

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. Geol. 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 $5\frac{1}{2}$ 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

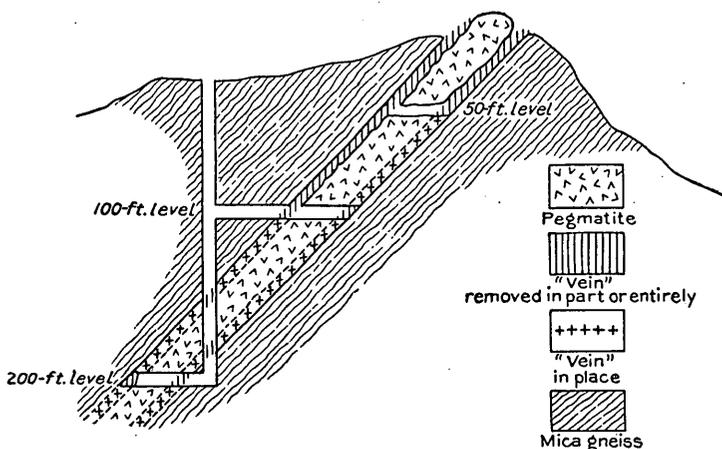


FIGURE 29.—Generalized cross section of No. 1 or New York mine, near Custer, S. Dak.

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 $5\frac{1}{2}$ 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 $1\frac{3}{4}$ 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

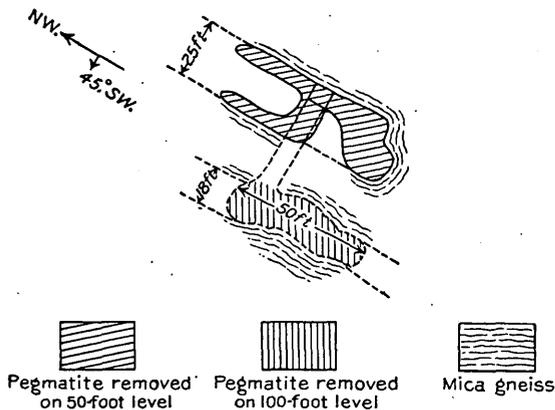


FIGURE 30.—Plan of No. 2 or White Spar mica mine, near Custer, S. Dak.

pegmatite and gneiss is straight, though as a rule it is somewhat curved and rolling.

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 esti-

mated 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 flat-

tened 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 $3\frac{1}{2}$ 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 $2\frac{1}{2}$ 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

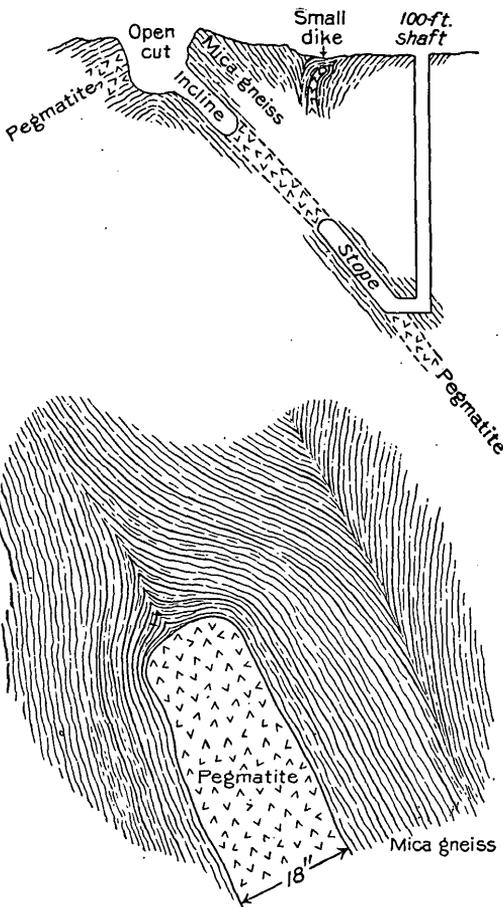


FIGURE 31.—Generalized cross section of Crown mica mine, near Custer, S. Dak., with sketch showing relation of pegmatite dike to inclosing gneiss.

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.

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.

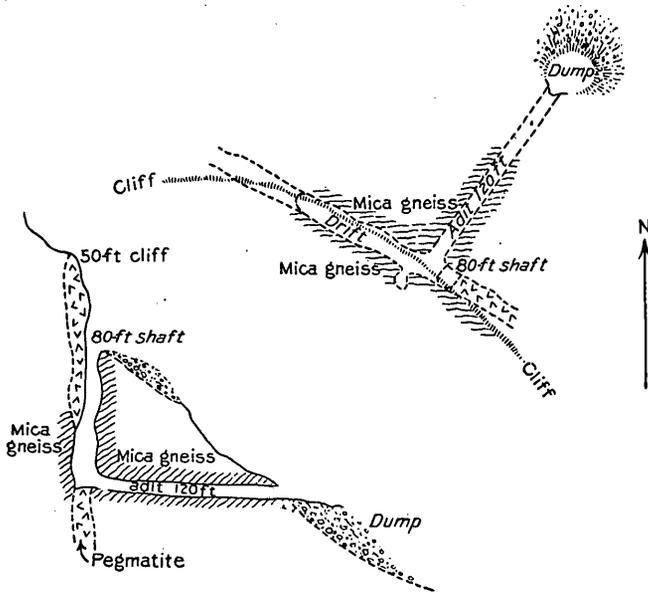


FIGURE 32.—Plan and cross section of Great Northern or Old Mike mica mine, near Custer, S. Dak.

OLD MIKE MINE.

The Old Mike mica mine, now called the Great Northern, is $3\frac{1}{2}$ 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 boulders 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 $4\frac{3}{4}$ 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 $1\frac{3}{4}$ 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 $2\frac{1}{2}$ 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, $4\frac{1}{2}$ 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 $4\frac{1}{2}$ 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 $2\frac{3}{4}$ miles S. 25° W. of Custer, on the southwest side of a prominent outcrop of pegmatite, which is about 35 feet across and stands 25 feet above the level country around it. The country rock is mica gneiss and, with the inclosed pegmatite, strikes N. 25° W. and dips about 45° SW. An interesting feature at this prospect is the abundance of 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 $5\frac{1}{4}$ 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.

BAIN, H. F. Fluorspar deposits of southern Illinois. In Bulletin No. 225, pp. 505-511. 1904. 35c.

BALL, S. H. Mica in the Hartville uplift, Wyoming. In Bulletin No. 315, pp. 423-425. 1907.

——— Graphite in the Haystack Hills, Laramie County, Wyo. In Bulletin No. 315, pp. 426-428. 1907.

BREWER, W. M. Occurrences of graphite in the South. In Seventeenth Ann. Rept., pt. 3, pp. 1008-1010. 1896.

BURCHARD, E. F. Barite. In Mineral Resources U. S. for 1906, pp. 1109-1113. 1907. 50c.

——— Fluorspar. In Mineral Resources U. S. for 1906, pp. 1063-1066. 1907. 50c.

——— Fluorspar and cryolite. In Mineral Resources U. S. for 1907, pt. 2, pp. 637-641. 1908.

——— Barytes and strontium. In Mineral Resources U. S. for 1907, pt. 2, pp. 685-696. 1908.

DILLER, J. S. Asbestos. In Mineral Resources U. S. for 1906, pp. 1123-1129. 1907. 50c.

——— Asbestos. In Mineral Resources U. S. for 1907, pt. 2, pp. 711-722. 1908.

EMMONS, S. F. Fluorspar deposits of southern Illinois. In Trans. Am. Inst. Min. Eng., vol. 21, pp. 31-53. 1893.

FULLER, M. L. The occurrence and uses of mica. In Stone, vol. 19, pp. 530-532. 1899.

HAYES, C. W., and PHALEN, W. C. A commercial occurrence of barite near Cartersville, Ga. In Bulletin No. 340, pp. 458-462. 1908.

——— Graphite deposits near Cartersville, Ga. In Bulletin No. 340, pp. 463-465. 1908.

HOLMES, J. A. Mica deposits in the United States. In Twentieth Ann. Rept., pt. 6, pp. 691-707. 1899.

KEITH, A. Talc deposits of North Carolina. In Bulletin No. 213, pp. 433-438. 1903. 25c.

KEMP, J. F. Notes on the occurrence of asbestos in Lamoille and Orleans counties, Vt. In Mineral Resources U. S. for 1900, pp. 862-866. 1901. 70c.

——— Graphite in the eastern Adirondacks. In Bulletin No. 225, pp. 512-514. 1904. 35c.

PHALEN, W. C. (See Hayes, C. W., and Phalen, W. C.)

PHILLIPS, W. B. Mica mining in North Carolina. In Mineral Resources U. S. for 1887, pp. 661-671. 1888. 50c.

SMITH, G. O. Graphite in Maine. In Bulletin No. 285, pp. 480-483. 1906.

——— Graphite. In Mineral Resources U. S. for 1906, pp. 1139-1143. 1907. 50c.

SMITH, W. S. T. (See Ulrich, E. O., and Smith, W. S. T.)

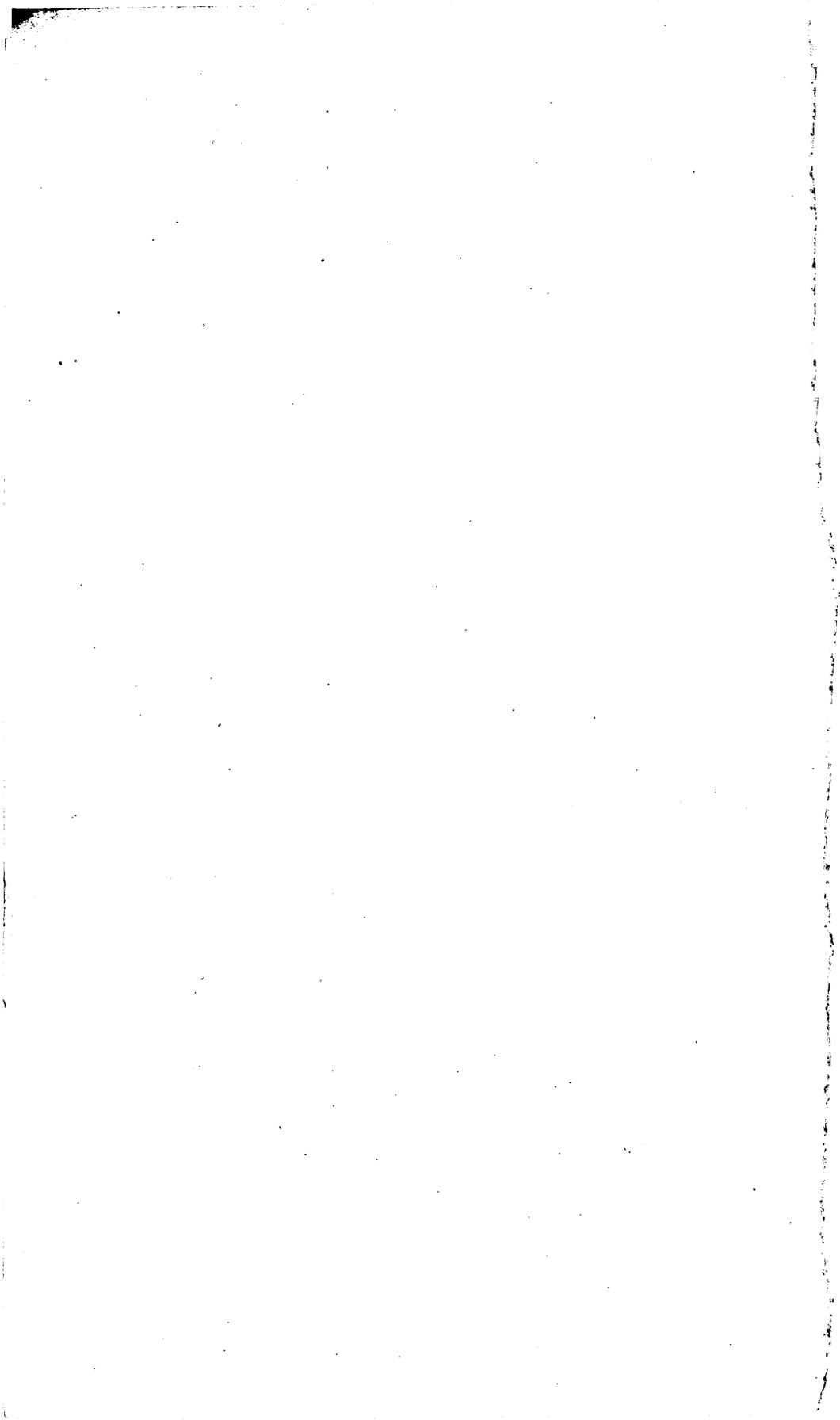
STERRETT, D. B. Mica deposits of western North Carolina. In Bulletin No. 315, pp. 400-422. 1907.

——— Mica. In Mineral Resources U. S. for 1907, pt. 2, pp. 741-750. 1908.

——— Meerschaum in New Mexico. In Bulletin No. 340, pp. 466-473. 1908.

STOSE, G. W. Barite in southern Pennsylvania. In Bulletin No. 225, pp. 515-517. 1904. 35c.

ULRICH, E. O., and SMITH, W. S. T. Lead, zinc, and fluorspar deposits of western Kentucky. In Bulletin No. 213, pp. 205-213. 1903. 25c.



INDEX.

		Page.
	A.	
Abrasives, bibliography of.....	364-365	
Adler mine, description of.....	269	
Alabama, manganese in.....	272	
<i>See also</i> Chattanooga district.		
Alaska, work in.....	18	
Alaskan publications, segregation of.....	7	
Albertite, character of.....	291	
Althouse district, Oreg., mineral resources of.....	70	
Aluminum, publications on.....	13-14, 282	
Anderson, Robert, on Nevada asphaltite.....	283-285	
work of.....	15	
Anderson & Wilson mine, description of.....	75	
Annie No. 1 claim, description of.....	142-143	
Annual reports, publication of.....	8	
Appalachian region, iron ores of.....	220-252	
iron ores of, distribution of.....	222	
<i>See also</i> Hematite; Clinton ores; Mountain brown ores; Valley brown ores; Oriskany ores; Magnetite; Carbonate ores.		
geology of.....	220	
manganese in.....	259-263, 272	
sections in.....	221	
figure showing.....	223	
work in.....	20	
Applegate district, Oreg., map of.....	48	
mineral resources of.....	66-68	
Applegate region, Oreg., copper of.....	75-79	
geography of.....	48-49	
geology of.....	49-54	
gold placers of.....	63-75	
gold quartz of.....	55-63	
mineral resources of.....	54-79	
structure of.....	54	
Arizona, manganese in.....	274	
work in.....	18	
<i>See also</i> Whetstone Mountains; Chiricahua Mountains.		
Arkansas, grahamite in.....	295-296	
manganese in.....	267-270, 272	
section in.....	267	
Arnold, Ralph, work of.....	15	
Arnold, Ralph, and Johnson, H. R., on sodium sulphate in California.....	369-371	
Asphalt, bibliography of.....	298	
papers on.....	283-297	
<i>See particular districts, places, etc.</i>		
Asphaltite, character and distribution of.....	283-285	
	B.	
Bales mine, description of.....	268-269	
Ball clays, analyses of.....	355	
occurrence and character of.....	353-356	
	C.	
Ball clays, section of.....	356	
Bancroft, H., work of.....	19	
Batesville district, Ark., manganese in.....	267-270	
Baxter mine, description of.....	269	
Bearpaw shale, occurrence and character of.....	328	
Benson, Ariz., tungsten near.....	164-165	
Benson mine, description of.....	67	
Birkinbine, John, on iron ores of Hanover.....	210-212	
Black Fork Mountain, grahamite of.....	294-295	
Black Gold Channel mine, description of.....	65	
Black Hills, geology of.....	383-385	
mica in.....	382-383, 385-386	
mines of, description of.....	387-396	
tin ores in.....	135-144	
Black Metal claims, description of.....	150-152	
Black Rock prospect, description of.....	116	
Blue Bird claim, description of.....	137	
Blue Jay mine, description of.....	115-116	
Blue Ridge, Va., iron ores of.....	218, 219	
iron ores of, analyses of.....	218	
manganese of.....	259-263	
section in.....	260	
Bluestone mine, description of.....	106-108	
Boggy Creek, Okla., grahamite in.....	296	
Bohemia district, Oregon, copper in.....	84	
geology of.....	80-81, 82	
gold of.....	82-84	
metamorphism in.....	82	
ore deposits of.....	81	
mining in.....	83-84	
silver of.....	84	
topography of.....	80	
Box Canyon district, Colo., mineral resources of.....	28, 38	
Braden mine, description of.....	56-58	
Bradley prospect, description of.....	116	
Brantner mine, description of.....	67-68	
Brooks, A. H., work of.....	18	
Building stones. <i>See</i> Stones, building.		
Bulletins, publication of.....	8, 12, 16, 17	
Burchard, E. F., on tonnage of Clinton ores.....	169-187	
work of.....	15	
Butler, B. S., work of.....	19, 20	
Butts, Charles on Pennsylvania ganister.....	337-342	
	C.	
California, manganese of.....	270-271	
San Luis Obispo Co., sodium sulphate in.....	369-371	
work in.....	18-19	
Carbonate ores, analysis of.....	251	
character and distribution of.....	251	
Carboniferous rocks, occurrence and character of.....	289	

	Page.		Page.
Carriso Plain, Cal., soda on	369-371	Copper Creek, Colo., iron deposits on	190-192
Cason mine, description of	268	iron deposits on, map showing	191
Cason shale, manganese in	268	Cracker Creek district, Oreg., faulting in	88-90
Cement materials, bibliography of	13, 343-345	geology of	86
demand for	335	map of	87
mixture of	332	section of	87-88
papers on	314-342	section of, figure showing	89
requirements for	318-319, 333-334	structure of	88-90
<i>See particular districts, places, etc.</i>		topography of	85-86
Chattanooga Creek, Ga., iron of	179-180	veins of	90-93
Chattanooga district, Tenn., iron of	176-182	section of	92
Chattanooga region, Tenn.-Ala.-Ga., Clinton		Cretaceous rocks, character and distribution	
ores of, analyses of	186	of	52
Clinton ores of, estimates of	169-187	Crimora mine, description of	261
summary of	187	Cross Mountain district, Colo., mineral re-	
Chiricahua Mountains, Ariz., geography of	299	sources of	30
geology of	301-304	Crown mine, description of	391-393
map of	300	section in, figure showing	392
marble of	305-311	Currin Valley mine, description of	263
tests of	311		
metamorphism in	304	D.	
section of, figure showing	301	Dale, T. N., work of	15
structure of	303-304	Darton, N. H., work of	15
topography of	300-301	Deep Gravel mine, description of	73-74
Chumbler Hill mine, description of	265	Devonian rocks, occurrence and character	
Cinnabar, occurrence of	79	of	289-290
Clays, bibliography of	13, 358-360	Diller, J. S., work of	19
papers on	346-359	Diller, J. S., and Kay, G. F., on Grants Pass	
publications on	14	region, Oregon	48-79
Climax mine, description of	395	Dobbins mine, description of	266
Clinton iron ores, analyses of	232-233	Dry Run mine, description of	260-261
estimates of, in Chattanooga district	169-187		
character of	232-233	E.	
distribution of	228	Emmons, W. H., work of	19
geology of	228	Etta mine, columbites from	159-160
ore beds of	230-232	columbites from, analyses of	160
sections of	229-231	description of	158-161
figure showing	230	minerals from	149
Colorado, Boulder and Laramie counties, ce-		Eucluee district, Tenn., iron of	173-174
ment materials in	320-326		
geology of	316-318	F.	
map of	315	Field work, progress of	14-15, 18-20
topography of	314-315	Firestone mine, description of	394
Gunnison Co., copper of	23, 30, 32, 39-40	First Find claim, description of	142
economic geology of	21-40	Florida, brickmaking in	346-347
geography of	21-23	clays of	346-357
geology of	23-28	analyses of	348-350, 352, 355
gold of	30-40	sections of	352, 354, 356
iron of	40	mining of	356-357
lead of	29, 32, 33, 39-40	section of	347
map of	30	Foots Creek district, placers of	65-66
mineral resources of	28-40	Forest City claim, description of	140-141
section in	24	section of, figure showing	141
sections in, figures showing	27	Fort Bowie, Ariz., marbles west of	305
silver of	28-29, 32-38	Fourche Mountain, Ark., grahamite in	295-296
structure of	26-28	Fuel publications, segregation of	7-8
zinc of	29, 35, 39-40	Fuller's earth, bibliography of	358-360
manganese in	273		
work in	19	G.	
<i>See also Taylor Peak; Whitepine.</i>		Gadsden district, Ala., iron of	182-185
Columbite. <i>See Tantalum.</i>		Galesburg mine, description of	395-396
Concrete, publications on	14	Ganister, analyses of	337-338
Connecticut, manganese in	271	brick from	341-342
Cook mine, description of	66	analysis of	341
Copper, bibliography of	120-122	character of	337-338, 340
papers on	99-119	geologic relations of	338-339
<i>See particular districts, places, etc.</i>		manufacture of	340
		mining of	339

Page.	Page.
Gas, natural, publications on.....	13, 15
Geography. <i>See particular districts, etc.</i>	
Geologic folios, publication of.....	9-11, 13
Geology. <i>See particular districts, etc.</i>	
Georgia, manganese of.....	264-267
section of.....	265
<i>See also Chattanooga district.</i>	
Gertie claim, description of.....	135-137
Glass sand, bibliography of.....	363
Glen Ditch mine, description of.....	66
Gold, bibliography of.....	94-98
papers on.....	21-93
Gold Brick district, Colo., mineral resources of.....	29, 32-34
Gold Hill district, Oreg., placers of.....	64
Good Luck claim, description of.....	152
Gossan ore, analyses of.....	218
Grahamite, analyses of.....	296
character and distribution of.....	286-297
Granite, Nev., mines at.....	118-119
Granite Hill mine, description of.....	58-59
Grants Pass quadrangle. <i>See Applegate region.</i>	
Graton, L. C., work of.....	19
Grayels, character and distribution of.....	26
Grizzly Bear Creek, S. Dak., tantalum on....	161
Gypsum, publications on.....	13, 362
H.	
Hanover district, N. Mex., faulting in.....	203-204
faulting in, figure showing.....	203
geography of.....	199-201
geologic map of.....	200
geology of.....	201-209
igneous rocks of.....	204-206
iron ores of.....	209-214
analyses of.....	211-212
metamorphism in.....	206-209
Harder, E. C., on Appalachian iron ores in Virginia.....	215-254
on manganese deposits.....	255-277
on Taylor Peak and Whitepine dis- tricts, Colo.....	188-198
work of.....	14-15
Harney Peak, tin ores at.....	134-135
tin ores at, assays of.....	134
Havre district, Mont., cement material of....	328-333
cement material of, analyses of.....	329-332
fuel at.....	333
geology of.....	328-329
map of.....	327
markets and transportation from.....	334-335
water of.....	334
Hayes, C. W., introduction by.....	7-11
on nonmetallic minerals and iron ores....	12-15
Hematite, specular, analyses of.....	218-228
character of.....	227-228
geology of.....	224-225
ore bed of.....	225-227
structure of, figure showing.....	226
Henry Petit claim, description of.....	153-154
Hess, F. L., on tin, tungsten, and tantalum of South Dakota.....	131-163
on wolframite of Arizona.....	164-165
work of.....	19
High Gravel mine, description of.....	72-73
Hill, J. M., on southeastern Gunnison County, Colo.....	21-40
Hill, J. M., work of.....	19
Hill City, S. Dak., tungsten near.....	150-154
Homestake prospect, description of.....	61-62
Hornsilver district, Nev., description of.....	41-43
gold and silver of.....	42-43
Horsehead mine, description of.....	71
I.	
Igneous rocks, character and distribution of.	52-54
Impson Valley, Okla., grahamite in.....	290-292
Ingersoll claim, tantalum on.....	161
Inman area, Tenn., iron of.....	177
Intervalley mine, description of.....	114-115
Intrusive rocks, character and distribution of.	25-26
Iron ores, bibliography of.....	278-281
papers on.....	13-15, 169-254
<i>See also particular districts, places, etc.</i>	
Iron ores, manganiferous, distribution of.....	256-257, 272-273
Irving, J. D., on Lead tungsten deposits....	155-157
J.	
Jackfork Valley, Okla., grahamite of.....	292-293
Jacksonville district, Oreg., mineral re- sources of.....	68-70
James River valley, iron ores in.....	217-219
iron ores in, analyses of.....	218
manganese in.....	258-259
Jewett mine, description of.....	61
Johnson, H. R., and Arnold, Ralph, on sodium sulphate, California....	369-371
Johnston mine, description of.....	67
Josephinite, occurrence of.....	79
Judith River formation, occurrence and char- acter of.....	328
Jurassic rocks, character and distribution of.	52
K.	
Kay, G. F., work of.....	19
Kay, G. F., and Diller, J. S., on Grants Pass region, Oreg.....	48-79
Kerby district, Oreg., mineral resources of....	75
Klamath Mountains. <i>See Applegate region.</i>	
L.	
Ladd mine, California, manganese in.....	271
Lake Superior, manganese near.....	272
Lance mine, description of.....	66
Layton mine, description of.....	66-67
Lead, bibliography of.....	129-130
papers on.....	123-129
<i>See also particular districts, places, etc.</i>	
Lead, S. Dak., tungsten near.....	154-157
Lime, bibliography of.....	361
Limestone, analyses of.....	51
character and distribution of.....	50-51
Lindgren, Waldemar, on metalliferous ores....	15-19
on Tres Hermanas district, N. Mex.....	125-128
Loco, grahamite in.....	296-297
Logan, Simmons & Cameron mine, descrip- tion of.....	74
Lookout Creek, Tenn., iron of.....	178-179
Lost Bonanza mine, description of.....	394-395
Louise claim, description of.....	139-140
Lowe mine, description of.....	267
Ludwig mine, description of.....	112-114
Lyndhurst mine, description of.....	261-262

M.	Page.		Page.
McCaskey, H. D., work of.....	20	New River region, manganese in.....	263
McConnell mine, description of.....	110-111	New York, manganese in.....	271
MacDonald, D. F., on Bohemia district, Oreg. work of.....	80-84 19	New York mine, description of.....	387-389
McGee Creek, Okla., grahamite in.....	293-294	section in, figure showing.....	388
McIntosh Canyon, marbles near.....	306-309	Niobrara limestone, analyses of.....	324-326
Magnesite, publications on.....	13, 361	occurrence and character of.....	317-318
Magnetite, analyses of.....	219, 251	sections of.....	320-322
character and distribution of.....	250-251	use of, for cement.....	320-322
Maid of the Mist mine, description of.....	61	North Carolina, manganese of.....	264
Malachite mine, description of.....	110	North Chattanooga area, iron of.....	176-177
Manganese, deposits of.....	255-277	O.	
deposits of, descriptions of, by States.....	258-274	Oklahoma, southeastern, geology of.....	289-290
distribution of.....	256-258	grahamite in.....	286-297
publications on.....	13, 14-15, 278-281	map of.....	287
sources of.....	255-257	structure in.....	290
uses of.....	275-276	topography of.....	288-289
Manganese industry, condition of.....	276-277	Old Mike mine, description of.....	393-394
Marksville, Va., iron ores of, analyses of.....	219	section of, figure showing.....	393
Martin, G. C., on Niobrara limestone of Colo- rado.....	314-326	Old Sturgis mine, description of.....	69-70
Mason Valley mine, description of.....	108-110	Oligocene clays, analyses of.....	348-351
Massachusetts, manganese in.....	271	occurrence and character of.....	347-351
Matson, G. C., on Florida clays.....	346-357	Olympia claim, description of.....	138
Mayburn mine, description of.....	266	Ooltewah area, Tenn., iron of.....	177-178
Meeker mine, description of.....	269	Ordovician rocks, occurrence and character of.....	290
Metamorphism. <i>See particular districts, places,</i> <i>etc.</i>		Oregon, work in.....	19
Mica, bibliography of.....	398-399	<i>See</i> Applegate region; Bohemia district; Cracker Creek district.	
paper on.....	382-397	Oriskany brown ores, analyses of.....	249
uses of.....	382-383	character of.....	248-250
Mica schist, character and distribution of.....	49-50	distribution of.....	245-247
Miller & Savage mine, description of.....	71	geology of.....	245-247
Mineral paint, bibliography of.....	366	ore beds of.....	247-248
Mineral resources. <i>See particular districts,</i> <i>places, etc.</i>		sections of.....	246, 247
Miocene clays, occurrence and character of.....	351	section, figure showing.....	248
Missouri, manganese of.....	273	Oscar Creek mine, description of.....	71
Mohawk claim, description of.....	143-144	Ouachita region, Okla., grahamite in.....	286-288
Monographs, publication of.....	9	P.	
Montana, manganese of.....	273-274	Paige, Sidney, on Hanover iron deposits, N. Mex.....	199-214
<i>See also</i> Havre.		on marble in Arizona.....	299-311
Montgomery mine, description of.....	269	Paleozoic rocks, character and distribution of.....	24-25, 50-51
Mountain brown ores, analyses of.....	240-241	Papers, grouping of.....	8
character of.....	238-241	Pardee, J. T., on Cracker Creek district, Oreg.....	85-93
distribution of.....	233	Pearce mine, description of.....	70
geology of.....	233-234	Peerless mine, tantalum at.....	161
ore beds of.....	234-238	Pegmatite, origin of.....	396-397
section of, figure showing.....	236, 239	Pennsylvania, Blair Co., cement materials in.....	337-342
Mountain Lion mine, description of.....	59-60	<i>See also</i> Ganister.	
Mountain View, Nev., mines at.....	118	manganese in.....	271
Munn, M. J., work of.....	15	Pepperberg, L. J., on cement material near Havre, Mont.....	327-336
N.		Petroleum, publications of.....	13, 15
Naiad Queen claim, description of.....	139	Phalen, W. C., work of.....	8
Nevada, manganese of.....	270, 274	Philip Geering prospect, description of.....	396
northeastern, asphaltite in.....	283-285	Phosphates, publications on.....	15, 367-368
petroleum in.....	285	Piedmont Manganese Co.'s mine, description of.....	259
work in.....	19	Pierre shale, analyses of.....	325-326
<i>See also</i> Hornsilver district; Round Moun- tain; Yerington district.		occurrence and character of.....	318
Nevada-Douglas mine, description of.....	114	use of, in cement.....	322-323
New Jersey, manganese in.....	271-272	Pigeon Mountain area, Ga., iron of.....	180-181
New Mexico, manganese in.....	274		
<i>See also</i> Tres Hermanas district; Hanover district.			

Page.	Page.		
Pine Creek, tungsten from.....	154	Southern mine, description of.....	270
Plaster, bibliography of.....	362	Spaulding mine, description of.....	69
Pleistocene clays, analyses of.....	352	Star mine, description of.....	60
occurrence and character of.....	352	Sterling mine, description of.....	68-69
sections of.....	352	Sterrett, D. B., on mica of South Dakota..	382-397
Pliocene clays, analyses of.....	355	Stibnite, occurrence of.....	79
occurrence and character of.....	351-352, 353-356	Stones, building, road metal, etc., bibliog-	
section of.....	356	raphy of.....	312-313
Polk-Southern mine, description of.....	270	publications on.....	13, 299-311
Pre-Cambrian rocks, character and distribu-		<i>See also particular districts, etc.</i>	
tion of.....	23	Storrs, James, work of.....	48
Professional papers, publication of.....	9, 12, 16, 17	Structural materials, publications on.....	15
Publications of Geological Survey, outline of.	8-9	Structure. <i>See particular districts, etc.</i>	
Purdue, A. H., work of.....	15	Sucker Creek district, Oreg., mineral re-	
Pyrite, bibliography of.....	381	sources of.....	70
deposits of.....	251	Sugar factories, waste of, analyses of.....	325
<i>See also particular districts, places, etc.</i>		waste of, use of, as cement material.....	323
Q.		Sulphur, bibliography of.....	381
Quartz Creek district, Colo., mineral resources		origin of.....	378-379
of.....	29, 34-36	paper on.....	373-380
Queen of Bronze mine, description of.....	76-78	<i>See also particular districts, places, etc.</i>	
R.		Sunnyside mine, description of.....	44-47
Ransome, F. L., on Hornsilver district, Nev..	41-43	level in, plan of.....	45
on Round Mountain, Nev.....	44-47	T.	
on Yerington copper district, Nev.....	99-119	Taff, J. A., on Oklahoma grahamite.....	286-297
work of.....	19	work of.....	15
Rare metals, bibliography of.....	162-163, 166-168	Tantalum, bibliography.....	162-163, 166-168
papers on.....	131-165	papers on.....	131-161
Recent clays, occurrence and character of....	353	<i>See also South Dakota.</i>	
Reeves mine, description of.....	268	Taylor Peak district, Colo., geology of.....	188-194
Rising Fawn area, Ga., iron of.....	179	iron deposits of, importance of.....	194
Roach mine, description of.....	269	structure of.....	190-194
Rockwood-Cardiff area, Tenn., iron of.....	171-173	maps of.....	189, 191, 193
Rockwood district, Tenn., iron of.....	170-176	Taylor Ridge area, Ga., iron of.....	181-182
Rough and Ready claim, description of.....	145-147	Taylor River, Colo., iron deposits on.....	192
Round Mountain, Nev., description of.....	44-47	iron deposits on, map showing.....	193
gold of.....	45-47	Tennessee, manganese ores.....	263-264
mine at, level at. plan of.....	45	<i>See also Chattanooga district.</i>	
S.		Tertiary rocks, character and distribution of.	52,
St. Louis mine, description of.....	395	104-105	
Salines, bibliography of.....	372	Texas, manganese in.....	272
paper on.....	369-371	Thermopolis, Wyo., geography of.....	373-374
<i>See also particular districts, places, etc.</i>		geology of.....	374-376
Sallie Cavanaugh claim, description of.....	138-139	hot springs at.....	376
Schrader, F. C., work of.....	18	structure of.....	375-376
Sherrad district, mineral resources of.....	36-37	sulphur at.....	377-380
Shinbone Ridge, Ala., iron of.....	182-183	travertine at.....	377-380
Silurian rocks, occurrence and character of.	289-290	Tin, bibliography.....	162, 166-167
Silver, bibliography of.....	94-98	paper on.....	131-163
papers on.....	21-93	<i>See also South Dakota.</i>	
<i>See also particular districts, places, etc.</i>		Tin Boom claims, description of.....	143
Silver ores, manganiferous, distribution of..	257,	Tin City claim, description of.....	139
273-274		Tineup district, Colo., mineral resources of.	29, 30-32
Soda, analyses of.....	370-371	Tin Pan mine, description of.....	60
occurrence and character of.....	369-371	Tin Queen claim, description of.....	141
South Carolina, manganese of.....	264	Tin Plate group, description of.....	138
South Dakota, mica in.....	382-397	Tinton area, S. Dak., tin mines of.....	144-147
manganese in.....	272	Tomichi Creek, Colo., districts south of, min-	
southwestern, geology of.....	132	eral resources of.....	28, 37-38
tantalum of.....	132-133, 157-161	mineral resources of.....	29, 38-40
tin of.....	132-149	Tourmaline, occurrence of.....	149
topography of.....	131-132	Trent mine, description of.....	269
tungsten of.....	132-133, 149-157	Tres Hermanas district, N. Mex., geology	
work in.....	19	of.....	123-124, 125
		lead of.....	123-128
		metamorphism in.....	125

