fishbone" crystals. These deposits are irregular in shape and range from 1 foot to 8 or 10 feet in thickness and 15 to 20 feet in length. They occur among the large masses of feldspar and quartz. Beryl crystals are abundant and there are probably over 2 tons in sight on the dumps and in the workings. The beryl crystals seen were opaque and ranged from 4 to 18 inches in diameter. Black tourmaline was found in a small pit east

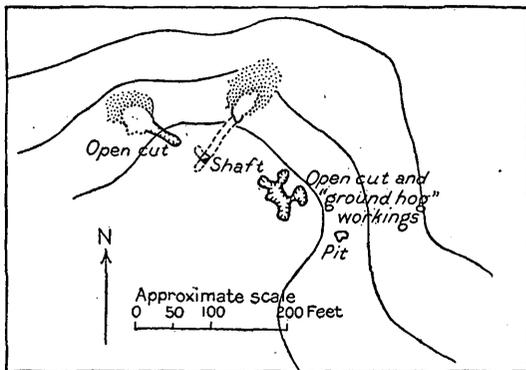


FIGURE 45.—Plan of Bigger mica mine, 9 miles southwest of Morrison, Jefferson County, Colo.

The shaft cut through pegmatite into the underlying diorite, but at what depth could not be determined. The pegmatite has an exceedingly variable texture, and in places the segregations of the different component minerals are large. Masses of pink orthoclase or microcline feldspar, 8 feet thick, composed of several large crystals, and irregular segregations of quartz, some with a pale rose tint, of similar size, were encountered in the workings. Mica occurs in large aggregations or deposits of "wedge," "A," "ruled," and "fishbone" crystals. These deposits are irregular in shape and range from 1 foot to 8 or 10 feet in thickness and 15 to 20 feet in length. They occur among the large masses of feldspar and quartz. Beryl crystals are abundant and there are probably over 2 tons in sight on the dumps and in the workings. The beryl crystals seen were opaque and ranged from 4 to 18 inches in diameter. Black tourmaline was found in a small pit east

of the main workings. But little muscovite mica was found in the pegmatite at this place, and most of it was associated with biotite mica.

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

*Thomas mine.*—The Thomas mica mine is in the steep slope of the west side of a tributary of Deer Creek, about  $1\frac{1}{2}$  miles southeast of the Bigger mine. It has been worked by an open cut 15 to 30 feet wide, extending for a height or distance of about 50 feet in a N.  $60^\circ$  W. direction up the hill, with two short tunnels and a room stoped out near the bottom of the cut. A small cleaning mill had been erected near the lower tunnel.

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

Apparently scrap mica was rather plentiful in parts of the pegmatite. Much of the pegmatite was crushed in the upper part of the mill, and the product was distributed by gravity over coarse sieves below, where the mica was separated from it.

#### CONCLUSION.

Mica is an important mineral in the industrial world, where it meets a demand not supplied by any other material. Sources of supply are therefore of both present and future importance. Many good mica deposits are known in the United States and the production is increasing. The imports of mica are generally greater than the domestic production, but the mica mines of the United States could be made to

supply all but that small part of the domestic demand which calls for the softer Canadian "amber" mica. This output could be readily furnished if some of the mines in several States were operated on a large scale, or even as they have been worked in the past. Good mica mines have been worked in North Carolina, New Hampshire, South Dakota, Idaho, New Mexico, Virginia, South Carolina, and Alabama, and promising deposits are known in several other States.

The occurrence of mica deposits in numerous other countries insures future supplies of mica for the world for some years to come, and the many undeveloped mica deposits of the United States may be considered among these resources. Under present conditions the mica deposits of the United States will probably continue to yield a considerable part of the mica used in this country.

