MISCELLANEOUS NONMETALLIC PRODUCTS.

MICA DEPOSITS OF SOUTH DAKOTA.

By Douglas B. Sterrett.

INTRODUCTION.

The mica mines described in this paper are all located within a radius of 8 miles of Custer, S. Dak., in the southern part of the Black Hills. This area includes the better deposits of mica so far located, though some deposits occur 12 to 15 miles north of Custer, on the north side of Harney Peak. With the limited time available for examination it was not possible to visit all the mines, even of those around Custer. The field notes for the present article were obtained during the first part of August, 1908. At the time of visit there were but two mines in operation—the No. 1 or New York mine, and the No. 2 or White Spar mine, both of the Westinghouse Electric and Manufacturing Company. The writer is indebted to Mr. Joseph Pyne, superintendent for the Westinghouse Company, and to several citizens of Custer for making it possible to examine the mines described below.

Previous to 1906 the production of mica in South Dakota had been small for several years, being often only that obtained from assessment work on the claims, but in that year the Westinghouse Company took up several mines and prepared for systematic and extensive work. The success of this company has raised South Dakota to second rank among the mica-producing States. Of the 1,060,182 pounds of sheet and 3,025 tons of scrap mica, with a total value of $392,111, produced during 1907 in the United States, South Dakota contributed nearly a third. If some of the mines now idle or worked only in a desultory way could be equipped for operation on a large scale, the production of South Dakota would be largely increased. If the total production of mica in the United States could be increased nearly three times, the domestic demand could be satisfied with the domestic production, with the exception of the soft "amber" or phlogopite mica necessary in the manufacture of commutators for electric dynamos and motors. A quantity of this variety would still have to be imported from Canada, as there are no deposits known to be of value in the United States. It is probable that other consumers of mica could develop deposits in one or more of the mica regions of the United States and supply their own demands as the Westinghouse Company has done—that is, with the exception of the soft "amber" mica.

The commercial applications of mica are numerous. The principal use at the present day is in the manufacture of electric apparatus. In the early days of the industry in this country the chief demand for mica was for glazing purposes, principally in stove manufacture. This has now become one of the lesser uses, along with the manufacture of gas lamp chimneys, etc. The value of good sheet mica suitable for glazing is higher than that of the material suitable for electric purposes. The demand for glazing mica is insufficient to use all the sheet mica produced, so only the best quality and larger sheets are used for this purpose. "Micanite" or built-up mica board, for the manufacture of which much smaller sheets can be used, is an amply good substitute for large sheet mica in electric work.

Mica from one locality may have properties rendering it more suitable for certain applications than that from another, though not necessarily excluding it from other uses. Thus, the Canadian "amber" is especially adapted to commutator insulation; the best North Carolina "rum" colored, when in thick sheets, or "white" mica, when in thin sheets, is well suited for glazing. The South Dakota mica in general is a little softer and less clear than the North Carolina mica and therefore not so satisfactory for glazing. It is, however, well adapted to the manufacture of "micanite" and other products for use in electric machinery and apparatus.

GENERAL GEOLOGY.

The geology and mineral resources of the Black Hills have been described by numerous writers. Of the reports on geology those of Newton and Jenney[a] and of Darton,[b] taken together, furnish an excellent description. The mica resources have been treated in the South Dakota Geological Survey reports and have been mentioned in a number of the annual reports on the mineral resources of the United States published by the Federal Survey. A booklet with geologic map by Samuel Scott,[c] of Custer, S. Dak., serves as a useful guide to the general geology of the Black Hills.

[a] Newton, Henry, and Jenney, W. P., Geology and Resources of the Black Hills of Dakota: U. S. Geog. and Geol. Survey Rocky Mt. Region, 1880.

[b] Darton, N. H., Preliminary description of the geology and water resources of the southern Black Hills: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 4, 1901.

[c] Rocks, minerals, and other resources of the Black Hills.

The Black Hills are a group of mountains rising to a maximum elevation, in Harney Peak, of 7,240 feet above the sea, or 3,000 to 4,000 feet above the surrounding plains. They form an oval uplift about 125 miles long from north-northwest to south-southeast and 60 miles wide. The core of this uplift is composed of highly metamorphosed slates, gneisses, and schists with granitic intrusions. This core of ancient rocks is completely encircled by strata of later formations, which dip away from the core on all sides and were evidently once continuous over its top as a dome. The oldest of these strata flanking the core is a conglomerate and sandstone formation of Cambrian age, called Potsdam by Newton and Jenney and Deadwood by Darton. The Deadwood formation is overlain by other formations, among which are limestone of Carboniferous age, red beds and shale of Triassic (?) and Jurassic age, Upper and Lower Cretaceous sandstones, shales, and limestones, and Tertiary "badland" formations. These formations outcrop at successively greater distances from the central core of metamorphic rocks, and some of the outcrops form hogbacks with the scarp toward the center of the uplift.

Newton and Jenney call attention to a marked difference in the metamorphic rocks of the northeastern part of the area from those of the southwestern part. Those of the northeastern part are less metamorphosed and more nearly slates in texture and structure, while those of the southwestern part are highly metamorphic gneisses and schists, micaceous, chloritic, hornblendic, and quartzitic in composition. Newton and Jenney call the gneisses and schists "Older Archean" and the slates "New Archean." In a report on the Cretaceous formation of the Black Hills,[a] the northeastern metamorphic area is called Algonkian and the southwestern area Archean. Whatever the age of these formations, that in the southwestern part, in which the mica deposits occur, is composed of true gneisses and schists in which the mashing has been extreme and the development of metamorphic minerals extensive. In comparing typical specimens of the slates and mica slates of the northeastern area with the gneisses and schists of the southwestern area, the writer was impressed with the extreme difference in the degree of metamorphism they had undergone. Newton and Jenney state that granites occur only in the "Older Archean" rocks, and that granitic pebbles were found in the Cambrian conglomerate overlying them. They therefore conclude that the granite is pre-Cambrian and older than the slate formation. Whether all the granite can be included in this category it would not be safe to say.

The granite formation of the Black Hills has its greatest development around Harney Peak and southward to Custer. Other smaller

[a] Ward, L. F., Jenney, W. P., Fontaine, W. M., and Knowlton, F. H., Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1899, Pl. LIII.

bodies and the pegmatites, into which it appears to grade in some places, occur in various parts of the highly metamorphic areas. Much of this granite has a very coarse texture and in some places it is difficult to know whether to classify the rock as granite or pegmatite. The pegmatite occurs both in the metamorphic rocks and in the granite. The prevailing trends of the gneisses and schists and of many of the inclosed pegmatites in the region of Custer is northwest to north. The dip is more variable, though in the many localities noted it was to the southwest or vertical. The gneisses and schists are much folded in places and are to some extent crinkled with minor folds.

OCCURRENCE OF MICA.

In the Black Hills as elsewhere muscovite mica of commercial value is found in pegmatite. In this rock mica occurs as an accessory mineral of more or less prominence, the essential constituents of pegmatite being feldspar and quartz. The feldspars are commonly orthoclase or microcline, though a plagioclase, albite, or oligoclase is present in some pegmatites, and locally plagioclase is the predominant feldspar. Pegmatites thus have the same constituent minerals as granites, though generally deficient in biotite and lacking in other accessory minerals, as hornblende or pyroxene. The proportions of the constituent minerals vary widely, not only in different bodies, but even in the same body. In some places the mass is chiefly feldspar with but small amounts of quartz and accessory minerals; in others quartz is the principal mineral. The deposits of mica-bearing pegmatites around Custer probably have a more uniform mixture of feldspar and quartz than many of those in North Carolina.

The occurrence of accessory minerals in the pegmatites of the Black Hills is variable. In several of the deposits north of Harney Peak large spodumene crystals, columbite, cassiterite, beryl, etc., have been found in some quantity. In the mica deposits near Custer these minerals are rare or confined to one or two occurrences. In nearly every one of the mines examined around Custer black tourmaline was found, and in many it was abundant in crystals of large size. J. A. Holmes[a] mentions this occurrence and contrasts it with the general scarceness of tourmaline in the tin-bearing pegmatites north of Harney Peak. On the same page it is stated that mica apparently is not found plentifully in commercial sizes in the pegmatites of the tin region. Around Custer, where the best mica deposits have been found, only one pegmatite in many carries sufficient mica to pay to work. Holmes[b] estimates that in some portions of the New York mine mica composes 10 per cent of the whole peg-

[a] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 6, continued, 1899, p. 699.
[b] Op. cit., p. 693.

matite, but that in others it forms not more than 1 per cent. Figures given by Mr. Pyne, the present superintendent, show that the rough mica obtained along the walls of the pegmatite (the only portion worked for mica in this mine) amounts to 6 or 7 per cent. The interior of the pegmatite at this mine carries very little mica, say 0.5 per cent; this would give about 2.5 per cent of mica in the whole mass of pegmatite.

The texture of pegmatite may be like that of very coarse granite, sometimes called giant granite, or the individual minerals may be separated out into large masses in different positions in the pegmatite. These masses may be very irregular in shape or arranged in bands generally parallel with the walls, giving the mass a veinlike appearance, as in many of the mica "veins" of North Carolina.[a] The mica-bearing pegmatites around Custer show a tendency to have an evenly granular texture or irregular segregation of mineral masses rather than a banded structure. In much of the rock there is, however, a rough banded arrangement in the segregation of the mica crystals along one or both walls. This structure does not resemble that of a vein so much as where bands of a single mineral, as quartz or feldspar, occur. The crystals of feldspar and irregular masses of quartz may attain dimensions of several feet across in pegmatite.

The shape of pegmatite bodies is variable. Some are rather persistent in length and form dikelike or veinlike bands or sheets that can be traced for several hundred yards. Others are lenticular in shape and occur either in short, thick masses or in long, slender bodies. Many of the pegmatite masses are very irregular in shape and are very difficult to follow in mining. Some pegmatite bodies lie conformable with the schistosity of the inclosing gneiss or schist either through part or the whole of their extent; others cut across the bedding of the rock formations. In places the lenses or sheets follow the irregularities of the inclosing rock. In this way they may be interfolded with gneisses and schists, or bulge or elbow out abruptly. Pegmatites may range in thickness from less than an inch to many yards, and the lenses may vary in length from 2 to 20 or more times the thickness. The pegmatites observed around Custer exhibit many of the above described characters. Some occur in regular sheets whose outcrops can be traced for several hundred yards; others are typically lenticular. Some lie parallel with the schistosity of the inclosing rock and others cut across the rock. The general features of the pegmatites around Custer resemble those of dikes, the veinlike type being rare or absent.

[a] Sterrett, D. B., Mica deposits of western North Carolina: Bull. U. S. Geol. Survey No. 340, 1907, pp. 400–422.

DESCRIPTION OF MINES.

No. 1 MINE.

The No. 1 mine of the Westinghouse Company, formerly called the New York mine, is 5¼ miles southwest of Custer, between Hay Creek and Fourmile Creek. The mine is in a small prominent hogback-like knob 700 feet long and about one-third as wide. This knob is nearly 200 feet higher than the level of Hay Creek on the southeast, and about 100 feet higher than the gentle slope from its base to the valley of Hay Creek.

The earlier work at the New York mine consisted of open cuts, inclines, and stopes, which extend in one place from the surface nearly to the present 100-foot level. The workings of the present company are systematic, and consist of a vertical shaft to the 200-foot level, with a 16-foot sump at the bottom and drifts with stopes on the 50-foot, 100-foot, and 200-foot levels. The mine is equipped with a 400-horsepower boiler and engine of Westinghouse make. Power is transmitted electrically from two 150-kilowatt generators. The mine is lighted with incandescent electric lights and the camp with arc lamps. The hoist, grinding plant, and shop are also operated by electric power. Air drills are used throughout the mine.

The country rock is biotite gneiss and schist striking northwesterly and dipping about 50° SW. The pegmatite is approximately conformable with the inclosing gneiss. The contact of the two is sharp, though with gentle rolls along the strike. The pegmatite has a thickness across the dip of about 30 feet at the surface, 25 feet on the 100-foot level, and 28 feet on the 200-foot level. The mica occurs in two streaks or "veins" in the pegmatite from 1 to 8 feet thick along each wall. The interior of the pegmatite is nearly barren of mica or too poor to pay for working. Although the mica streaks vary in thickness and richness they are unusually regular for mica "veins." Through the greater part of the mine opened up to the time of visit the veins were found sufficiently rich to pay for working, and in places the mica was very abundant. The mica crystals have a tendency to occur in flattened or tabular blocks lying perpendicular to the walls of the pegmatite, though without other definite orientation. The more common size of crystals range from 2 to 8 inches in diameter and from 1 to 5 inches in thickness. Crystals a foot in diameter are not rare while some measuring a yard across are found.

Figure 29 represents a generalized cross section of the pegmatite "veins" and workings at the New York mine. The first operations at this mine were influenced largely by the position of the outcrop of the pegmatite. This rock forms the top and southwest side of the knob in which the mine is located. The hanging wall lies near the surface of this side of the knob and was readily worked by open cuts.

The foot wall of the pegmatite outcrops along the top of the knob. Besides numerous smaller openings on the outcrops, drifts have been run to the northwest on each " vein " on the 50-foot level. The entrance to the 50-foot level is made from an open cut on the outcrop of the vein about 50 feet below the top of the hill. The drift on the hanging-wall " vein " was run about 130 feet and a small amount of stoping was done. The " vein " was rich in mica to a point within 15 feet of the end of this drift, but at the end the mica content was low. A crosscut connects this drift with the foot-wall " vein," the drift on which was carried about 250 feet to the northwest. For 100 feet of this length the "vein " has been stoped out, to the top of the knob 50 feet above, and beyond this stretch good vein matter is held ready for stoping. At the southeast limit of the surface workings, about 200 feet from the shaft, the pegmatite contains a large quantity

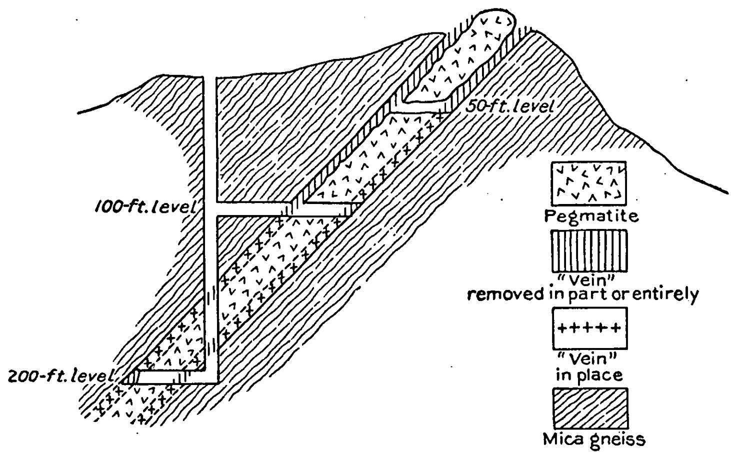

FIGURE 29.—Generalized cross section of No. 1 or New York mine, near Custer, S. Dak.

of black tourmaline in crystals ranging from 1 inch to several inches in diameter and as many feet long. The mica content of the pegmatite is very low at this point.

The shaft is located to the southwest of the pegmatite, through which it cuts between the 100-foot and 200-foot levels. Only the hanging wall has been worked on the 100-foot level. This level is connected with the shaft to the southwest by a short crosscut. Drifts have been run from the crosscut about 300 feet to the northwest and 250 feet to the southeast. The vein was stoped out to the 50-foot level for a distance of 200 feet to the northwest and work was being carried farther. The pegmatite at the end of this drift was found to be very poor in mica and to be composed of large feldspar crystals, massive quartz, rosettes of radiated feldspar columns, 8 to 12 inches in diameter, and black tourmaline. The drift was to be carried farther in search of richer "vein" matter. In the southeast drift much of the "vein" has been stoped out to the surface for a distance of about 240 feet from the crosscut. At this point the vein becomes poor in mica and carries abundant black tourmaline like that seen in the surface workings. Some of the tourmaline crystals measure 10 inches in diameter. They do not appear to have any definite position relative to the wall of the pegmatite. The vein was found to be rich nearly to the end of each drift and in the large stopes. The strike of the contact of the vein is nearly straight throughout the length of the drifts except at one point a few feet southeast of the crosscut. Here the mica schist wall elbows out into the pegmatite for several feet across the strike of the vein.

A room has been made southeast of the shaft on the 200-foot level for the placing of an electric pump, loading cars on the cage, etc. A crosscut of 10 feet from this room to the southwest cuts the foot wall of the pegmatite, which is about 28 feet thick. Mica is present in the foot-wall "vein" here, but it had not been developed at the time of visit. Drifts were started on the hanging-wall "vein" in each direction and when seen were each in about 20 feet. These drifts have since been carried 175 feet to the northwest and 125 feet to the southeast. At the end of the southeast drift an irregularity in the "vein" or a fault has been encountered and is being investigated by the company. The vein matter seen in the 40 feet of drift on the 200-foot level was very rich and contained considerable large-sized mica. Several blocks over a foot across and a large number of smaller ones were seen in the walls.

Mention has already been made of the richness in mica of various parts of the "vein." Data for estimating the percentage of mica in the "veins" are given by Mr. Pyne, the superintendent, whose records show an average of 600 pounds of rough mica to 10 square feet of "vein" removed. The "veins" average from 5 to 6 feet thick, say 5½ feet. If the weight of a cubic foot of pegmatite is estimated at 163 pounds, it is found that the rough mica obtained averages about 6.6 per cent of the vein matter.

No. 2 MINE.

The No. 2 mine of the Westinghouse Company, formerly known as the White Spar mine, is 1¾ miles S. 40° W. of Custer. This mine has been equipped with two 45-horsepower boilers, a bucket hoist also serving as a pump, electric lights, air drills, mine cars, and tracks. It was opened irregularly from the surface by open cuts, inclines, and drifts to a depth in places of nearly 40 feet. The workings of the present company consist of a vertical shaft 110 feet deep, 10 feet at the bottom serving as a sump, with a crosscut and drift on the "vein" at the 100-foot level and drifts and stopes on the 50-foot level. The shaft is in the " vein " for 50 feet from the surface down and then passes through the foot wall into the country rock. A general plan of the workings of the Westinghouse Company on the 50-foot and 100-foot levels, as seen in August, 1908, is given in figure 2. The " vein " is about 40 feet thick at its outcrop, 25 feet thick at the 50-foot level, and 18 to 20 feet thick at the 100-foot level.

The country rock is biotite gneiss, in which highly schistose beds are prominent. Some of the more schistose layers are much crumpled. The gneiss has a strike varying from N. 30° W. to N. 60° W. and a dip of about 45° SW., though the dip is variable in places. The pegmatite is roughly conformable with the inclosing biotite gneiss, though locally very irregular. On the 50-foot level it pinches out at a distance of 40 feet southeast of the shaft, and the gneiss folds around it, as indicated in figure 30. In places the contact of the pegmatite and gneiss is straight, though as a rule it is somewhat curved and rolling.

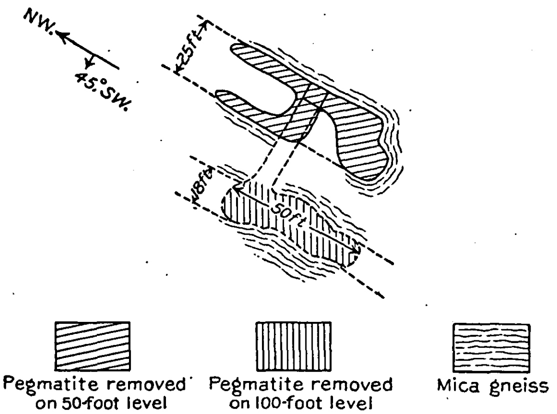

FIGURE 30.—Plan of No. 2 or White Spar mica mine, near Custer, S. Dak.

The mica is distributed through the pegmatite with varying regularity. In some places the pegmatite contains little mica for several feet in different directions; in others it is very rich for equally large areas. It was estimated that in one such portion southeast of the shaft on the 50-foot level mica composed nearly 50 per cent of the pegmatite. This mica occurred in blocks of all sizes up to a foot in diameter. The edge of one block of mica, or several blocks closely joined together, projecting from the floor of the room southeast of the shaft, was nearly 5 feet long and from 2 or 3 to 12 inches thick in different parts. The mica crystals do not appear to have any definite orientation, but lie mixed with the quartz and feldspar of the pegmatite. The feldspar is coarsely crystallized, and in one place a section of an orthoclase crystal 4 feet through was seen in the wall. Quartz occurs in large, irregular masses, several feet through, in the pegmatite. Other minerals found are black tourmaline, a few garnets, and white to pale-greenish beryl. One broken beryl crystal 6 inches in diameter and 8 inches long was seen. The mica is of good quality for many electric purposes, and some of it could be used for glazing. Part of it contains inclusions of flattened garnets between the laminæ and tourmaline grown through the crystals at different angles.

Pegmatite ledges are plentiful in the neighborhood and two other large ones outcrop about 50 to 80 feet to the southwest of the main ledge. It was intended to continue the crosscut on the 100-foot level to cut one of these.

NO. 3 MINE.

The No. 3 mica mine of the Westinghouse Company is 3½ miles west of Custer and has not yet been actively developed.

NO. 4 MINE.

The No. 4 mica mine of the Westinghouse Company is 5 miles N. 15° E. of Custer, in a ridge separating two branches of the headwaters of French Creek. The mine is about 300 feet higher than the valley on the northwest. The greater part of the work was done before the Westinghouse Company took hold, and that company abandoned work temporarily after a small amount of development. Openings have been made at two points—one on a small knob, the other about 200 yards S. 65° E. of it. These openings are apparently on different pegmatite bodies. The pegmatite ledge running through the knob strikes N. 15° W. and dips 60° E. The ledge at the other opening has a complex structure and its direction was not determined. Between the two openings a strong ledge of pegmatite outcrops with a strike of N. 65° W. and a dip of 40° N. This ledge extends to that on the knob, by which it seems to be cut off. Other pegmatite bodies with similar variable directions occur in the vicinity.

The pegmatite cutting through the knob is about 25 feet thick and has been traced to the south along the knob for a distance of nearly 100 yards. It is composed of large, irregular masses of feldspar and pale rose-colored quartz, with variable amounts of mica and black tourmaline and small quantities of biotite mica, apatite, and garnet. The mica seems to occur principally along the hanging wall, which has been worked by an open cut on the north end of the knob. Many mica crystals project from the pegmatite for some distance along the outcrop.

At the other opening a tunnel was run in from an open cut in a direction N. 60° W. At the entrance to this tunnel biotite gneiss was exposed in the floor and on one side. It had a strike of N. 65° W. and a dip of about 30° N. In the open cut the pegmatite dips in the opposite direction. Mica seemed to have been found plentiful and of fair size in this opening.

CROWN MINE.

The Crown mica mine, of the Chicago Mica Company, is 2½ miles northwest of Custer. It has been worked by several open cuts—the main one about 130 feet long and 25 feet deep and wide—a 20-foot incline from the bottom of the cut, and a 100-foot shaft with a cross-cut to the "vein," a drift, and a stope. The stope reaches about half-way to the bottom of the incline. The mine has been equipped with a 40-horsepower boiler, hoisting engine, and air-drill compressor, three pumps, storage and loading house, office, etc.

The country rock is muscovite-biotite gneiss, with straight slaty cleavage in some places and a plicated structure in others, especially near the pegmatite bodies. The gneiss strikes about N. 35° W. and has a variable dip. The pegmatite is about 10 feet thick and is in part, at least, conformable with the schistosity of the gneiss. It has the form of an anticlinal fold whose axis pitches south-eastward about 10° or 15° down the slope of a low ridge. At the northwest end of the open cut the crest of folded pegmatite forms a blanket over the top of a small hill and has been worked for a width of 40 feet by a shallow open cut. The north-eastern limb of the fold has been followed down on a dip of about 40° by a 20-foot incline. Sufficient development work has not been done to determine the dip of the other limb of the fold to the southwest. The open cut has been made along the axis of the fold and cuts through the pegmatite.

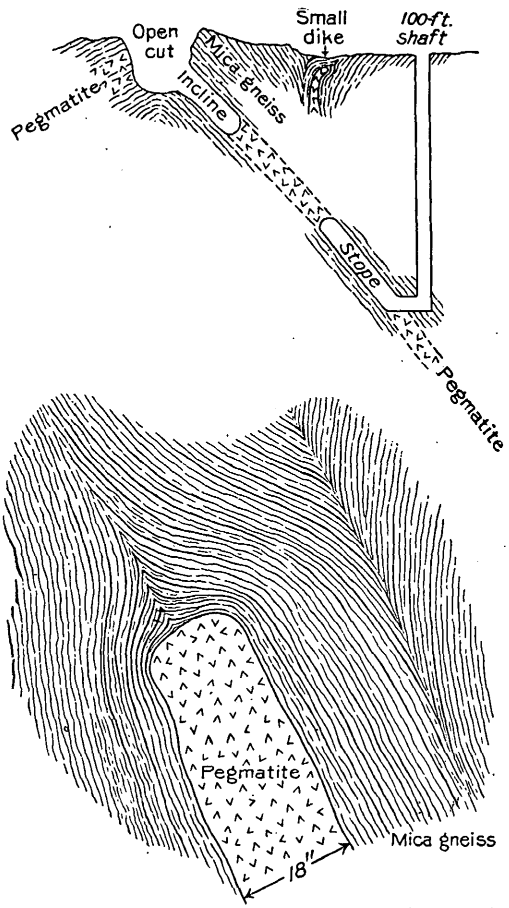

FIGURE 31.—Generalized cross section of Crown mica mine, near Custer, S. Dak., with sketch showing relation of pegmatite dike to inclosing gneiss.

While assessment work was being done, an 18-inch pegmatite dike was encountered about 50 feet northeast of the main body. This pegmatite failed to reach as far as the present surface by several feet and was discovered by accident. It is conformable with the strike of the inclosing gneiss, which it has split apart and crushed in the direction of its intrusion. The mica gneiss between this small dike and the main one is somewhat plicated and has been folded into a syncline. Figure 31 gives a generalized cross section of the formation and development work at this mine, also a sketch of the small dike and its relation to the inclosing gneiss. The main pegmatite body contains inclusions or horses of mica gneiss in long streaks lying parallel to the walls and ranging from a few inches to 2 or 3 feet in thickness.

In portions of the exposures of pegmatite remaining in the mine mica is plentiful, though only small sizes have been left. The small dike does not carry merchantable mica, so far as it has been opened, but is of interest as an illustration of the method of intrusion of a pegmatite dike and also of the way in which such dikes, and consequently some mica veins, pinch out abruptly.

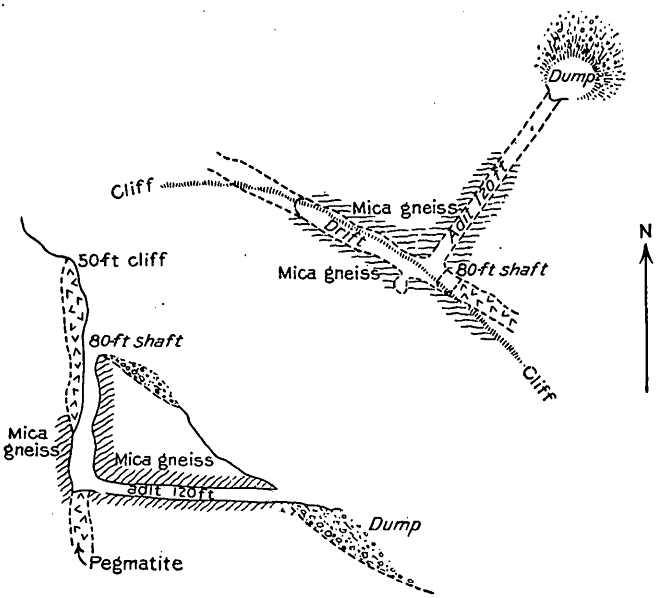

FIGURE 32.—Plan and cross section of Great Northern or Old Mike mica mine, near Custer, S. Dak.

OLD MIKE MINE.

The Old Mike mica mine, now called the Great Northern, is 3¾ miles N. 20° W. of Custer, on the north end of the ridge extending northward from Buckhorn Mountain. The pegmatite at this mine forms a cliff facing northeastward and rising about 50 feet above the steep slope at its base. Other cliffs rise back of and above this one to the southwest. The mine has been opened by a shaft 80 feet deep, a crosscut or adit 120 feet long, and a drift with stopes on the vein. (See figure 32.) A small amount of work has been done at the base of the cliff. The country rock is muscovite-biotite schist, which strikes nearly east and west and has a northerly dip. The pegmatite cuts across the schist with a strike of N. 65° W. and a vertical dip. It is from 10 to 15 feet thick in the drift and has irregular curving walls. The mica is irregularly distributed through the pegmatite and in some of the places, where the latter bulges out into the schist, is abundant. Here and there the pegmatite is fine grained and barren of merchantable mica. Mica is exposed in the face of the cliff, where a little work has been done. Most of the work in the cliff has been done for the columbite and cassiterite, which have been found here in varying amounts. Masses and crystals of columbite several pounds in weight have been obtained alongside of and in a quartz streak in the pegmatite cliff. Crystals of brownish to black cassiterite occur in places through the finer-grained portions of the pegmatite, and bowlders of the tin-bearing pegmatite lie on the slope of the mountain below the mine. The mica from this mine has a "rum" color and appears to be clearer than that from many of the other South Dakota mines.

FIRESTONE MINE.

The Firestone mica mine is 4¾ miles S. 20° W. of Custer. It has been opened by a crosscut through the schist and barren portion of the pegmatite, an open cut 20 feet deep, and an incline on the "vein." The incline was reported to be 75 feet deep, and has a 30-foot drift to the northeast at the 20-foot level, below which the incline is filled with water. The country rock is muscovite-biotite schist striking N. 25° E. and dipping 60° NW. The pegmatite is about 15 feet thick, and is conformable with the inclosing rock. A few thin sheets or partings of schist are included in the pegmatite and lie parallel with its walls. Near the outcrop on the southwest side of the open cut, part way down the incline, the mica streak is along the hanging wall and is about 1 foot thick. In the northeast face of the cut the mica streak is in the midst of the pegmatite and is about 4 feet thick. In the drift also the "vein" is in the body of the pegmatite, and has a thickness of several feet. Mica seems to be plentiful in portions of the "vein," and some crystals several inches in diameter were seen. The feldspar and quartz of the pegmatite occur in irregular masses 2 or 3 feet across. Some of the quartz has a pale rose color.

LOST BONANZA MINE.

The Lost Bonanza mica mine is 1¾ miles due north of Custer, on the east end of Buckhorn Mountain. The pegmatite cuts through a small knob with a strike of N. 80° W. and a dip of 40° S., and is conformable with the inclosing muscovite-biotite gneiss. The mine has been worked by an open cut with an incline and a tunnel over 200 feet long with stopes. The tunnel is about 40 feet lower than the top of the hill, and almost all of the "vein" between the two has been worked out. The outcrop of the pegmatite is exposed for nearly 100 yards along the strike. The pegmatite varies from 15 inches to over 8 feet in thickness. At the east end of the open cut a portion of the pegmatite is nearly barren of mica, and carries a large amount of black tourmaline crystals, some of which measure 6 and 10 inches in diameter.

CLIMAX MINE.

The Climax mica mine is 2 miles due east of Custer. It has been opened by three shafts, not over 50 feet apart, connected by drifts. One of these shafts was more than 60 feet deep. The country rock is schistose-biotite gneiss, striking northeastward and having a high dip, and the pegmatite is approximately conformable with it. As seen in the outcrop, the pegmatite is about 20 feet thick and carries mica in pockets containing crystals up to several inches in diameter. Regular streaks of mica may have been found in the workings. The mica is of good quality and has a wine-yellow color. Black tourmaline and smoky and opalescent quartz occur in the pegmatite.

About 100 yards northwest of the old workings another pegmatite body 2½ to 4 feet thick has been opened by a shaft and drifts with a small open cut. This "vein" lies conformable with the inclosing biotite schist-gneiss, which strikes N. 45° W. and has a vertical dip. The mica is scattered through the pegmatite.

ST. LOUIS MINE.

The mine of the St. Louis Mica Company is on the south side of French Creek, 4½ miles S. 65° E. of Custer. The pegmatite outcrop at this mine forms a bare floor nearly 100 feet square on the gentle slope of a hill. Several small streaks of mica gneiss with a strike of N. 70° W. and a dip of 65° SW. are included in it. Streaks of mica occur in different portions of the pegmatite and two of these have a northeasterly strike and a vertical dip. Small mica crystals are plentiful in these streaks. The development work consists of shafts and several open cuts. These openings were in such bad shape that little could be seen of the formation encountered. Good-sized blocks of mica are reported to have been found when the mine was operated.

GALESBURG MINE.

The mine of the Galesburg Mica Company is on the opposite side of French Creek from the St. Louis mine and 4½ miles S. 70° E. of Custer. It is in a sharp spur rising from the bottom land of French Creek. The spur is a hogback formed by the outcrop of a hard pegmatite ledge, which strikes about N. 70° W., dips 45° N., and is over 25 feet across. The hanging wall is biotite mica gneiss. The foot wall and full thickness of the pegmatite are not exposed. The whole has a roughly banded structure somewhat as follows: Next to the hanging wall is the "vein," or streak rich in mica, from 6 inches to 2 feet or more thick; then 10 to 15 feet of ordinary pegmatitic material; a massive quartz streak 6 to 10 feet thick; and more pegmatite with rosettes of feldspar (in part, at least, albite). Black tourmaline occurs through the pegmatite as usual.

PHILIP GEERING PROSPECT.

The Philip Geering prospect is 2¾ miles S. 25° W. of Custer, on the southwest side of a prominent outcrop of pegmatite, which is about 35 feet across and stands 25 feet above the level country around it. The country rock is mica gneiss and, with the inclosed pegmatite, strikes N. 25° W. and dips about 45° SW. An interesting feature at this prospect is the abundance of black tourmaline crystals in the pegmatite. These crystals range from 1 to 6 inches in diameter, and it is estimated that they compose nearly 50 per cent of the pegmatite in an area of 40 square feet exposed in the prospect. Their position is apparently nearly normal to the wall of the pegmatite. But little mica was seen in the pegmatite and it was not learned whether a good pocket had been encountered.

WYOMING LODE.

The Wyoming mica lode, owned by F. T. Peterson, is 5¾ miles S. 15° W. of Custer. Pegmatite or pegmatitic granite forms a large portion of the country rock at this prospect. Little mica schist is exposed, but what was seen occurs in streaks included in the pegmatite and has a strike west of north and a southwest dip. The mica was found in a pocket or streak at one place; the greater part of the pegmatite in the outcrop is rather fine grained and carries only small mica. The mica obtained from the prospect has a rich "rum" color. Pink orthoclase, some with graphic intergrowths of quartz, is exposed in the pit in masses several feet across. Black tourmaline and a small amount of pale rose-colored quartz are also found.

ORIGIN OF THE PEGMATITE.

The origin of pegmatite is explained in various ways. In one place the pegmatite can be proved to be a dike; in another it is a vein. In the former it represents a magma intruded into the rock formations and crystallized; in the latter it has been deposited from magmatic solutions assisted by the presence of mineralizing vapors, as boron, fluorine, etc. Between the evident dike and vein types are found all gradations. This is to be expected, in view of the general opinion that there is no sharp line to be drawn between conditions of fusion and solution in highly aqueous magmas or concentrated magmatic solutions. Thus, although no definite statement can be made regarding the intermediate types of pegmatite, the distinction between the end types may be more decided. To the writer's mind most of the pegmatites associated with mica in the region around Custer resemble dikes in their nature. This opinion is gained by comparing the larger deposits with the small one and its larger mother lode at the Crown mine shown in figure 31. That the small pegmatite shown in B is a dike intruded as somewhat viscous magma is evident by the way in which it has crushed the gneiss in front of it and finally stopped in its course when it became too viscous or when the pressure became insufficient to force it farther. The rounded outline of the end is a characteristic form of highly viscous bodies. That the schists were not crushed by the force of crystal growth from material in solution is shown by the absence of any pegmatitic material along the course by which the solutions would have escaped after depositing part of their load. This small dike illustrates another point. The mica gneiss at the Crown mine has been folded somewhat, as shown in the figure. The small dike has split the axis of a sharp V-shaped fold, thus following along a line of weakness. As certain bands of the schistosity are lines of weakness, the dikes have a tendency to follow them also, thus producing pegmatite bodies more or less conformable with the inclosing gneiss.

The formation of the pegmatite bodies in the Black Hills is evidently an end phase of the granite intrusions of that region; for they cut the granite masses and in some places grade into granite itself. The age of the granite intrusions around Harney Peak and Custer has not been definitely determined. Though considered Archean by Newton and Jenney, there are indications pointing to a later age.

SURVEY PUBLICATIONS ON MISCELLANEOUS NONMETALLIC PRODUCTS, INCLUDING MICA, GRAPHITE, FLUORSPAR, ASBESTOS, AND BARITE.

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

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