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MICA-BEARING PEGMATITES OF NEW HAMPSHIRE

A PRELIMINARY REPORT

BY

J. C. OLSON

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MICA-BEARING PEGMATITES OF NEW HAMPSHIRE

A PRELIMINARY REPORT

By J. C. Olson

ABSTRACT

Mica has been mined in New Hampshire since 1803. Production from 1908 through 1939 has aggregated 13,326,990 pounds of sheet and punch mica, an annual average of 416,470 pounds. Since 1931 production has been below this average, because of economic conditions rather than depletions.

The mica-bearing pegmatites of the Grafton and Keene districts occur mostly in sillimanite-mica schist adjacent to large areas of biotite gneiss. The pegmatite bodies range from a fraction of an inch to more than 200 feet in thickness; most of them are crosscutting, and about 75 percent strike northeast. Mica occurs sporadically in most of them but where present in commercial quantities it is localized in one or more of the following zones: (1) In quartz-plagioclase-muscovite zones 2 to 10 feet from the walls of large pegmatite bodies, (2) in or near quartz masses that occur mostly near the centers of the bodies, (3) in thin dikes 5 to 15 feet thick or in similar offshoots from larger bodies, (4) within large pegmatite bodies, in more or less tabular streaks or zones composed principally of plagioclase, quartz, and muscovite.

Sixty-seven mica and 18 feldspar mines and prospects were examined in the Grafton district, 16 mica and 29 feldspar mines in the Keene district, and 1 mica mine in Strafford County. Six of the feldspar mines and two of the mica mines were in operation at the time of the writer's visit, in the fall of 1940. Mica from 60 percent of the 131 mines was of a light-amber color. Pegmatites that contain abundant biotite generally yield mica that is of a light-amber or ruby color; those that contain abundant cleavelandite or lithium minerals commonly yield a light yellowish-green mica.

Tests made by the National Bureau of Standards on 76 samples of carefully selected sheet mica from 65 of the mines indicate that this sheet mica meets the exacting specifications for certain electrical uses.

Only a general estimate of reserves can be made because of the erratic distribution of mica in pegmatites. On the basis of an average annual production of 416,470 pounds of sheet and punch mica over the 32-year period 1908-39, it is estimated that an annual production of 500,000 pounds of sheet and punch mica, of which from 100,000 to 125,000 would be sheet, could be maintained for several years at a cost slightly higher than the average of the past. With more intensive development, a possible annual production of 1,000,000 pounds or more of sheet and punch mica might be attained.

INTRODUCTION

Mica in some form is used as an insulating material in nearly all electrical equipment. The poorer grades appear in many common household appliances. Sheet mica of the best grades has been used mainly for radio transmitter condenser films, for receiver and trimmer condenser films, for radio tube supports and bridges, and in airplane motor spark plugs. Of greater quantitative importance than sheet mica are the thin films of mica about 0.001 inch thick known as splittings, used in the manufacture of mica board or built-up mica. Splittings are not ordinarily produced in the United States because of the high cost of the labor necessary to split the mica. High-grade sheet mica and splittings have been obtained in the past mainly from foreign sources, principally India, and are therefore regarded as strategic materials. The present investigation is directed toward determining, insofar as possible, to what extent the pegmatites of New Hampshire could supply such mica.

Mica has been mined from New Hampshire pegmatites since 1803. The principal mines are in two areas, hereafter referred to as the Keene and Grafton districts (see fig. 38), that include the productive parts of a belt of pegmatites extending northwestward from Cheshire County through Sullivan and Merrimack Counties into Grafton County. Mica has also been produced from Strafford and Coos Counties.

The main belt of mica-bearing pegmatites follows approximately the divide between the Connecticut and Merrimack Rivers, in a glaciated region of wooded hills and numerous lakes and ponds, in which altitudes range from 650 to 2,100 feet. Bold outcrops of resistant pegmatite are prominent topographic features. Graded town roads and paved highways make all parts of the mica districts accessible, although many of the roads to woodlands and abandoned farms are overgrown and covered with fallen timber. The Boston and Maine Railroad, which serves the western part of New Hampshire, has stations in the mica districts at Canaan, Grafton, Danbury, Plymouth, Rumney, Newport, Walpole, and Keene.

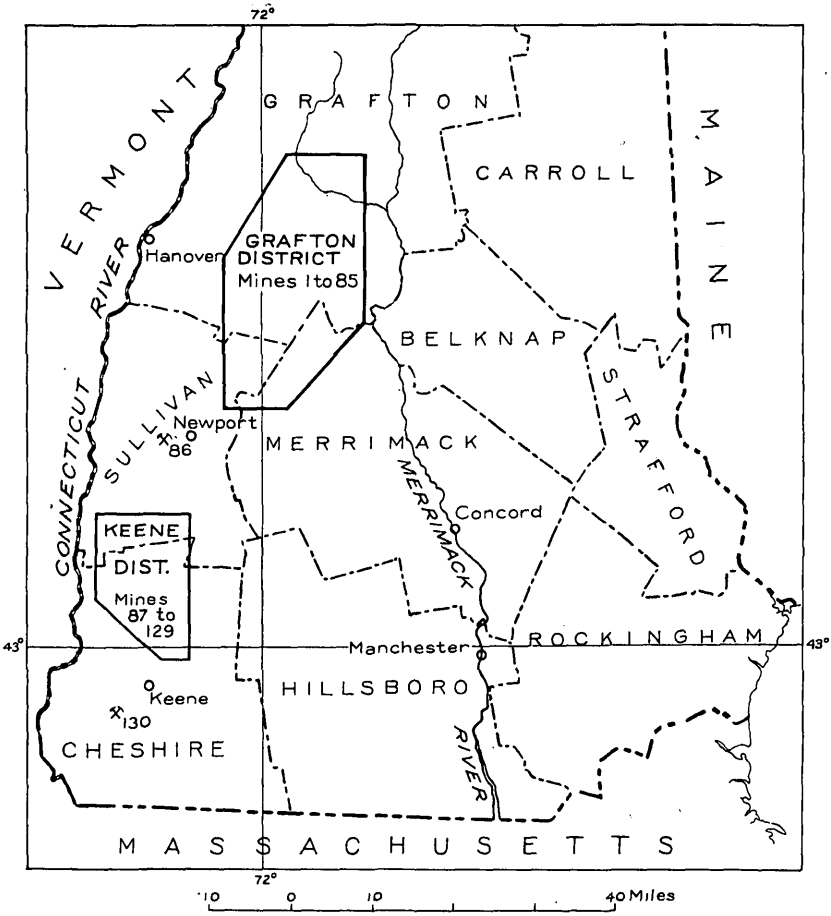

Figure 38.—Index map of New Hampshire showing locations of the Grafton and Keene districts.

Previous work

A comprehensive report on the geology of New Hampshire, in which the mica deposits and their association with sillimanite-mica schist were discussed, was published by Hitchcock 1/ in 1877. Sterrett examined many of the mica mines in 1914, and included

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1/ Hitchcock, C. H., The geology of New Hampshire, Concord, N. H., 1877.

his descriptions in a report [2] on mica deposits of the United States. In the last decade, the geology of a large part of Grafton County has been described by a number of authors.[3]

Field work and acknowledgments

Field work was carried on by the writer during 3½ months in the fall of 1940, with the assistance of F. W. Hinrichs for 1½ months and of R. I. Edwards for 2 months. Practically all the feldspar and mica mines in the area, a total of 131, were examined and located on topographic maps having a scale of 1:62,500; and an area of about 2 square miles, at Alstead in the Keene district, was mapped on a scale of 1:24,000 to show the extent and structural relations of the pegmatites. The work was under the supervision of T. L. Kesler, who accompanied the writer during 2 weeks of preliminary reconnaissance. Miners and other residents of the mica districts helped the party to find mines and to reconstruct local mining history. Messrs. L. F. Crowe, of the General Electric Co., and Paul French, of Eugene Munsell & Co., kindly gave permission to publish company production figures. Production records of the Bureau of Mines, United States Department of the Interior, were made available by Messrs. P. M. Tyler and K. G. Warner. To Mr. Tyler the writer is especially indebted for suggestions and criticisms concerning procedure for testing mica samples.

2/ Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, 1923.

3/ Billings, M. P., Geology of the Littleton and Moosilauke quadrangles, N. H.: New Hampshire Planning and Development Comm., Concord, N. H., 1935.

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Chapman, C. A., Geology of the Mascoma quadrangle, New Hampshire: Geol. Soc. America Bull., vol. 50, pp. 127-180, 1939.

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GEOLOGY

The oldest rocks in the region are amphibolite, quartzite, mica schist and gneiss, sillimanite-mica schist and gneiss, staurolite-mica schist, and other metamorphosed sedimentary rocks of Ordovician, Silurian, and Devonian age, which crop out over large areas in western New Hampshire. Belts of these rocks trend about N. 20° E., the average strike of their foliation, which generally dips to the east.

Biotite gneisses, which occur in north to northeast-trending belts, appear to have intruded the more schistose rocks as thick sills or laccolithic bodies. The gneisses locally grade into nonfoliated granitic rock, but in the areas in which mica-bearing pegmatites occur they are distinctly foliated and commonly contain large phenocrysts or metacrysts of orthoclase. The foliation of the gneiss is conformable in general with that of the surrounding schist.

Small intrusive masses of a granite younger than the gneiss occur in the eastern part of the Grafton district. Dikes of granite, mostly less than 3 feet thick, are abundant in Grafton and adjacent towns, where they cut across the foliation of both the schist and the gneiss.

The mica-bearing pegmatites appear to be younger than the granite dikes. Dikes of basalt, diabase, camptonite, and other basic rocks cut all the older rocks.

From structural relations the gneiss, granite, and pegmatites are believed to be post-Lower Devonian,[4/] probably late Devonian. The age of the pegmatite at the Ruggles mine has been estimated from the lead-uranium ratio to be 304 million years (late Devonian).[5/]

4/ Billings, M. P., Paleozoic age of the rocks of central New Hampshire: Science, new ser., vol. 79, pp. 55-56, 1934.

5/ Shaub, B. M., The occurrence, crystal habit, and composition of the uraninite from the Ruggles mine, near Grafton Center, New Hampshire: Am. Mineralogist, vol. 23, pp. 334-341, 1938.

Grafton district

In the Grafton district, most pegmatite bodies that have been mined for mica are near the contact between biotite gneiss and sillimanite-mica schist, principally in the schist. Proximity to this contact suggests a genetic relation between gneiss and pegmatite, and is one of the evidences of an intrusive origin of the gneiss. However, the pegmatites were emplaced after the development of foliation in the gneiss, and have undergone very little metamorphism. Small bodies of granite enclose some of the pegmatites, and have been the source of some of the pegmatitic material.

Alstead area, Keene district

Typical rocks of the Keene district are exposed in the Alstead area, a geologic map of which forms plate 61. At Alstead the country rocks generally strike north to N. 10° W., and dip from 30° E. to vertically. From west to east they consist of: (a) Amphibolite interbedded with thin layers of quartzite; (b) coarse feldspathic biotite gneiss that is partly garnetiferous; (c) quartz-mica schist, mica gneiss, and quartzite, containing needles of sillimanite in places. A band in which quartzite is most abundant is indicated on the map, although quartzite is also interbedded with other parts of the quartz-mica schist. The sillimanite is increasingly abundant westward toward the contact with the biotite gneiss, but the amount differs considerably in adjacent layers. Pegmatites, as much as 200 feet across, strike north to northeast, most of them cutting across the foliation of their wall rocks at low to moderate angles. The pegmatites that have produced the most mica (the French, Big, and Island mines) are in quartz-mica schist containing sillimanite, adjacent to the feldspathic biotite gneiss. Large pegmatites in other parts of the Alstead area, and also to the east and west of the area mapped, have been mined for feldspar, but apparently contain less commercial mica. Other pegmatites mined for mica, south of the Alstead area, at the Nichols,[6] Isham, Jehial White, and Bingham Hill mines, are in wall rocks similar to the schist in which the French, Big, and Island mines occur.

MICA-BEARING PEGMATITES

Size

The pegmatites range in size from thin pods or stringers to large irregular masses such as those at Beryl Mountain, which are 200 feet thick, and at Aaron Ledge, which are 250 feet thick, and those massive ledges in the west part of the town of Groton, whose dimensions are measured in hundreds of feet but which have not been mined extensively for mica. Many of the pegmatites are more than 1,000 feet long. Thicknesses of individual pegmatites are seldom constant even for short distances. The pegmatite at the United mine, for example, as much as 20 feet thick in surface outcrop, is said to be only 18 inches thick within a distance of 90 feet down the incline.

Relation to older rocks

Pegmatites that are rich in sheet mica are practically confined to mica schist, sillimanite-mica schist, and quartz-mica schist, and to biotite gneiss adjacent to them. Pegmatites in other rocks, such as amphibolite, quartzite, and granite, generally contain less commercial muscovite than those in micaceous rocks, and have been mined principally for feldspar.

Most large pegmatites have irregular shapes and cut across the foliation of their wall rocks. Pegmatites 10 or 15 feet thick and offshoots from the larger masses cut across the

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6/ Mines are numbered in table 8 and located by corresponding numbers on plates 62 and 63.

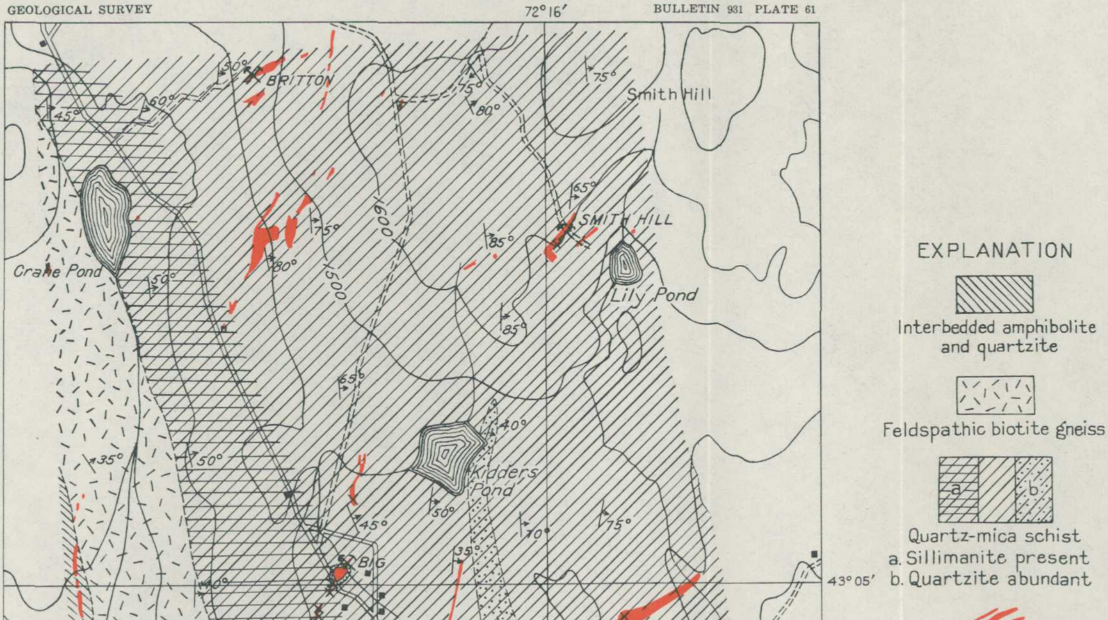
foliation in some places and are conformable in others. About 75 percent of the pegmatites strike northeast, generally between N. 10° E. and N. 65° E. Their dips are generally greater than 60°. Pre-pegmatite jointing may have determined in part the location and forms of pegmatites.

The crescent shapes of at least three pegmatites result from injection parallel to folds in the older rocks. At the Kimball Hill (India Mica Co.) mine, however, the mica in the vicinity of the fold was mostly bent and broken, according to Sterrett, and this may indicate continuation of the folding after the mica books had formed.

Introduction of the pegmatite into the country rocks appears to have been dominantly an intrusive process. This is indicated by the large size and irregular shape of the bodies, the distortion of wall rocks, and the relatively clean-cut though irregular contacts. Contacts with wall rocks are commonly sharp, though some are hazy owing to moderate replacement by pegmatitic material, and some inclusions are partly replaced. Inclusions are usually parallel to the structure of the adjacent country rock, but some appear to have been rotated.

Relation to faults

Postpegmatite faults are not common in mica mines, because in faulted pegmatites the mica books are likely to be crushed and of little or no value as sources of sheet mica. Postpegmatite faults with throws of less than 5 feet were observed, however, at the Kilton, Powell, and Evans mines. The mica is distorted near the faults. A slightly lower proportion of flat sheets and a higher proportion of distorted mica in the Acworth-East Alstead area than is usual elsewhere may be a result of localized postpegmatite deformation.



GEOLOGIC MAP OF THE ALSTEAD AREA, KEENE DISTRICT, NEW HAMPSHIRE

1000 0 5000 Feet

Mineralogy

More than 30 minerals have been reported from the pegmatite at the Ruggles mine alone, and many other pegmatites have yielded specimens of mineralogic interest. Only the more abundant minerals are described in this section. Muscovite is not included here; its mineral associations and distribution in the pegmatites are described in the section on localization of mica (p. 374).

Quartz occurs, unevenly distributed, in every pegmatite, and is associated with every pegmatitic mineral. Common gray quartz predominates, but rose, white, and clear varieties were seen. In general, pegmatites less than 15 feet thick contain a slightly higher proportion of quartz than the thicker bodies. The centers of mica-bearing pegmatites are generally quartzose, and commonly are marked by discontinuous quartz masses as much as 15 feet thick which in some places contain crystals of potash feldspar, beryl, or muscovite.

Feldspar has been the principal product in 47 of the mines examined, and has been a byproduct in many of the mica mines. Commercial quantities of feldspar generally are associated with massive gray quartz in the central parts of pegmatites. Microcline, the potash feldspar, is the variety generally mined, chiefly because it is coarse-grained; it forms blocks as much as 6 feet long.

Plagioclase is subordinate to potash feldspar in most of the pegmatites, but is the dominant feldspar in a few. Wide pegmatites (over 6 feet) seem to contain a greater proportion of potash feldspar than some of the thin bodies or offshoots from larger masses. Plagioclase is most abundant near the walls but also occurs in other parts of pegmatites. Cleavelandite, the platy variety of albite, is present in minor quantities at more than a dozen of the mines examined. It is typically associated with tourmaline, yellowish-green muscovite, and apatite, and was found in every pegmatite that contained the lithium minerals spodumene, triphylite, and lithiophilite.

Biotite, seen at roughly two-thirds of the mines, is a common constituent. Typical are lathlike strips as much as 5 feet long, which appear to have formed in seams or cracks that cut through graphic granite, microcline, quartz, and less commonly plagioclase. Such biotite strips are especially plentiful with graphic granite and microcline. Intergrowths of biotite and muscovite are common in pegmatites containing both minerals, but where the quantity of biotite is great, muscovite is less abundant; furthermore, the muscovite commonly splits poorly and is called tanglesheet. Most pegmatites mined for mica, therefore, contain little biotite, and intergrowths of the two micas are relatively scarce at most large mines, though seen at many prospects.

Garnet is an accessory mineral usually associated with quartz, plagioclase, and mica. Crystals as much as 2 inches in diameter were found at the Evans mine. Both flat and euhedral garnets are intergrown with muscovite at many mines, and with biotite at a few.

Beryl was seen in 61 of 131 pegmatites examined. Gem beryl was the principal product of three mines in Springfield, but most of the beryl is of the common green variety. Beryl encountered in feldspar or mica mining is often set aside and sold for $30-$35 per ton, but the relatively small quantities of byproduct beryl obtained do not go far to defray mining costs. Hitchcock [7/] describes a beryl crystal weighing 2,900 pounds, and another calculated to weigh 2½ tons, at the Alger mine. Beryl occurs most commonly as hexagonal crystals near the middles of pegmatites in quartz that may also contain crystals of potash feldspar. A beryl crystal several inches long was found in wall

7/ Hitchcock, C. H., op. cit., p. 515.

rock adjacent to a large pegmatite west of the French mine, but such an occurrence is unusual.

Apatite is most abundant at the Foss mine in Strafford County, where it is associated with cleavelandite, but it was also seen at about a fourth of the mines examined, generally associated with plagioclase, quartz, garnet, or other minor accessories. Hexagonal crystals of apatite that penetrate mica books commonly are oriented with the c axes perpendicular to the cleavage of the mica, indicating a crystallographic relationship between the two minerals.

Spodumene, triphylite or lithiophilite, and a little lepidolite were seen in about a dozen pegmatites, associated with cleavelandite.

Roughly three-fourths of the pegmatites examined contain tourmaline. It is most plentiful (1) in quartzose parts of pegmatites, (2) associated with cleavelandite, (3) near contacts, either in pegmatite or wall rock. Blue and green varieties were seen in two pegmatites that also contain cleavelandite and lithium minerals, but all the tourmaline seen elsewhere is black. Black needles are abundant in wall rock adjacent to tourmaline-bearing pegmatites, particularly in quartz-mica and sillimanite-mica schist. Crystals of black tourmaline in the pegmatite at the Baer mine are as much as 10 inches in diameter.

Minor quantities of sulfide minerals, including pyrrhotite, pyrite, a: enopyrite or lollingite, molybdenite, and chalcopyrite, are enclosed i ne quartz of the pegmatites. Typical examples may be s south of C Hill quarry in a pegmatite composed almost e rely of massive quartz.

Mineral zones an eaks

As a general rule, the value of a pegmatite depen large part on the degree to which its valuable minerals are segregated. Pegmatites composed of the feldspar-quartz intergrowth graphic granite, of which there are many, cannot be mined profitably apart from certain zones, streaks, or pockets rich in feldspar or mica. Pegmatites less than 6 feet thick are mined from wall to wall, but a large pegmatite that is minable for its entire width, such as the one in the French mine (see fig. 45), is exceptional.

Many of the large pegmatites (over 25 feet thick) that have been mined for mica are zoned as follows: (1) The pegmatite within a foot or two of the walls is composed of quartz, plagioclase, muscovite, and occasionally tourmaline, and most of the mica books are oriented with their cleavage perpendicular to the contacts. (2) Inward from this contact zone there is a zone several feet thick composed of the same minerals in larger grains, from which large mica books are mined. (3) Between the mica zone and the center, the pegmatite consists mainly of intergrown quartz and feldspar, which in places contains strips of biotite. (4) The central part consists of discontinuous quartz masses, which are commonly lenticular and similar in attitude to the enclosing pegmatite. Some of these masses contain crystals of potash feldspar and beryl. Typical thinner pegmatites also have quartzose centers, with marginal zones of plagioclase, quartz, microcline, and mica.

The minerals of some pegmatites, instead of being zoned in the manner described, are concentrated in streaks or zones several feet thick, generally parallel to the long sides of the pegmatite, but not systematic in arrangement. Streaks rich in biotite, muscovite, cleavelandite, tourmaline, or apatite are common.

MICA

Localization

Muscovite is distributed sporadically in most pegmatites, but minable bodies are localized in zones, streaks, or pockets, in which the amount of recoverable mica ranges from 2 to 10 percent of the rock, and averages about 4 percent. The mica in most rich streaks is associated with quartz and plagioclase rather than with potash feldspar, and almost never with graphic granite.

The principal modes of occurrence of commercial mica are listed below. Further notes on the occurrence and character of mica in 131 pegmatites are included in table 8, at the end of this report.

(1) In quartz-plagioclase-muscovite zones in large pegmatites, near contacts with walls or inclusions. Pegmatite consisting of quartz, plagioclase, and muscovite is typically fine-grained within 1 or 2 feet of the walls, in a zone in which small mica books are oriented with their cleavage perpendicular to the contact. From 2 to 10 feet from the contact, however, there are large mica books in rock of approximately the same composition but of larger grain size. Such mica-rich zones may lie along either or both walls. Mica is also localized along the lower margins or sides of inclusions or pendants in some large pegmatites, such as those at the Keyes and Strain mines (fig. 42).

(2) In thin pegmatites and offshoots from large cross-cutting pegmatites, generally conformable to their wall rocks and from 6 to 15 feet thick. Such offshoots commonly contain a higher proportion of plagioclase than the larger masses, but like them are generally more quartzose near their centers. In some, mica books occur throughout the entire thickness; in others, they are more abundant near the walls.

(3) Marginal to large masses of quartz, 2 to 15 feet thick, generally in the central parts of pegmatites. Mica occurs within some of the quartz masses, but more commonly it is found in quartz-feldspar pegmatite adjacent to them. Such concentrations of mica near quartz are seldom continuous for very great

distances. Large quartz masses are numerous in pegmatite outcrops, but mica is associated with relatively few. Aggregates composed almost entirely of small green wedge-shaped books less than 2 inches in diameter, with subordinate plagioclase, tourmaline, or garnet, occur in a number of the larger pegmatites. Such an aggregate, 12 feet thick and 20 feet long, at the Ruggles mine is apparently associated with a large mass of quartz that contains blocks of potash feldspar. This and other masses of similar character seem to be related to massive quartz bodies near the centers of pegmatites.

(4) In more or less tabular mica-rich zones or streaks within pegmatites such as those at the Ruby and Palermo mines (fig. 40). Where mined they are 3 to 15 feet thick, and are composed mostly of quartz, plagioclase, and mica, with minor amounts of tourmaline, apatite, garnet, and other accessory minerals.

Physical properties and uses

Muscovite, the principal mica of commerce, has the approximate formula $K(Al,Fe)_2(Al,Si)_4O_{10}(OH,F)_2$. It crystallizes in the monoclinic system as six-sided crystals with prominent basal cleavage. Very few of the books mined, however, are euhedral crystals. The perfect cleavage of muscovite and its physical properties determine its uses in industry and its value.[8/] The combination of a number of peculiar physical properties makes mica essential for certain electrical uses. The principal physical properties have been described and illustrated by Sterrett,[9/] and the following are the more important in determining the value of mica and its uses.

8/ For uses of mica, see Wierum, H. F., and others, The mica industry: U. S. Tariff Commission, Rept. 130, 2d ser., pp. 11-26, 1938.
9/ Sterrett, D. B., op. cit., pp. 11-18, pls. 3-8.

Staining.--Clear domestic mica contains no inclusions of iron oxide or other substances. That which contains inclusions (principally iron oxide) is specked or stained, and is used mainly in electrical appliances that do not demand the best grades. The specks are distributed at random through some sheets, but in others magnetite or hematite inclusions are crystallographically arranged parallel to the lines of the percussion figure. "Spotted," "black-stained," "powder-specked," "electric," and "black" mica are other terms used to denote iron-oxide staining.

Mica is said to be clay-stained if fine particles of clay have been introduced between the sheets. Such staining is relatively rare in New Hampshire because the pegmatites have been weathered only to a shallow depth.

Air and water bubbles between sheets, if they are few, can be removed by careful splitting, but if abundant they reduce the value of the mica.

Flexibility.--In the manufacture of airplane spark plugs, films of "cigarette" mica, not over twelve ten-thousandths of an inch thick, are wrapped around a rodlike spindle, and they must be flexible enough to be rolled into a cylinder a little more than an eighth of an inch in diameter without cracking.[10] Mica for this purpose must not only be highly flexible, but must have flat cleavage faces and be free from inclusions and other imperfections.

Cleavage.--Perfect cleavage is one of the most important of mica's valuable properties. To be suitable for the most exacting uses, mica must split easily into perfectly flat sheets of uniform thickness throughout. Wavy or curved cleavage surfaces generally result from distortion of the mica crystal. Other cleavage irregularities, such as "A" wedge and herringbone structures, apparently originated at the time of crystallization

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10/ Wierum, H. F., and others, op. cit., p. 19.

of the mica, presumably forming under slightly different conditions from the flat books. "A" mica has two sets of cleavage imperfections, called ridges or reeves, which intersect at an angle near 60°, forming an A. "A" mica is present in different amounts in nearly every pegmatite, but the best mines contain relatively little. Books of "A" mica that are thicker at one end than at the other are called wedge mica. Wedge mica is relatively uncommon in New Hampshire, but at several mines, such as the one at Chandler Station in Newport, it constitutes practically the entire output. Flat sheets can be trimmed from the centers of some "A" books, but as a general rule a high proportion of "A" mica means a high proportion of scrap.

Herringbone mica differs from "A" in having three sets of reeves, two of them intersecting a central spinelike set at angles of about 60°. Herringbone mica does not split easily and is called tanglesheet. Some books grade from herringbone on one side to flat, easily splitting sheets on the other. Most muscovite that is intergrown with biotite is tanglesheet or has herringbone structure. Sheets that are difficult to split because of random fine cracks are said to be haircracked.

Another cleavage imperfection, known as ruling, apparently results from deformation of the mica book. Some books that are otherwise of large size are ruled to such an extent that they are worthless except as scrap. Since ruled, crumpled, and wavy mica is most abundant near faults, the best mica mines are in pegmatites that have not been deformed.

Intergrowths with other minerals.--Intergrowths of other minerals lower the value of a mica book. Sheets of biotite and muscovite commonly form parallel intergrowths. Flat tourmaline needles and garnet, both flat and euhedral, also occur between sheets of muscovite; and apatite, quartz, and albite are also commonly intergrown with muscovite. Flat tourmaline and garnet at the Island mine are more abundant in "A" mica than in flat.

Color.--The terms most commonly used to describe color are ruby, rum, green, white, and brown. Ruby and rum micas are the most desirable because they are usually slightly better than the green and brown in respect to certain electrical properties such as power factor. Mica from about 60 percent of the mines was classified in the field as light rum, and the color of much of the New Hampshire mica is notably uniform. Ruby mica occurs at a number of mines, and there are gradations between it and the light rum. Other colors that occur less commonly in New Hampshire are light yellowish green, greenish white, dark greenish rum, and other shades of rum and green.

The color of mica from a given pegmatite is relatively constant. Exceptionally, two or more colors may be reported from different parts of the same pegmatite. At the French mine (see fig. 45), most of the product was stained light-rum mica, but ruby and light green were also found.

Variations in the color of muscovite doubtless reflect a variation in composition. Green muscovite probably contains more iron than ruby. Most mica that is stained by iron-oxide inclusions is green rather than ruby. Muscovite closely associated with iron-rich biotite is generally of a ruby or rum color (less iron); where biotite is scarce or absent, the muscovite tends to be green or stained (more iron). Although this is not an invariable rule, it indicates a relationship between iron content and color.

Mica that occurs with cleavelandite and lithium minerals is almost invariably light yellowish green and may be either clear or stained.

In some mica books ruby- and rum-colored zones alternate from the center out to the edges of the cleavage plates.

Dielectric constant.--The simplest expression of the dielectric constant of mica is the ratio of stored energy in a dielectric field occupied by the mineral to the stored energy that would exist in the same space if air were used in place of mica.[11/] The dielectric constant of most mica ranges from 6.5 to 8.5 averaging about 7.2. Staining and color of mica seem to have little effect on its dielectric constant. In determining the suitability of mica for condensers, the dielectric constant need not be considered, because mica that is otherwise suitable for this purpose always has a sufficiently high dielectric constant.

Power factor.--The power factor of a substance, expressed in percent, is a measure of the loss of electrical energy in a condenser in which that substance forms the dielectric medium. Since excessive power loss results in overheating and destruction of the condenser, mica of low power factor is essential. Mica with a power factor greater than 0.04 percent is seldom used for condensers.

To determine the approximate suitability of New Hampshire mica with regard to the important property of power factor, carefully selected samples representing 65 mines were split into films 1 to 4 mils thick and submitted to the National Bureau of Standards. The tests of power factor were made by E. L. Hall. A part of the explanatory section of his report follows:

> The power factor was measured at room temperature at a frequency of 1,000 kilocycles per second. A small electrical condenser was prepared from each sample using two small pieces of lead foil attached on opposite sides of the mica specimen * * *. The power factor tests were made using a type 513-C radio-frequency bridge made by General Radio Company, Cambridge, Massachusetts. The standard in terms of which the measurements were made was a General Radio type 722-N precision variable air condenser.

The results of these tests indicate a low power factor for almost all of the samples. Of the 76 New Hampshire mica specimens tested, 33 of the measurements were 0.01 percent, 33 were 0.02 percent, 6 were 0.03 percent, 3 were 0.04 percent, and one was 0.09 percent. The specimens were carefully selected so that the results are not representative of the total output of the

11/ Wierum, H. F., op. cit., p. 22.

respective mines. They indicate, however, that by proper selection mica of low power factor is obtainable from many mines. The following is a list of mines from which samples were tested, together with mine numbers (as shown on pls. 62 and 63, and table 8) and power factors of the specimens:

Table 5.--Power factors of New Hampshire muscovite
[Tests made by the National Bureau of Standards]

Mine	Mine No.	Power factor (percent)
African	45	0.02
Akerman prospect	25	.02
Alger	58	.01
Alstead	97	.01
Bailey	32	.02
Bennett Bros.	64	.02
Beryl Mountain	89	.04
Big	110	.02
Boardman	53	.01
Carpenter, Frank	68	.02
Colby	72	.02
Cole	61	.02
Columbian Gem Co	75	.02
Danbury	35	.02
Danbury	35	.01
Davis, Charles	16	.02
Diamond Ledge	14	.01
Evans	62	.01
Evans	62	.02
Fletcher	2	.01
Fletcher	2	.01
Ford, Harry	42	.02
Foss	131	.09
French	47	.02
Globe	73	.02
Glover	63	.01
Hale	70	.02
Hanley	10	.01
Hoyt Hill	48	.01
Hutchins Hill	30	.02
Isham	122	.02
Island	112	.02
Keyes	40	.01
Kilton	57	.01
Marston	24	.03
Marston	24	.02
McGinnis, Whicher, and Pillsbury prospect	9	.02
Nichols	115	.01
Nims	126	0.03
Palermo	19	.01
Palermo	19	.04
Palermo	19	.02
Patten	26	.02
Playter	74	.02
Plume	17	.01
Powell	81	.01
Prescott Hill	65	.01
Price	128	.03
Price	128	.03
Reynolds	76	.01
Rice	20	.02
Rice	20	.01
Roby	37	.01
Ruby	51	.01
Ruby	51	.03
Ruggles	56	.03
Ruggles	56	.04
Ruggles New Hill	54	.01
Standard (Belden)	44	.01
Standard (in Alexandria)	28	.02
Strain	43	.01
Strain	43	.01
Straw	52	.02
Tenney	36	.01
Trow Hill	85	.02
Tucker	29	.02
Union	7	.01
United	69	.02
Valencia	1	.02
West Rumney	5	.02
White, Jehial	124	.01
Whitehall	50	.02
Whitehall on Braley Hill	33	.01
Wilmot	82	.01
No name, in Alstead	111	.01
No name, in Grafton	60	.01

Other tests made by the National Bureau of Standards demonstrate the effect of air bubbles on power factor. The tests were performed on a thick piece of mica from the Frank Carpenter mine (No. 68). The results are quoted:

> The piece first tested, designated A, had a thickness of 20 mils. Two large bubbles or pockets were observed within the mica and under the lead foil electrodes. The power factor was 0.05 percent.
>
> Piece B, 2 mils thick, was split from A, a new electrode attached under that first placed on A and the power factor measured as 0.02 percent. No bubbles were present.
>
> The thick piece remaining, (A minus B), 18 mils thick, was measured and a power factor of 0.09 percent obtained. The bubbles previously mentioned were in this splitting of mica.
>
> Another piece C, 4 mils thick was split off which contained the bubbles. The power factor was 0.06 percent.
>
> The thick piece then remaining, without visible bubbles, 14 mils thick, was measured and found to be 0.005 percent.
>
> A piece about 9 mils thick was split off, measured, and a power factor of 0.005 percent obtained.
>
> The remaining piece, about 5 mils thick, was measured and a power factor of 0.01 percent obtained.
>
> These tests were all made transversely through the same mica, some sections appearing in several of the tests. It is evident from these results that the presence of bubbles between the electrodes increased the power factor.

Sheet mica sizes and prices

New Hampshire mica that is not mined by consuming companies is generally sold to buyers as scrap or as mine-run mica and is bought by the ton. The price for scrap mica is fairly uniform, ranging from $15 to $20 per ton. The buyers grade and classify mine-run mica according to their own uses. The price for mine-run mica ranges from $40 to more than $100 per ton, depending upon (1) the economic condition of the mica industry, (2) the quality of the sheet mica, and (3) the proportion of the larger sizes in the mine run. The mica produced at most mines is 65 to 95 percent scrap. At the best mines the average is about 75 percent. The remainder is about 25 percent sheet and 75 percent punch.

Punch mica.--Punch mica in the domestic classification includes (1) clear mica that is smaller than 1½ by 2 inches but larger than a circle 1¼ inches in diameter, and (2) stained mica smaller than 2 by 2 inches but larger than a circle 1½ inches in diameter. Prices for punch mica range from 5 to 15 cents per pound.

Sheet mica.--Table 6 shows the various sizes into which clear sheet mica is graded according to the domestic classification, their price ranges, and the approximate percentage of each size that might be obtained from a good mine. The proportions of these sizes, however, are by no means constant throughout a given pegmatite, and vary considerably in different mines. Some mines are well known for the large sizes that they produce; others yield nothing larger than 4 by 6 inches.

Table 6.--Size distribution and price ranges of trimmed domestic sheet mica

Size (inches)	Probable proportion of total (percent)	Price range per pound
1½ x 2	25	$0.15-$0.60
2 x 2	22	.30- 1.00
2 x 3	22	.45- 1.40
3 x 3	10	.60- 2.00
3 x 4	7.5	.80- 2.30
3 x 5	8	1.00- 2.65
4 x 6	5	1.75- 3.60
6 x 8	.4	2.25- 7.00
8 x 10	.1	3.50-11.00
	100.0	

Past production

Commercial production of mica in the United States began in 1803, at the Ruggles mine, Grafton County, N. H. New Hampshire furnished all the mica used in the United States prior to 1868, when production began in other states, and has been a major producer every year since that time. Total production of sheet and punch mica in New Hampshire during the period 1908-39 is shown in table 7. Most of this production has come from a few relatively large mines. Of the total of 11,457,271 pounds produced since 1917, nearly half was obtained from the French,[12]

[12] The mines are numbered in table 8 and are designated by corresponding numbers on plates 62 and 63.

Alexandria, and Wilmot mines. The Alexandria mine produced 4,031,067 pounds of mine-run mica (including scrap) during the years 1917-31, an average of 268,738 pounds per year.[13/] Most of the remainder during the period 1917-39 was produced by the following 10 mines: Valencia, Standard, Nichols, Ruby, Alstead, Palermo, Danbury, Big, Strain, and Ruggles. Approximately 30 other mines produced smaller quantities of mica between 1917 and 1939.

Table 7.--Production of sheet and punch mica in New Hampshire, 1908-39 1/

Year	Pounds	Value	Year	Pounds	Value
1908	12,000	$1,200	1924	744,133	$88,737
1908	55,808	12,086	1925	1,120,857	198,858
1910	117,170	26,109	1926	1,371,890	235,890
1911	289,473	35,103	1927	720,219	78,849
1912	308,047	32,238	1928	774,143	63,470
1913	731,478	65,765	1929	984,778	82,657
1914	133,556	39,588	1930	673,064	53,304
1915	96,685	59,414	1931	441,164	36,368
1916	125,502	64,386	1932	146,014	17,978
1917	472,519	159,822	1933	167,464	22,008
1918	376,900	106,200	1934	161,430	14,423
1919	235,724	90,915	1935	131,586	13,727
1920	284,862	83,811	1936	285,822	22,920
1921	491,743	63,249	1937	235,055	20,119
1922	475,647	63,240	1938	2/ 282,836	49,254
1923	835,751	107,674	1939	43,670	3,738

1/ Minerals Yearbook, 1940, p. 1405.
2/ Connecticut included.

The history of mining since 1803 provides many examples of mines that operated intermittently. Such records of alternate periods of operation and idleness indicate that at least a few of the mines now idle could be reopened, although their average rate of production might be lower than the average of the past. The Rice mine, reopened on October 18, 1940, produced 184,000 pounds of mine-run mica by May 31, 1941.[14/] The many prospects on pegmatites not mined in the past because of relatively small size of mica and high scrap content, contain potential reserves,

13/ Published by permission of the General Electric Co.
14/ Published by permission of L. F. Crowe, General Electric Co.

and it is reasonable to suppose that some of them would develop into new mines with further prospecting.

Cost of mining

Mining costs [15] at the French mine in 1923 and 1924 averaged only $82 per ton of mine-run mica produced. Although this figure is below average, several operators expressed the opinion that very few mines can be operated profitably if the value of their mine-run mica is less than $100 per ton. As an example, mine-run mica would be worth $100 per ton if it comprised 80 percent scrap ($20 per ton), 15 percent punch ($0.10 per pound), and 5 percent sheet ($0.54 per pound). If the total production of a mine is assumed to be scrap mica, valued at $20 per ton, recoverable mica must constitute 12½ percent of the rock if the total value of rock mined is to be $2.50 per ton. Only exceptionally, in rich pockets, does mica constitute 12½ percent of the pegmatite. The quantity of mica in the rock mined commonly ranges from 2 to 10 percent, of which from 65 to 95 percent is scrap. No New Hampshire pegmatite, therefore, can be mined solely for scrap. If, on the other hand, the mine run contains sheet and punch mica enough to raise its value to $100 per ton, recoverable mica need only constitute 2½ percent of the rock mined to make the tenor of the ore $2.50 per ton. The $100 mininum, however, is perhaps not to be regarded as absolute, for costs of mining depend upon a number of variable factors, being by no means constant in different parts of an individual mine.

Possible future production

The low power factor of much New Hampshire mica is indicated by the tests made at the National Bureau of Standards. Since properties other than power factor are also important in

15/ According to records furnished by Paul French, Eugene Munsell & Co., New York.

evaluating mica, the proportion of New Hampshire mica that would be of condenser quality can only be conjectured. The proportion of Indian mica that is classified as fair-stained or better (potentially of condenser quality) probably never exceeds 10 percent of the total sheet mica, and a good part of this is discarded in the process of splitting. Mica of condenser grade probably comprises no more than a few percent of the total sheet mica produced by a mine. Much of the New Hampshire mica is flat and splits easily. The cost of labor necessary to split and carefully grade mica has precluded the production of condenser films from New Hampshire mica in the past, but mica of the required quality doubtless occurs in the State.

The New Hampshire pegmatites are not depleted, and they should produce mica during the next several years at about the same rate as in the past. No closer estimate of future production seems possible because, from the nature of the deposits, none contain blocked-out reserves of ore.

The reserves of individual deposits cannot be estimated even approximately owing to the erratic distribution of mica within pegmatites. Although mica-bearing zones in some pegmatites have persisted for hundreds of feet, there is no assurance, in an undeveloped pegmatite, that they will do so; in mica mining there is no blocked-out ore. It is possible to sample qualitatively, but not quantitatively. Core drilling of pegmatites for feldspar has been attempted, but its value as a guide to mica mining is doubtful. Drilling could be used to locate pegmatite if there were reason to believe that thin pegmatites if present might bear mica, but it would not necessarily disclose the size or quantity of mica books. In the final analysis, prospecting and mining merge into one uncertain venture, and the actual value of any single deposit is determined by results.

The average annual production of sheet and punch mica in New Hampshire during the period 1908-39 was 416,470 pounds.

Production during the years 1931 to 1939, however, averaged only 210,000 pounds per year, and that in 1939 was only 43,670 pounds. The years of small production indicate severe competition from foreign sources of supply, not depletion of reserves. Recorded production of 96,685 pounds in 1915 has been exceeded every subsequent year except 1939.

From average annual production of 416,470 pounds of sheet and punch mica over a 32-year period and unpublished production figures from many mines, it is estimated that, at a slightly higher cost than the average of the past, a production of at least 500,000 pounds of sheet and punch mica could be maintained for a period of several years, of which between 100,000 and 125,000 pounds would be sheet. An annual production of 1,000,000 pounds or more of sheet and punch might be attained by more intensive mining.

MINES

Although many mines operated for feldspar or for mica produce the other as a byproduct, commercial potash feldspar and sheet mica generally occur in different parts of the pegmatite, so that every mine may be classified as a feldspar mine or as a mica mine. Byproduct mica from feldspar mining is largely scrap. Of 131 mines examined, mica is the principal product in 84 and feldspar in 47. Of 85 mines in the Grafton district, 67 are dominantly mica. Of 45 in the Keene district, 16 are dominantly mica. Six feldspar mines and prospects and 2 mica mines were in operation during the fall of 1940.

Most mica mines are operated as open pits or quarries, although mica-rich zones have been followed underground at some of the larger mines. The mines are caved in the decomposed pegmatites at the Standard (in Alexandria), African, and Alexandria, but mines elsewhere are open because most pegmatites are hard, resistant, and relatively unweathered. The Palermo mine (see fig. 40) is said to extend at least 300 feet down a 45° incline. The workings at the Ruggles mica-feldspar mine are more than 800 feet long. The Big feldspar cut (see fig. 44) in Alstead is nearly 200 feet across, and is said to have been more than 200 feet deep before the southeast wall caved. The French open cut (see fig. 45) is 125 feet deep and 700 feet long. Unless the pegmatite is less than about 8 feet thick, only the richest part is removed in mining. The attempt at the Standard (Belden) mine (see fig. 43), in Orange, to quarry the entire mass of a large pegmatite for mica proved costly, and subsequent operations have been confined to parts of pegmatites in which mica is localized.

The largest mines have been operated by companies, most of which are consumers as well as producers, that employ 8 to 30 miners each, but a few small mines or prospects are operated by 2 or 3 men each. Companies that consume their own product classify it according to their uses, and information as to relative proportions of various sizes of sheet mica in the mine run is therefore scarce.

On the following list (table 8) the mine numbers correspond to those showing the location of the mines on plates 62 and 63. The product mica is indicated by M, feldspar by F.

Table 8.--New Hampshire mica and feldspar mines, with notes on the character and occurrence of the mica

No.	Name	Product	Character of mica	Notes on occurrence of mica
1	Valencia.....	MF	Light rum...	(1) In plagioclase zone about 4 ft. below hanging wall; (2) elsewhere in large pegmatite, principally near quartz bodies. (See fig. 39.)
2	Fletcher.....	M	Rum, nearly ruby.	Associated with quartz in pegmatite 8-15 ft. thick, mostly near hanging wall.
3	Wheat........	M	Light green.	In large pegmatite.
4	Belden.......	M	Little seen.	Beneath quartz mass in large irregular pegmatite.

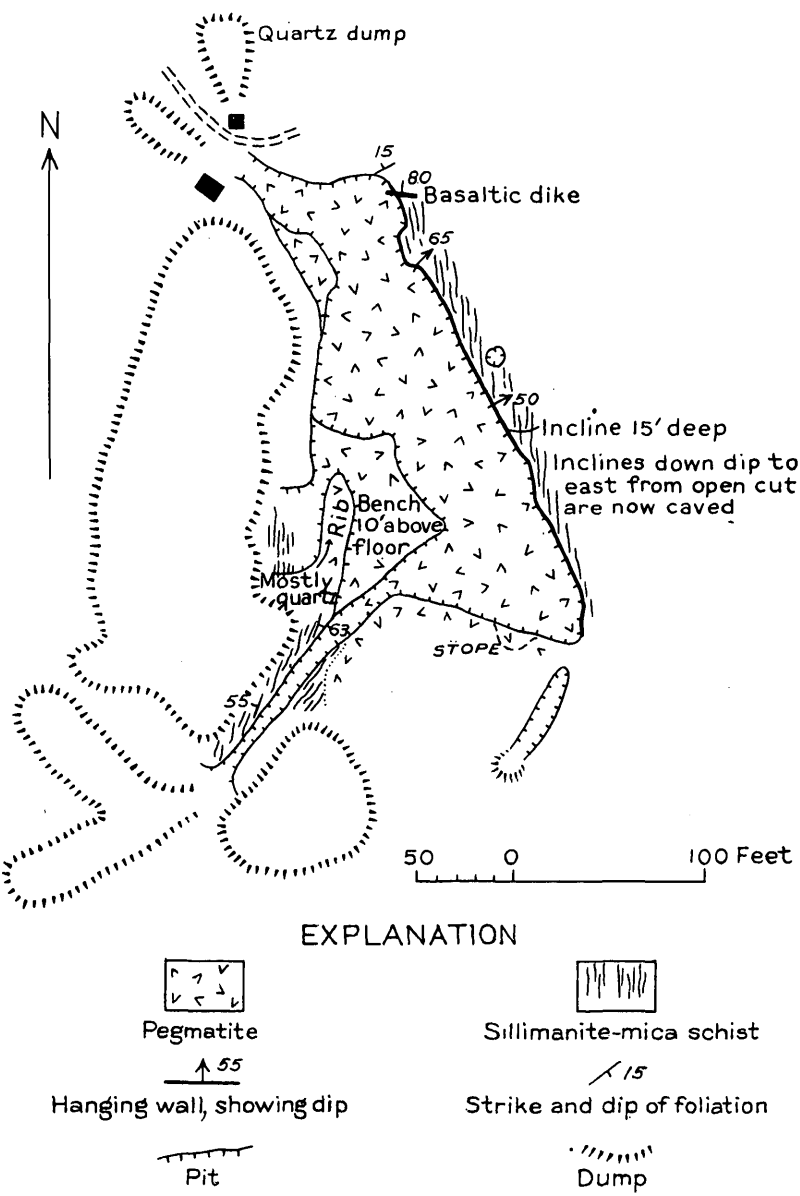
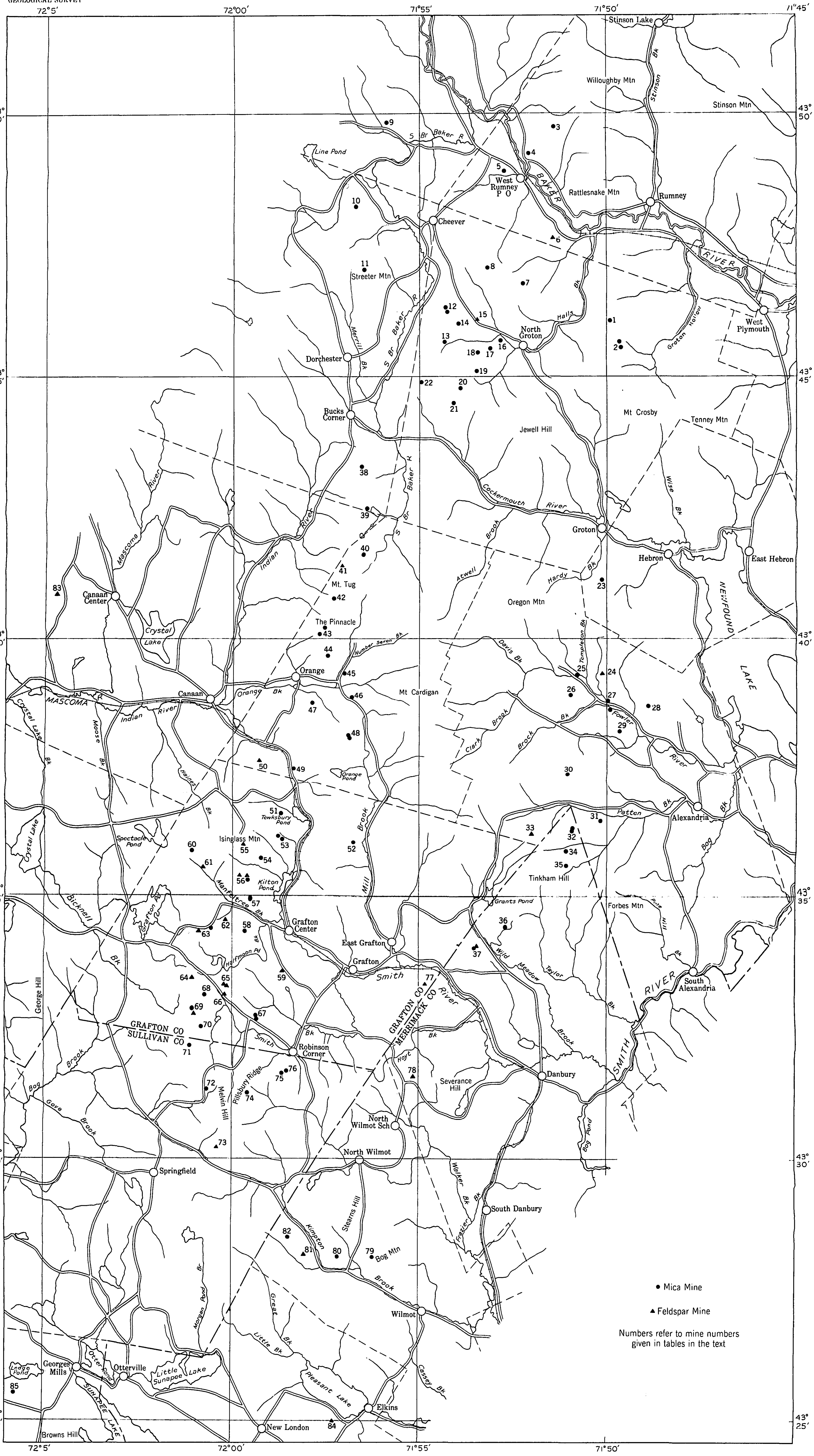


Figure 39.--Sketch map of the Valencia mine.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
5	West Rumney (Atwood, Burley).	M	Light rum, nearly ruby.	In pegmatite 4-20 ft. thick, mostly with quartz and plagioclase near hanging wall.
6	Burgess......	F	Light rum...	Feldspar mine. Pegmatite more than 50 ft. thick.
7	Union........	M	Light rum...	Entire thickness of 10-18 ft. removed.
8	J. W. Burley.	MF	Light rum; mostly scrap.	Beneath a quartz body 10 ft. thick in a pegmatite more than 50 ft. thick.
9	McGinnis, Whicher, and Pillsbury.	M	Light rum; small.	Near contacts of quartzose pegmatite 10 ft. thick.
10	Hanley.......	M	Light rum; small.	Near contacts in quartzose pegmatite 12 ft. or less thick.
11	On Streeter Mountain.	M	Little seen.	....
12	Frank Davis..	M	Light rum; scarce.	Near hanging wall of large pegmatite; another pegmatite 500 ft. south of mine was prospected, and contains a little greenish-rum mica.
13	Newt Kinney..	M	Light green; mostly scrap.	Near quartz body 5 ft. thick, 30 ft. below hanging wall.
14	Diamond Ledge	M	Light rum...	Near quartz body 3-5 ft. thick, 25 ft. above footwall of large pegmatite.
15	Pennsylvania Coal & Iron Co.	F	Light rum...	Feldspar mine. Mica intergrown with biotite and relatively scarce.
16	Charles Davis	M	Slightly stained; ruby.	Mostly near walls of a pegmatite 8-15 ft. thick.
17	Plume........	M	Light rum, nearly ruby.	Pegmatite 4-8 ft. thick, entire thickness removed.
18	Mica Products Co.	M	Light rum, nearly ruby.	In pegmatite 8-16 ft. thick, mostly near center.
19	Palermo (Hartford).	MF	Light rum, ruby, and yellow green.	Tabular quartz-plagioclase-muscovite zone in central part of large pegmatite. (See fig. 40.)
20	Rice.........	M	Light rum and ruby.	4 openings, on pegmatites 6-18 ft. thick that may be offshoots from a larger pegmatite to the south.
21	Pike Ledge...	M	Light rum; tangle-sheet.	In large pegmatite, with quartz, microcline and graphic granite.



MAP SHOWING LOCATIONS OF MICA AND FELDSPAR MINES OF THE GRAFTON DISTRICT, NEW HAMPSHIRE

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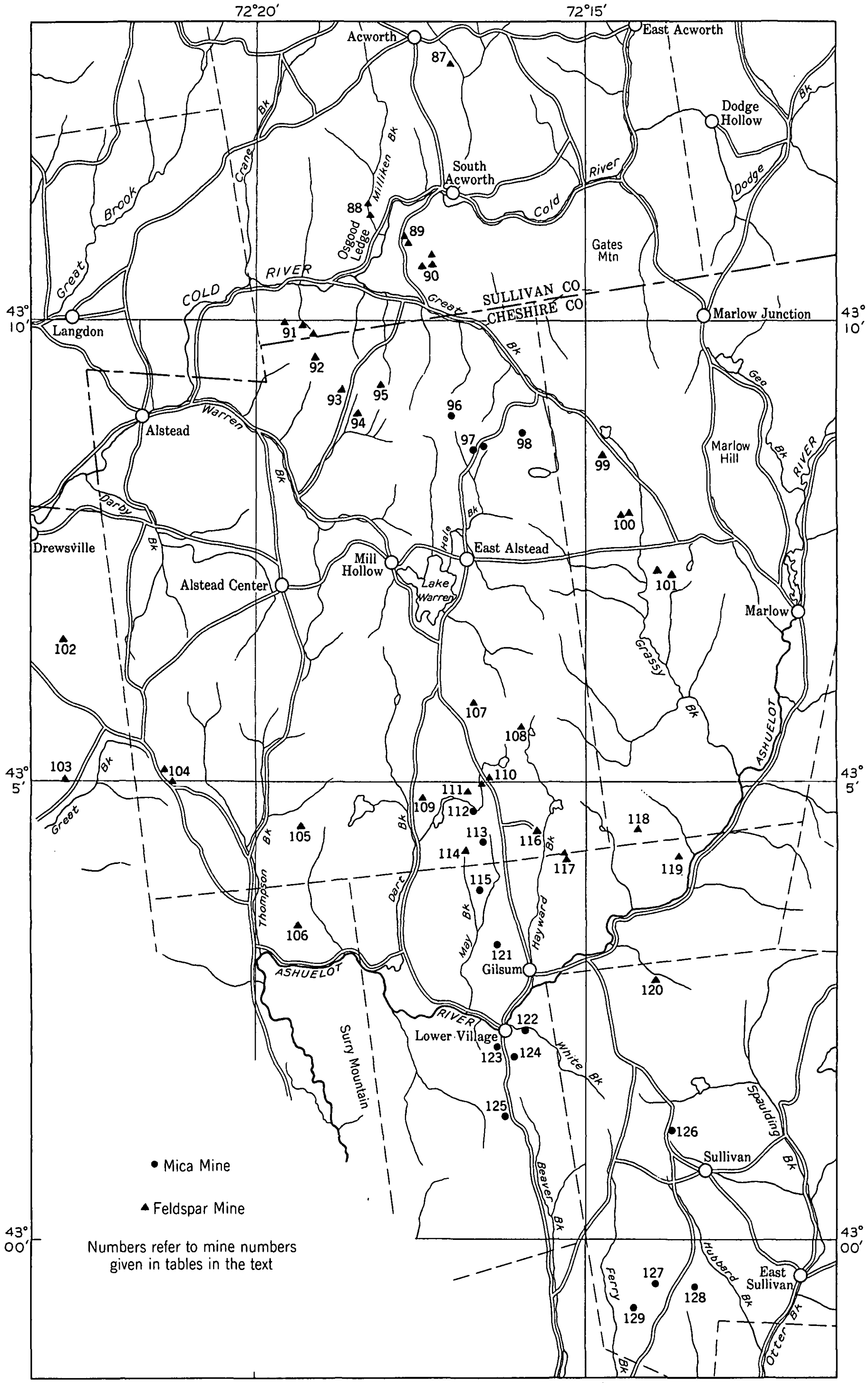

MAP SHOWING LOCATIONS OF MICA AND FELDSPAR MINES OF THE KEENE DISTRICT, NEW HAMPSHIRE

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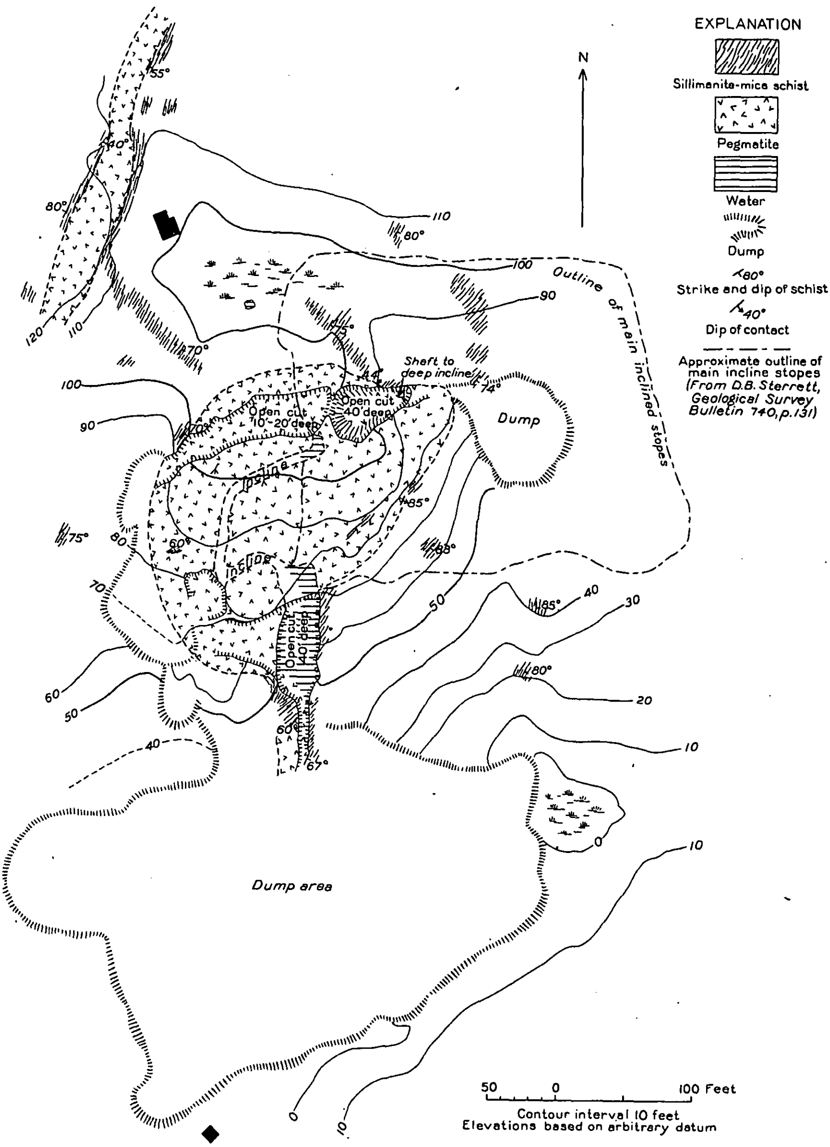

Figure 40.--Plan of the Palermo mine.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
22	Brown (Chapman).	FM	Light rum...	....
23	Hobart Hill (Hayes).	M	Yellow green; small.	With quartz, cleavelandite, beryl, and tourmaline in pocket near middle of pegmatite 60 ft. thick.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
24	Marston (East Branch).	MF	Light rum, nearly ruby.	Probably associated with quartz in pegmatites 10-15 ft. thick.
25	Akerman prospect.	M	Rum.........	Near quartz bodies 2 ft. or less thick on pegmatite outcrop 20 ft. wide.
26	Truman Patten	M	Light rum, some stained.	Near quartz bodies 2 ft. thick, at center of pegmatite 70 ft. thick.
27	Monarch (and Tasker).	M	Light rum...	Mine inaccessible.
28	Standard (in Alexandria).	M	Light rum...	3-15 ft. below hanging wall of thick pegmatite.
29	Eugene Tucker	M	Light rum...	With quartz and plagioclase, near hanging wall of pegmatite 10-12 ft. thick.
30	Hutchins Hill (New Haven Mica Co.).	M	Light green and ruby; mottled; herringbone.	With quartz, microcline, and beryl in zone 6 ft. thick in middle of pegmatite 25 ft. thick.
31	Alexandria (Mud).	M	Light green or white; some specked.	In zone 4-10 ft. thick along northwest wall of pegmatite 30-50 ft. thick.
32	Bailey........	M	Light rum...	On west side of quartz mass 6 ft. thick in pegmatite more than 40 ft. thick.
33	Whitehall (on Braley Hill).	FM	Greenish rum	In gray quartz bodies in large pegmatite that is mostly graphic granite.
34	Howe..........	M	Light rum...	Pegmatite 6-8 ft. thick.
35	Danbury......	M	Light green or white; specked.	With quartz and microcline in zone 8-10 ft. thick, separated from hanging wall by 2-4 ft. of fine-grained pegmatite. (See fig. 41.)
36	Tenney........	M	Ruby; some stained.	Thin pegmatite consisting mostly of quartz, plagioclase, and small muscovite.
37	Roby (Wild Meadows).	M	Light rum...	Best mica said to occur with quartz and plagioclase in center of pegmatite 15 ft. thick; darker A mica near hanging wall.
38	Rousseau prospect.	M	Light rum; scarce.	Scattered prospect holes on pegmatite outcrop 40 ft. wide.
39	Kimball Hill (India Mica Co.).	M	Light rum...	With quartz and plagioclase, between discontinuous central quartz bodies and fine-grained pegmatite along contacts of pegmatite 6-18 ft. thick.

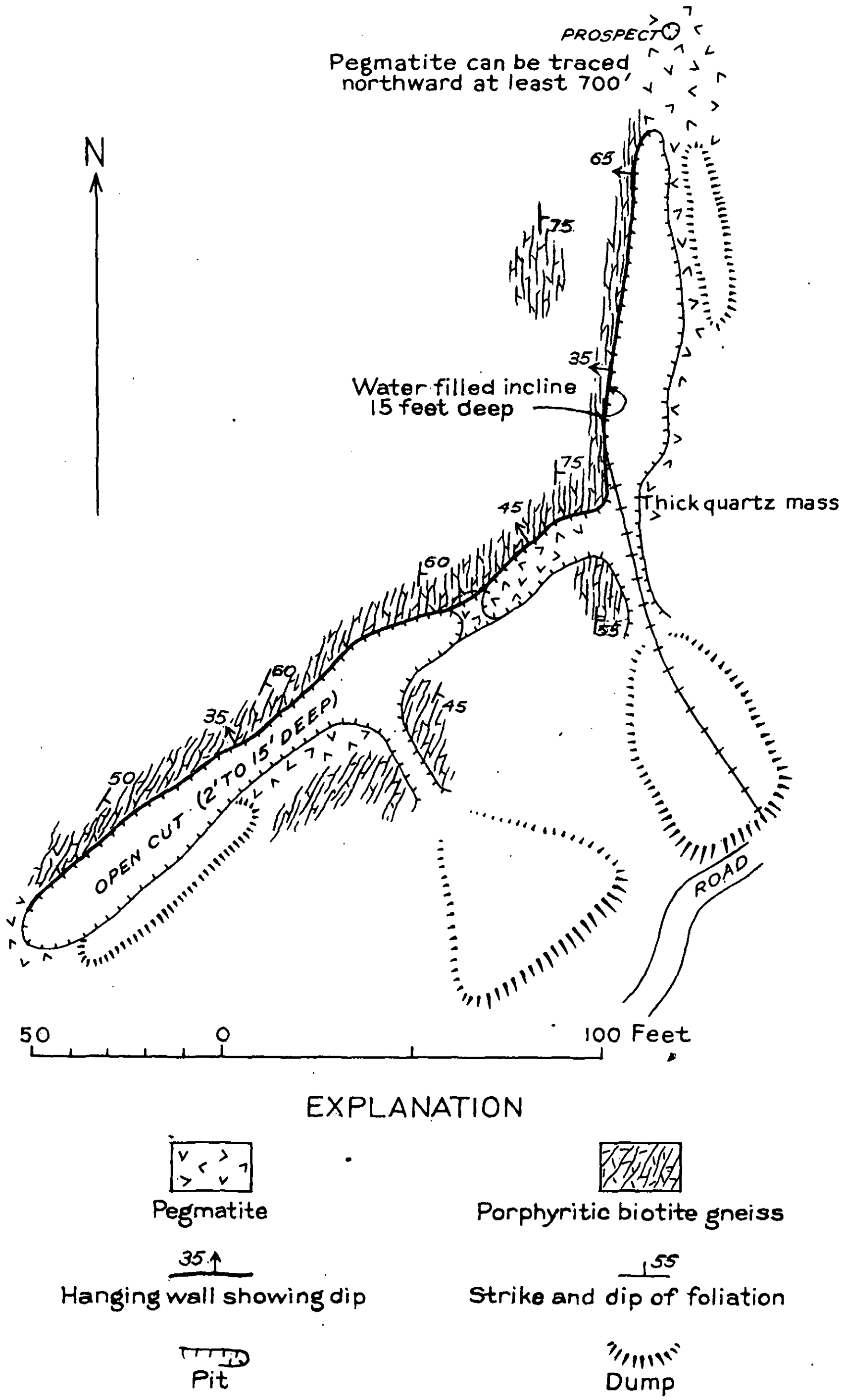

Figure 41.—Sketch map of the Danbury mine.

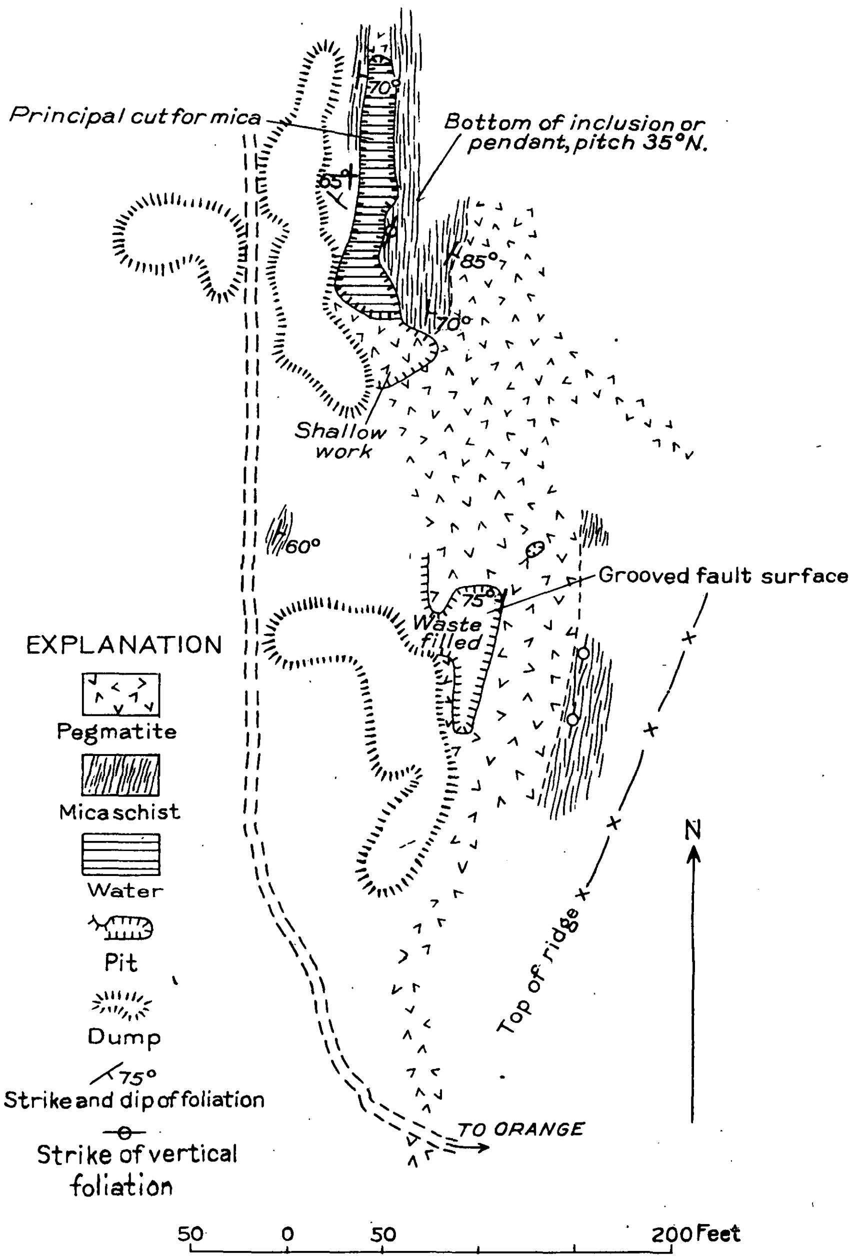

Figure 42.—Sketch map of the Strain mine.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
40	Keyes........	M	Light rum...	(1) Near inclusions in pegmatite; (2) near or in quartz masses 3 ft. or more thick in pegmatite over 40 ft. thick.
41	Smith Pasture (Wilkins).	F	Light rum; scarce.	Feldspar prospects. A little A mica associated with large quartz bodies.
42	Harry Ford (McConnell)	M	Yellow green	(1) In streaks with quartz or cleavelandite enclosed in finer-grained parts of the pegmatite; (2) near inclusions.
43	Strain (Star, Sanborn).	M	Light rum or white.	In offshoot 10-12 ft. thick from large pegmatite 200 ft. across. (See fig. 42.)
44	Standard (Belden).	M	Light rum...	(1) Near or in quartz masses in pegmatite at least 50 ft. thick; (2) associated with quartz and cleavelandite. (See fig. 43.)
45	African (Fellows).	M	Ruby; mostly scrap.	Probably most abundant near inclusions in irregularly shaped pegmatite.
46	Baer (Hobart)	M	Yellow green	With quartz and cleavelandite in pegmatite, not over 7 ft. thick, that is probably an offshoot from a thicker body.
47	Staples......	M	Light green.	Associated with cleavelandite and tourmaline in pegmatite 20-30 ft. thick.
48	Hoyt Hill....	M	Ruby, some stained.	Pipelike pegmatite pitching north. Entire thickness as well as some wall rock removed in mining.
49	Summit Mica & Mining Co.	M	Light rum; scarce.	On large pegmatite outcrop 40-150 ft. wide and more than 500 ft. long.
50	Whitehall....	F	Light rum; scarce.	Feldspar prospect.
51	Ruby (and Barney).	MF	Light rum and ruby.	In tabular zone 10-15 ft. thick of quartz, plagioclase, mica, apatite, and a little microcline, near middle of pegmatite at least 100 ft. wide.
52	Straw........	M	Rum, small..	(1) Near walls; (2) with microcline in or near quartz mass 6 ft. thick.

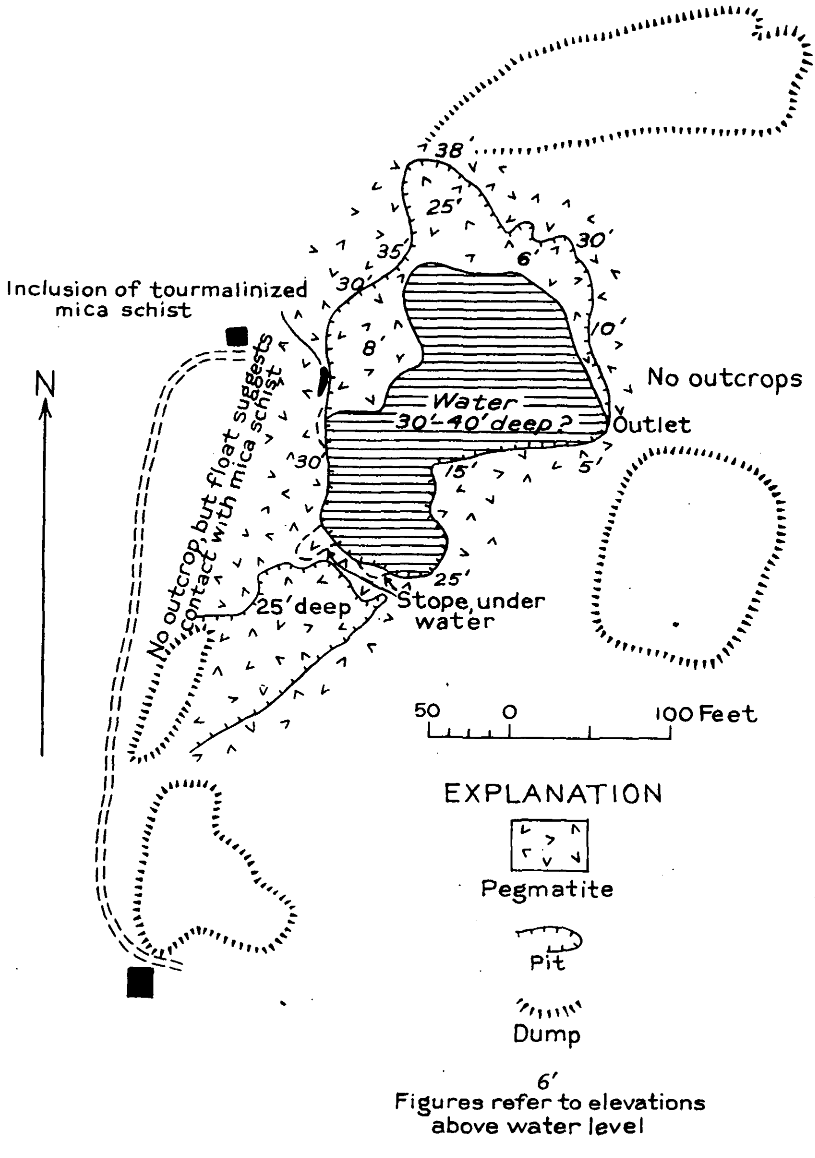

Figure 43.--Sketch map of the Standard (Belden) mine.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
53	Boardman.....	M	Light rum, near ruby.	At several places on pegmatite outcrop at least 150 ft. wide.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
54	Ruggles New Hill.	M	Light yellow green.	With quartz and cleavelandite, mostly near hanging wall of pegmatite 7 ft. or more thick.
55	Whitehall, on Isinglass Mountain.	F	Light rum, some greenish.	Mostly with plagioclase in pegmatite 100 ft. thick mined for feldspar.
56	Ruggles......	FM	Light rum...	Associated with quartz and plagioclase in zone 10-15 ft. thick near contacts of large crosscutting pegmatite that pitches south.
57	Kilton.......	M	Light rum, slight ruby cast.	In zone 10-12 ft. thick beneath flat-lying hanging wall of large pegmatite.
58	Alger........	MF	Light rum and ruby; some wedge	Wedge books common below and in lower part of a quartz mass 6 ft. thick. Also in other parts of the large pegmatite.
59	Rawlins......	M	Light rum...	Pegmatite 2-12 ft. thick. Mica scarce.
60	No name, in Grafton.	M	Light rum, near ruby.	Mostly near contacts of pegmatite 20 ft. thick.
61	Ed Cole......	FM	Light rum...	Much intergrown with biotite; pegmatite at least 50 ft. thick.
62	Evans (Eureka).	FM	Light rum and green wedge.	Best mica is 1-5 ft. below hanging wall of pegmatite 30 ft. thick.
63	Glover.......	M	Light rum and ruby.	With quartz and plagioclase in zone 4 ft. thick near footwall of pegmatite 35 ft. thick.
64	Bennett Bros.	FM	Light rum...	Mostly near quartz bodies in pegmatite whose outcrop is at least 100 ft. wide.
65	Prescott Hill (Gage).	F	Light rum; scarce.	Feldspar mine. Mica said to be richest near footwall of Gage (east) cut.
66	DeMott.......	M	Light rum...	Near quartz masses several feet thick.
67	Lovering prospect.	M	Ruby, scarce	In quartz in pegmatite 15 ft. thick, enclosed in granite.
68	Frank Carpenter.	M	Ruby, some stained.	In zone several feet thick of quartz, plagioclase, mica, tourmaline, and apatite, near middle of pegmatite outcrop at least 100 ft. wide.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
69	United.......	M	Light rum...	(1) Near discontinuous quartz bodies near middle of pegmatite 8-20 ft. thick; (2) near walls.
70	Hale (Buckley).	M	Ruby........	In quartzose zone near middle of pegmatite whose outcrop is at least 100 ft. wide.
71	Aaron Ledge (Lamb).	M	Light rum...	Scarce. Prospecting followed quartzose zones in large pegmatite outcrop as much as 250 ft. wide.
72	Colby (Randall, Joe Hill).	M	Light rum...	In irregular crosscutting pegmatite.
73	Globe........	FM	Light rum and light ruby.	Probably in quartzose parts of large flat-lying pegmatite.
74	Playter......	Beryl M	Ruby........	In pegmatite 3-15 ft. thick that thickens southeastward from mine.
75	Columbian Gem Co.	Beryl M	Ruby........	Little mica observed.
76	Reynolds.....	Beryl M	Ruby........	Pegmatite more than 8 ft. thick, poorly exposed.
77	Sargent......	F	Light rum and green, slightly stained.	Mica scarce.
78	Stewart Hill.	F	Scarce......	Feldspar prospect.
79	Bog Hill prospect.	M	Light rum; small.	Prospect on large pegmatite outcrop.
80	Currier prospect.	M	Light rum, some greenish rum.	Alongside a quartz mass 15 ft. thick, near middle of pegmatite 50 ft. thick.
81	Powell.......	FM	Light rum...	Most mica near walls of pegmatite 4-10 ft. thick, associated with plagioclase.
82	Wilmot.......	MF	Light rum...	....
83	Stone........	F	None seen...	Biotite present, but no muscovite.
84	Elkins prospect.	F	Rum.........	Mostly in quartz near middle of pegmatite 20-25 ft. thick, but also in other parts.
85	Trow Hill....	M	Light rum...	Pegmatite is 40 ft. thick at top of ridge; mined at southwest end where it is only 5-25 ft. thick.
86	Chandler Station.	M	Yellow green stained; mostly wedge, scrap.	(1) In zone 6 ft. thick near hanging wall; (2) in cleavelandite and quartz near quartz mass 12 ft. thick at center of pegmatite.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
87	Johnson......	F	Small; mostly scrap.	Feldspar prospect.
88	Grant........	F	Wedge, scrap	Two feldspar cuts. At north cut, small wedge mica at contacts of quartz with microcline.
89	Beryl Mountain.	FM	Light rum; mostly scrap.	Wedge mica at contacts of quartz masses with feldspar.
90	John Balla...	F	Light green or white; mostly scrap.	Three feldspar cuts. At one, mica occurs on lower side of inclusion in large pegmatite.
91	Yuhas........	F	Little seen.	Two open cuts for feldspar.
92	Cobb Hill....	F	Little seen.	Large feldspar producer.
93	Douglas......	F	Little seen.	....
94	Allen........	F	Light rum; mostly A.	Feldspar mine; little sheet mica seen.
95	Kimball......	F	Light green, stained; A.	Wedge mica with microcline and tourmaline in quartz mass in pegmatite at least 50 ft. thick.
96	Harry Craig..	M	Light ruby, bent.	Poorly exposed.
97	Alstead (Lyman, Granite State, Parsons).	M	Light rum, some specked; also light green.	(1) Near quartz bodies, or with quartz and cleavelandite, in pegmatite at least 100 ft. thick; (2) mostly near hanging wall of pegmatite 10 ft. thick that is probably an offshoot from the larger pegmatite.
98	Lakin prospect.	M	Light rum...	Small prospect in pegmatite at least 20 ft. thick.
99	Russell......	F	Light rum...	Feldspar mine; a little mica near walls.
100	Turner.......	F	Light rum...	Three cuts. Most mica seen was beneath wall rock pendant in southwest cut.
101	Windham......	F	Green and greenish-rum wedge.	Two feldspar cuts. Mica in center of one pegmatite 20-25 ft. thick, associated with quartz and microcline.
102	Damaziac.....	F	Mostly scrap	Small books with quartz and plagioclase in large pegmatite.
103	Chickering...	F	Yellow-green wedge.	Mostly in quartz in pegmatite whose outcrop is 100 ft. wide.
104	Porter Bros..	F	Little seen.	Small mica occurs near hanging wall.
105	Gates........	F	Little seen.	....

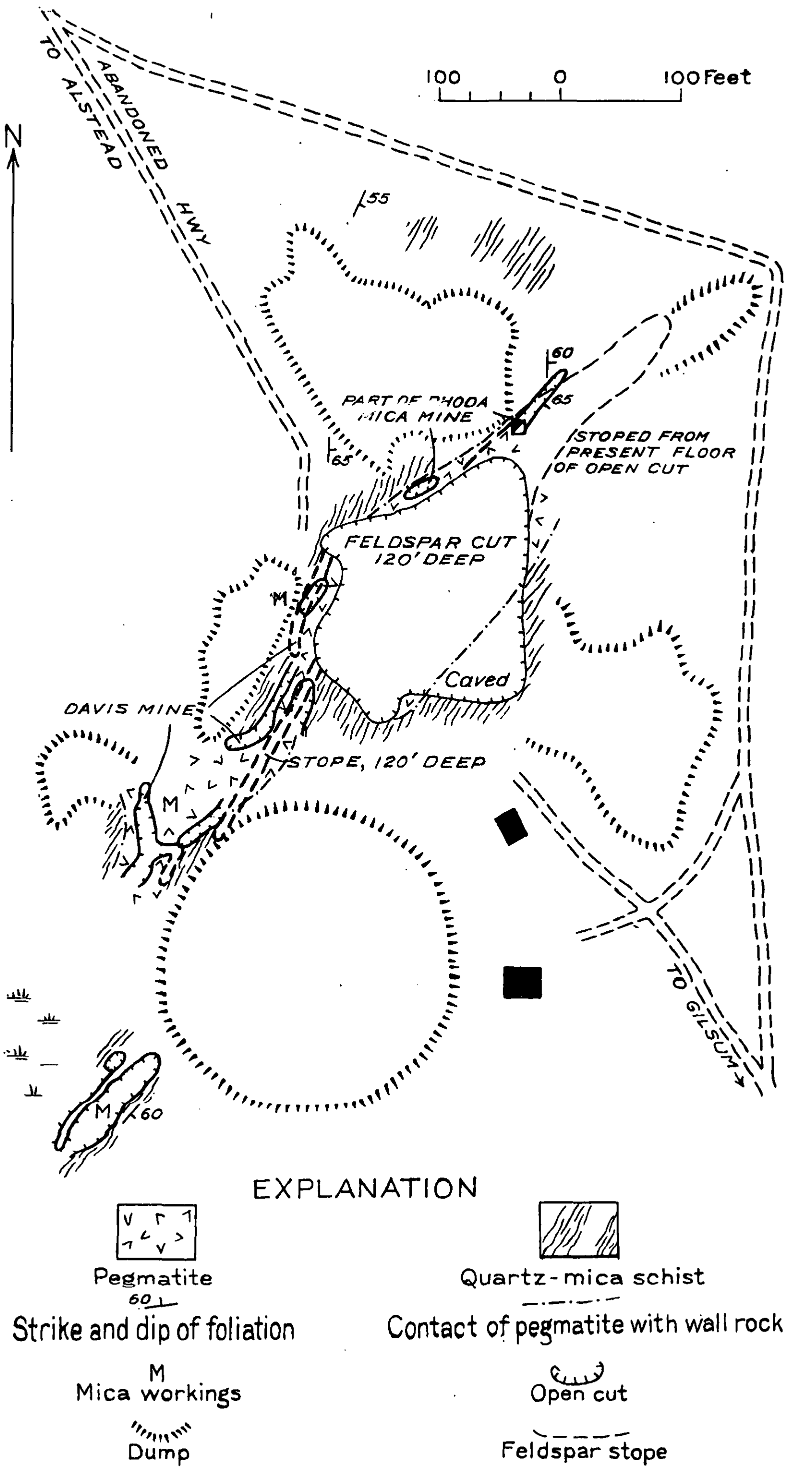

Figure 44.--Sketch map of the Big mine.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
106	Surry prospect.	F	Scarce......	In large pegmatite at northern of two prospects; intergrown with biotite.
107	Britton......	F	Light greenish rum; wedge.	(1) With microcline in central quartzose part of pegmatite 40 ft. thick; (2) near footwall.
108	Smith Hill...	F	Light greenish rum.	Feldspar mine, mica mostly scrap.
109	Wheeler......	F	Not abundant	Two feldspar prospects.
110	Big (Davis, Rhoda).	FM	Light rum; minor A.	Pegmatite as much as 100 ft. thick. Mica with quartz and plagioclase 3-15 ft. from walls, and in thinner parts of pegmatite to northeast and southwest, mostly near contacts. Also minor green A mica near quartz bodies, in central parts of large pegmatite. (See fig. 44.)
111	Tripp No. 1..	FM	Light rum, nearly ruby; herringbone.	Mostly at contacts of quartz with plagioclase or microcline in large, irregular pegmatite.
112	Island.......	M	Light ruby..	Along north edge of irregular outcrop of pegmatite 100 ft. across. Pegmatite contains large proportion of plagioclase feldspar.
113	French.......	M	(1) Cloudy specked rum; (2) light green; (3) ruby.	Distributed irregularly through pegmatite 100-150 ft. thick, but more abundant near walls and inclusions. (See fig. 45.)
114	No name, southwest of French.	FM	Rum.........	Mostly near quartz bodies as much as 7 ft. thick in pegmatite more than 30 ft. thick.
115	Nichols (Keene Mica Products Co.)	M	Light rum; some stained.	Near walls and inclusions. Most abundant near hanging wall and largest 2-3 ft. from contacts.
116	Eames........	F	Light rum...	Partly intergrown with biotite, in pegmatite more than 80 ft. thick.
117	Converse.....	F	Light greenish rum.	Not abundant. Feldspar mine.
118	Jones........	F	Light rum...	Not abundant. Much graphic granite.
119	Pomlow.......	F	Greenish rum and yellow green; some stained.	Mostly near walls of large pegmatite mined for feldspar.

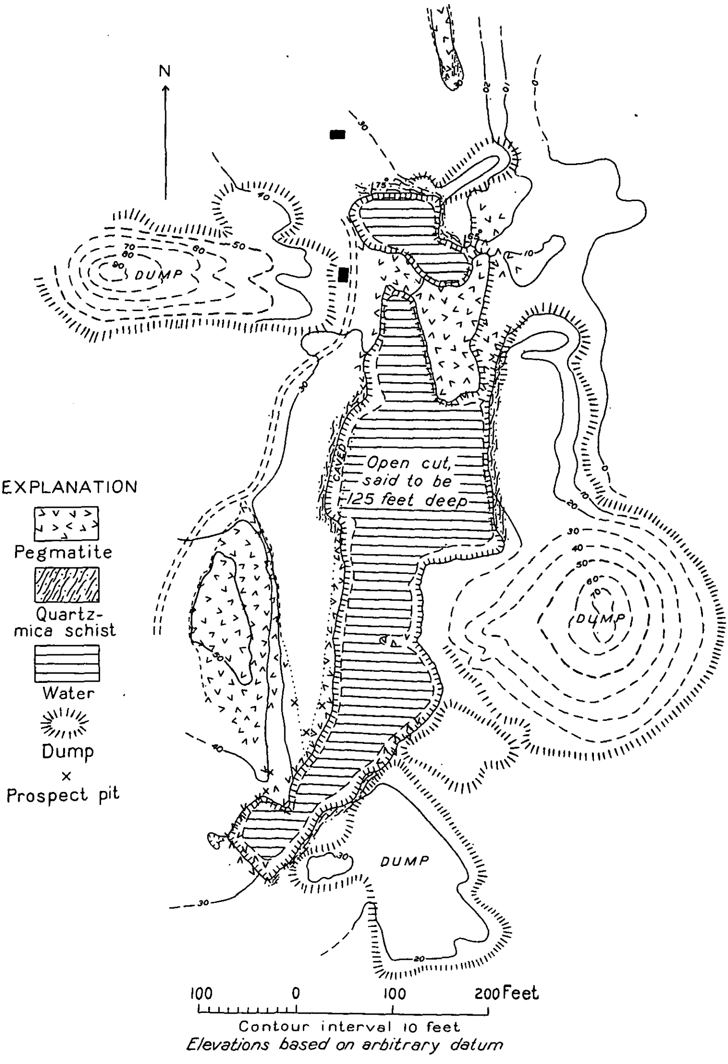

Figure 45.--Plan of the French mine.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
120	Caron (Cory).	F	Light rum...	Pegmatite 20-40 ft. thick mined for feldspar.
121	No name (in Gilsum).	M	Light rum; herring-bone.	Much intergrown with biotite.
122	Isham (Low White).	M	Light rum...	Scattered through pegmatite 20 ft. thick, but most abundant near quartz 2 ft. thick in middle.

Table 8.--New Hampshire mica and feldspar mines--Continued

No.	Name	Product	Character of mica	Notes on occurrence of mica
123	High White...	M	Nearly white; wedge, scrap.	In quartzose pegmatite at least 10 ft. thick.
124	Jehial White.	M	Light rum...	Near ragged contacts of pegmatite 8-10 ft. thick.
125	Bingham Hill (Kirk No. 1).	MF	Light rum...	4-10 ft. below hanging wall in pegmatite 7-60 ft. thick.
126	Nims.........	M	Yellow green	Pegmatite 20 ft. thick.
127	Brooks.......	M	Light rum...	Pegmatite at least 8 ft. thick.
128	Price........	MF	Light rum; some stained.	Mostly near footwall of pegmatite at least 40 ft. thick.
129	Pelkey.......	M	Rum.........	Mostly near hanging wall.
130	Aliber.......	F	Yellow green; scrap.	Feldspar mine; mica probably associated with cleavelandite.
131	Foss.........	MF	Yellow green; stained.	Mostly near walls of pegmatite 3-20 ft. thick, rich in cleavelandite.

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