MISCELLANEOUS NONMETALLIC PRODUCTS.

GRAPHITE NEAR RATON, NEW MEXICO.

By W. T. LEE.

A large body of amorphous graphite occurs in the canyon of Canadian River, about 7 miles southwest of Raton, in Colfax County, N. Mex. The bed lies practically horizontal and has been prospected for a distance of several miles along the outcrop in the Canadian and its tributary canyons and traced laterally into the principal coal bed of the Raton field, which contains bituminous coking coal. Igneous material was forced into the coal-bearing sedimentary rocks in many places in this field and usually formed coke where it came into contact with the coal, but in the Canadian Canyon the intrusive mass took the form of many sills above, below, and in the coal bed and apparently heated the sedimentary rocks through a considerable thickness. The coal has been most completely graphitized where the bed was fractured and diabase forced into it. The graphite occurs in "pockets" or irregular masses in the diabase and is more or less columnar, the columns usually standing normal to the faces of the igneous rock. The columnar parts are relatively pure, but the noncolumnar parts seem to have resulted from what was originally bony coal or carbonaceous shale.

Analyses of this graphite were made by Andrew S. McCreath, of Harrisburg, Pa., who reported that it contains no sulphur or other material detrimental to its use in the manufacture of paint. To test the effect that weather might have on the paint, the graphite was subjected to caustic alkali and to strong acids, including aqua regia, but these produced so little effect that the graphite was pronounced satisfactory as a base for paint.

Two analyses of graphitic coal from this region were published years ago,[1] as follows:

Analyses of graphitic anthracite from the Raton coal field, New Mexico.

	Soft.	Hard.
Moisture	1.19	1.22
Volatile matter	4.37	5.45
Fixed carbon	76.07	71.79
Ash	18.37	21.54
Sulphur	.19	.17
Iron	.....	.63
Sulphur required for FeS_2	.....	.72
Sulphur±	.....	.55

The writer collected a sample of the graphite for analysis 160 feet from the mouth of an old opening, at a point where the bed was about 3 feet thick. In order to obtain a representative sample, the weathered material was cleared from the exposed face of the bed. The sample represents the entire thickness of the graphite at this point, and therefore the analysis shows a greater percentage of impurity than would be found in pieces selected from the best material. The sample was analyzed as coal in the laboratory of the United States Geological Survey at Pittsburgh. The analysis is given in the table that follows as No. 6521.

The unmetamorphosed coal of the bed containing the graphite is mined at Van Houten, a mining camp located 4 miles southwest of the graphite opening. For purposes of comparison with the graphite two analyses of this coal are given. The bed in the mine is 10 to 15 feet thick. In some places it carries very little impurity, but in others small amounts of shale and bony coal are encountered. The following section of the coal bed was measured in the mine where the samples were taken for analysis:

Section of coal bed in the Willow mine, Van Houten, N. Mex.

	Ft.	in.
Sandstone.		
Coal[2]	1	3
Bony coal		½
Coal[2]		6
Bony coal		4
Coal[2]	3	4
Bony coal		10
Coal		1½
Shale		3
Coal[3]	4	5
Shale.		
	11	1

[1] Potter, W. B., The character and composition of the lignite coals of Colorado: Trans. Am. Inst. Min. Eng., vol. 5, 1877, pp. 365–375.

[2] Represented by analysis No. 6417 of the following table.

[3] Represented by analysis No. 6418 of the following table.

Analyses of graphite and coal samples from the Raton coal field, New Mexico.

[F. M. Stanton, chemist in charge.]

Laboratory No.	Air-drying loss.	Condition of sample.	Proximate.				Ultimate.					Heat value.	
			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
6521	0.40	Graphite, as received	1.31	6.07	76.11	16.51	0.17	....	.....	....	.....	.....	.....
		Graphite, air-dried	.91	6.09	76.42	16.58	.17	....	.....	....	.....	.....	.....
		Graphite, moisture-free	....	6.15	77.12	16.73	.17	....	.....	....	.....	.....	.....
		Graphite, moisture and ash free.	....	7.39	92.61	.....	.20	....	.....	....	.....	.....	.....
6417	1.40	Coal, as received	2.42	33.69	54.42	9.47	.66	5.21	72.84	1.10	10.72	7,303	13,145
		Coal, air-dried	1.03	34.17	55.20	9.60	.67	5.12	73.87	1.12	9.62	7,407	13,333
		Coal, moisture-free	....	34.53	55.77	9.70	.68	5.06	74.65	1.13	8.78	7,484	13,471
		Coal, moisture and ash free	....	38.24	61.76	.....	.75	5.60	82.67	1.25	9.73	8,288	14,918
6418	1.50	Coal, as received	2.51	34.64	54.03	8.82	.76	5.50	73.65	1.20	10.07	7,404	13,327
		Coal, air-dried	1.03	35.17	54.85	8.95	.77	5.41	74.77	1.22	8.88	7,517	13,531
		Coal, moisture-free	....	35.53	55.42	9.05	.78	5.35	75.54	1.23	8.05	7,594	13,669
		Coal, moisture and ash free	....	39.07	60.93	.....	.86	5.88	83.06	1.35	8.85	8,350	15,030

Although the graphite was originally coal, as is clearly indicated by its position, its chemical character gives little indication of its origin, and it was somewhat surprising to find 6.07 per cent of "volatile matter" in it, a percentage considerably higher than that carried by some other graphites of similar origin. At the writer's request Dr. H. C. Porter made a chemical examination of this volatile matter, with the following results:

Analysis of volatile matter contained in the graphite of Raton coal field, New Mexico.

Twenty grams, as received, crushed to rice size, heated 20 minutes in atmosphere of nitrogen at 930°–950° C.

		1	2
Total loss (includes moisture 1.31 per cent)	per cent	5.6	6.0
Water (includes moisture 1.31 per cent)	do	4.22	4.23
Tar		Trace.	Trace.
Gas	liters per kilo	16.2	15.0
	cubic feet per ton	520	480
Composition of gas:			
CO_2	per cent	9.1	.....
Illuminants	do	3.1	.....
CO	do	9.3	.....
CH_4	do	19.5	.....
H_2	do	52.7	.....
N_2	do	6.3	.....

This material seems to retain its graphitic streak after heating at a high temperature, which would seem to indicate that it is a true graphite, as does also the fact that it is extremely difficult to burn. The volatile matter * * * is very largely water, which I should say is in the form of combined water or water of crystallization. This is indicated also by the decrepitation on heating.

The prospect from which this sample was taken was opened in 1889 by the Standard Graphite Co., of New York, and 250 tons of graphite was shipped from it to Moosic, Pa., where the ore was tested

as to its availability in the manufacture of paint. One of the objects of the company was to ascertain whether the graphite could be handled profitably, and careful accounts were kept. According to the statement of one member of the company it was ascertained that the graphite could be placed in the bins at Moosic for $17.50 a ton, the greater part of the cost being shipping charges. At Moosic, at an additional cost of 90 cents a ton, it was ground and separated from some of its impurities by means of air blasts. The refined product contained 80 per cent of carbon, the 20 per cent impurity being mostly silica, which was not regarded as objectionable in the manufacture of paint. The tests were satisfactory to the company, and the mill was being taken apart for shipment to Raton when it was destroyed by fire. Nothing has since been done toward developing the graphite.

MICA IN IDAHO, NEW MEXICO, AND COLORADO.

By DOUGLAS B. STERRETT.

INTRODUCTION.

The mica deposits described in this paper were briefly examined during the course of other work. The deposits in Idaho were visited in June, 1910; those in New Mexico in June, 1911; and the one in Colorado in July, 1911.

The mines examined in Idaho and New Mexico include some of the best mica deposits known in those States and some that are no more than prospects. An examination of the deposit of mica in Colorado was made in consequence of numerous requests for information regarding its possible value. Idaho and New Mexico have been large contributors to the production of sheet mica in the past. During the last few years, however, these States have produced little or no mica. Colorado has been more important as a producer of scrap mica.

Muscovite or white mica is the only variety mined in the United States, with the exception of a small quantity of biotite and lepidolite, the latter of which is used in the manufacture of lithia salts. In 1910 the production amounted to 2,476,190 pounds of sheet mica, valued at $283,832, and 4,065 tons of scrap mica, valued at $53,265. This output came chiefly from North Carolina, South Dakota, and New Hampshire. That there is a market for a far larger output of sheet mica is shown by the fact that 1,961,523 pounds, valued at $724,525, was imported and entered for consumption during the same year. The value of the imports of mica has for many years, with the exception of the year 1908, greatly exceeded that of the domestic production. The imports consist chiefly of large sheet mica and the softer phlogopite or "amber" mica, which is not found in deposits of commercial value in the United States.

In the mining of mica there is always a considerable yield of scrap, and the most desirable type of mine is that in which the output of good sheet mica is large. To work at a profit a deposit yielding scrap mica only it is essential that the mica be mined cheaply, for there is a limited market for scrap mica and a large part of the present production of about 4,000 tons a year is supplied by waste from mining

and trimming sheet mica. If such a deposit can not be made to pay a sufficient profit with a production of a few hundred tons of scrap mica annually, and a guaranteed market is not secured for a larger output, it will be an investment of doubtful value.

The principal use for mica 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 use in glazing, principally in stoves. This is now one of the less important uses. The value of good sheet mica that is suitable for glazing is greater 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 much electric work. Waste and scrap mica when ground have a wide application in the manufacture of wall paper, lubricants, and electric insulating material.

OCCURRENCE OF MICA.

Mica deposits of commercial value in the United States are confined to pegmatites. In these rocks 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 plagioclase, in the form of albite or oligoclase, is present in some pegmatites, and locally plagioclase is the predominant feldspar. Pegmatite is therefore allied to granite in composition but is distinguished from it by having a coarser texture. Pegmatite also presents greater variations in texture and composition than granite. The texture ranges from the coarsely granular to that in which the individual minerals occur in crystals or masses several feet across. These masses may be very irregular in shape or arranged in sheets, in places parallel with the walls. The proportions of the constituent minerals are rather variable. In some pegmatites the quantity of feldspar present is several times greater than that of the quartz and other minerals; in others quartz is the principal constituent and may compose more than four-fifths of the mass. Here and there over half of the pegmatite is composed of mica.

Pegmatite bodies are of various shapes. Some are rather persistent in length and form dikelike or veinlike sheets that can be traced for several hundred yards. Others are lenticular and occur either in long, slender bodies or in short, thick masses, some of which are nearly round. 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. Pegmatites range in thickness from less than an inch to many yards.

Mica-bearing pegmatites in the United States have been found in areas of metamorphic crystalline rocks of pre-Cambrian age. Some of these rocks are gneisses and schists in which the predominating constituent is muscovite or biotite mica, garnet, cyanite, staurolite, or hornblende. These rocks have been much folded, faulted, mashed, and recrystallized in most areas where they are exposed and some have been intruded by later granite and other igneous rocks. The pegmatites owe their origin to the intrusion of masses of granite into the gneisses and schists and in some places probably to the metamorphic processes that produced those rocks. They are common associates of granite masses and cut other rocks surrounding the granite. They represent the later phases of activity of the granite magmas and were probably given off as magmas, solutions, and emanations and introduced into the surrounding rocks as dikes and veins. It is not generally possible to state whether a pegmatite body is a dike or a vein, as the characters of these forms, like their modes of origin, grade into each other.

MICA IN LATAH COUNTY, IDAHO.

Deposits of mica have been found in several counties in Idaho, and some of them have been developed on a large scale. The deposits described below are in Latah County and lie in a north-south belt about 2 miles wide and several miles long. The mines and prospects examined are in T. 41 N., R. 2 W., from 3 to 6 miles north of Avon. They lie at elevations of 3,400 to 4,700 feet above sea level, along the top and to the west of a high mountain ridge extending south from the Thatuna Hills. The principal properties are the Muscovite claim of Alexander Munro, about 5 miles north of Avon, in sec. 22; the Levi Anderson mine, about 4 miles north of Avon, in secs. 22 and 27; the Maybe mine of Alexander Munro, about 1 mile southwest of the Muscovite claim, in sec. 22; and the Luella mine of the Western Mica Co., about 1½ miles southwest of the Muscovite, in sec. 21. Other claims are owned by Alexander Munro and David Peterson, in sec. 15. In order from south to north along the ridge the mines are the Levi Anderson claim, the Muscovite, Atlas, Violet, and Morning Star claims of Alexander Munro, and the Sunshine claim of David Peterson. The Maybe and Luella mines are in the valley to the west of this ridge. The location of the different deposits is given in figure 49. At the time of the writer's visit the Muscovite was the only mine in operation; it had been idle a few years and was being cleaned out preparatory to mining. The elevations given were determined by barometric measurement.

The mica deposits occur in an area of highly schistose metamorphic rocks of pre-Cambrian age. Muscovite and biotite schists and gneiss, in which quartz is generally a prominent constituent, are the principal rock types of the region. Locally certain bands of the gneiss

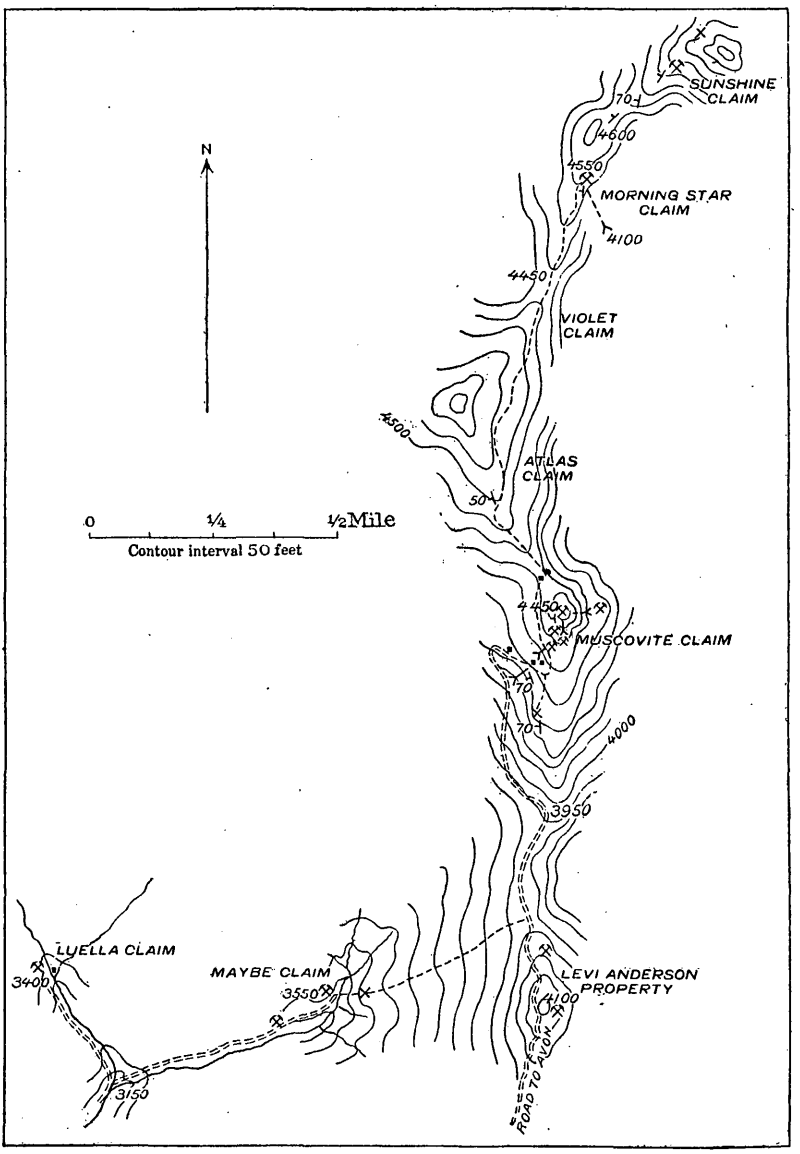

FIGURE 49.—Map showing mica deposits in Latah County, Idaho.

have an abundant development of black tourmaline crystals, especially near large pegmatite bodies. The gneisses and schists of this region strike roughly north and south, and the dips range from 50° W. to vertical. Masses of pegmatite cut the gneiss and schist and are

in many places entirely conformable with the schistosity and in others only in part or not at all. Some of the pegmatite bodies outcrop continuously for distances of several hundred yards, with few variations in thickness or direction. Others have smaller outcrops. A bulging or swelling of the pegmatite bodies into chimney-like deposits also occurs and in some places is associated with rich deposits of mica. The gneisses and schists apparently contain more pegmatite in the valley to the west of the high mountain ridge than in the ridge itself. It is asserted by the miners that the deposits along the top of the mountain are on the same ledge of pegmatite. This may be true, but it has not been proved. There may be separate sheets of pegmatite that do not connect, though nearly in line or overlapping one another. Even if a single pegmatite body should prove so persistent as to extend over several claims, the mica content is variable and in places the rock contains none.

The rocks have been deformed, but the larger folds are not easily distinguished in the small area under consideration. Small folds whose dimensions can be measured in feet and with schistosity turned across the bedding were observed in a few places. In general the strike and dip are rather regular for a region of tilted metamorphic rocks.

The Levi Anderson mine is in a low, rounded knob on the ridge, at an elevation of nearly 4,100 feet. The main opening is on the east side near the top, and a second opening has been made about 200 yards to the north at a lower level. The main working consists of an open cut about 20 feet wide, 30 feet long, and 15 feet deep, with short tunnels to the north and to the south and an incline from the bottom. The workings have fallen in badly. As exposed in the open cut the pegmatite is about 20 feet wide and approximately conformable with the inclosing rock. The country rock is mica schist and gneiss, with a strike of N. 10° W. and a dip of 60° W. The pegmatite carries a large amount of quartz with some black tourmaline and beryl crystals. Only small-sized crystals and sheets of mica were observed around the mine; mica in sheets of valuable size was seen in the possession of Mr. Anderson at Spokane. At the other working a shaft was sunk on a pegmatite ledge. Only small mica was left around this opening also. Part of the muscovite had biotite associated and intergrown with it.

The Muscovite mine was first worked in 1888 by Woody & Lamb. After that it was operated intermittently, the last work being done by the Muscovite Mica Co., of Spokane. The mine then passed into the hands of Alexander Munro, of Moscow, Idaho. The "vein" in the Muscovite mine cuts through the apex of a sharp knob whose elevation is 4,450 feet. The position of the different workings is shown in figure 50. An open cut with a shaft has been made on the

outcrop at the apex and other open cuts with drifts and a 60-foot shaft to the south on the hillside. The principal work was done from two crosscut tunnels with drifts and stopes at the ends. One

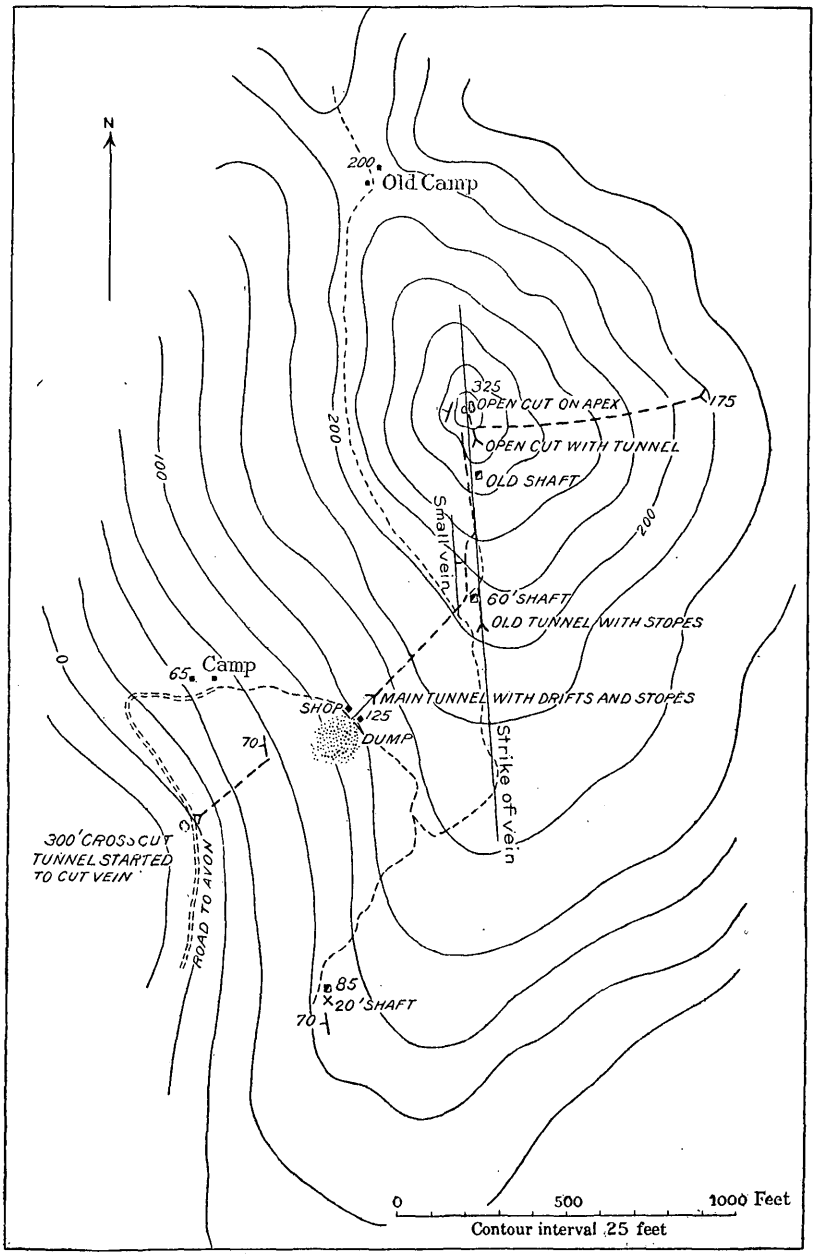

FIGURE 50.—Map showing position of workings on Muscovite mica claim of Alexander Munro, Latah County, Idaho.

of these tunnels was 150 feet lower than the apex and on the east side of the hill; the other was on the southwest side of the knob and 200 feet lower than the apex, and in June, 1910, this was the only part

of the mine open for examination. Another crosscut tunnel was started still farther down, about 325 feet below the apex; this has been driven about half of the 600 feet necessary to reach the "vein." Other test pits have been made nearly a quarter of a mile south of the apex, on a pegmatite outcrop, which may or may not be the same "vein." The tunnel open for examination had been driven some 200 feet to the "vein." Over 300 feet of drifts, with a large amount of stoping above them, were then carried to the north. At the junction of the tunnel and the drift at this level a room for a turntable had been made during previous operations. The timbers of the roof over this turntable and of the stopes in places farther along had given way, so that in order to reach the better part of the mine it was necessary to drive a new tunnel alongside of the main original drift. The 60-foot shaft formerly connected with the drift at the end of the crosscut tunnel. A short crosscut tunnel to the west of the new drift cut a pegmatite "vein," from 12 to 18 inches thick, in which small blocks of good mica and some beryl crystals were found.

The main pegmatite "vein" ranges in thickness from 4 to 6 feet in the main original drift and the stopes above and widens out to 12 feet thick at the end of the drift, where the vein includes a horse of gneiss several feet across. There was a large showing of mica "books," some of good size, in the end of the tunnel and at two places seen in the stopes above. It is said that the best mica in sight was removed when mining was stopped, though even then the "vein" contained sufficient mica to be termed rich. In the open cut at the apex the pegmatite mass encountered appears to be nearly 40 feet thick. The pegmatite at this point and to the side of the open cut carries considerable quartz. A portion that had not been mined still contains numerous blocks of fair-sized mica on the outcrop.

The country rock is strongly foliated muscovite-biotite gneiss. It has a strike of N. 10° W. to N. 10° E. and dips about 70° W. The pegmatite is conformable, or nearly so, with the gneiss. The course of the pegmatite is fairly regular, but a few minor deformations were encountered in the workings. Evidently the outcrop at the apex represents a large bulge or swelling of the pegmatite. The increasing thickness of the pegmatite in the end of the drift 200 feet lower than the apex indicates a continued thickness with depth. This drift probably does not lack more than 60 or 70 feet of being under the apex. This chimney or shoot of pegmatite outcropping at the apex is considered to be the richest part of the "vein." In the tunnel on the east, 150 feet lower than the apex, a large vein very rich in mica is reported to have been encountered. A peculiar feature of the "vein" is the small amount of quartz and feldspar it contains at a distance from the apex chimney. In the chimney the quartz and feldspar are plentiful and the pegmatite is more nearly normal in

composition. The production of mica from this mine has been large. No records have been kept, but Mr. Munro estimates that during two periods of operation in the past at least $40,000 worth of mica was taken out each time. The quality of the sheet mica from the Muscovite is very good, the color being light "rum" and the sheets clear. It is probable that the proportion of good sheet mica obtained from an average lot of books would not equal that of some of the better mines in other parts of the country, though there are probably few mines that will yield so abundantly from an equal amount of vein matter as the Muscovite mine.

The two claims taken up by Alexander Munro extending to the north from the Muscovite are intended to cover the outcrop, if any exists, of the pegmatite between the Muscovite and the Morning Star. On the latter claim the pegmatite outcrops strongly for some distance along the east side of the ridge. The hill slope below is steep, almost cliff-like in places. The pegmatite is about 20 feet thick and incloses a horse of gneiss, or there are two ledges of pegmatite separated by a sheet of gneiss. The ledge is conformable with the mica schist country rock and strikes east of north with a dip of about 60° W. Both the schist and the pegmatite contain black tourmaline. The amount of mica exposed in the outcrop of this ledge is small. About 450 feet lower a crosscut tunnel was started on the east side of the ridge and driven 660 feet under the outcrop. The dip of the pegmatite carries it still farther west and the tunnel will probably have to be carried about 90 feet farther. The rocks through which the tunnel cuts are muscovite and biotite schist and gneiss, with a slight banding in places across the foliation. The schistosity strikes east of north and dips 50°–70° W.

The Sunshine claim adjoins the Morning Star on the north. The pegmatite ledge outcrops strongly on the hillside and is probably the same ledge as that opened on the Morning Star. An open cut 20 feet long and 10 feet deep has been made in the hillside on a pegmatite body striking east of north with a dip of 50° W. It is conformable with the inclosing gneiss. Very little mica was found in this cut. The pegmatite carries tourmaline and also garnets larger than walnuts. It is said that a better showing for mica was found in a prospect opened about 200 yards to the north over the hill.

The Maybe mine, sometimes called the Silver White mine, is in a steep hillside in the bend of a stream. Several tunnels have been run into the hill and a few pits and other openings made, but these have caved in so badly that little could be seen. Either there are two or more ledges of pegmatite, or a single ledge is folded and lies somewhat like a blanket on the hillside. In one of the openings the mica schist country rock has a strike of N. 55° W., about parallel with the contour of the hill at that point. The pegmatite carries considerable tourmaline and some garnets up to walnut size. The

mica is clear and of a very light color, inclining to "rum." Judged by the waste mica left around the mine the sheets are of good quality and split well.

On the hillside, across the small stream to the east of the Maybe mine, several prospects for mica have been operated. This work is old, though the indications for mica are good. A few hundred yards southwest of the Maybe mine, near the corner of the claim, another pegmatite body was prospected for mica. A very good deposit of mica was found in the open cut, but a tunnel started 15 feet lower down very quickly lost the main "vein" and followed a stringer for nearly 300 feet.

The Luella mine was opened by a crosscut tunnel, run in a southwest direction, and an open cut on the outcrop above it. Evidently a large pegmatite deposit was found and much of it stoped out. Only small mica, though of good quality, was left around the mine. The pegmatite blocks on the dump contain black tourmaline and pink garnets, some of which are embedded in mica crystals. The country rocks are muscovite and biotite schist and gneiss. Blocks of fine-banded tourmaline-quartz rock, associated with the schists, were left on the dump.

A prospect was opened for mica on the roadside, at an elevation of 3,800 feet above sea level, on the spur of the mountain ridge, about half a mile south of the Levi Anderson claim. Little could be seen of the formation encountered or mica found.

The operation of mines in this region is facilitated by an abundant supply of good timber. Part of this timber is included in the claims and part is either on State land or in the Cœur d'Alene National Forest. On the mountains the important trees are tamarack or larch and red fir; in the valleys there are good stands of white pine, red pine, tamarack, red fir, and cedar. The rocks are not hard to drill, and Mr. Munro states that in some of the mines tunnels can be driven at the rate of 3 feet a day without power drills. The shipping point for the mines is Avon, on the Washington, Idaho & Montana Railway.

MICA IN RIO ARRIBA COUNTY, N. MEX.

The mica deposits described below are but a few of a large number that have been located in Rio Arriba County, N. Mex. Many of the deposits of this region were mentioned in a report by Holmes,[1] who gave brief descriptions of some of them. Notes for the accompanying descriptions were obtained during a very brief visit at a time when none of the deposits were in operation. Through the kindness of Mr. Moritz Leichtle, of Petaca, N. Mex., the few examinations made were possible.

[1] Holmes, J. A., Mica deposits in the United States: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 6, continued, 1899, pp. 706–707.

Deposits of mica have been found in other parts of New Mexico. One of these, in the Glorieta Mountains, was worked during 1909 by the Anderson Mica Co., of Topeka, Kans. The shipping point for this mine was Ribera, about 10 miles to the south, on the main line of the Santa Fe Railway. Other mica deposits are reported in Taos County.

Rio Arriba County lies west of the central part of northern New Mexico. The eastern part of the county, in which the mica region is situated, is composed of broken mountain country merging into partly dissected table-land. The mountains are a continuation of the San Juan Mountains of Colorado. The mica deposits lie at elevations ranging from 6,500 feet to over 8,000 feet, chiefly in the mountain country. The region is drained by the tributaries of Caliente River, some of which are dry during part of the year. The region is a semi-desert at the lower elevations but better watered and forested with pine in the higher parts. The mica deposits outcrop in two or more groups in a roughly north-south direction and are from 8 to 15 miles west of the Denver & Rio Grande narrow-gage tracks between Santa Fe, N. Mex., and Alamosa, Colo. Railroad stations that would serve as shipping points for the different mica deposits are Servilleta and Barranca. Petaca, a small settlement, chiefly of Mexicans, near the larger group of deposits, is about 9 miles by road southwest of Servilleta.

The mica mines examined were the Cribben or Cribbenville mine, about 2 miles southwest of Petaca; the American, about three-fourths of a mile S. 75° W. of Petaca; the Globe, about 5 miles south-southwest of Petaca and 12 miles north of west of Barranca; and the Antonio Joseph, 2 miles north of Ojo Caliente and 14 miles southwest of Barranca. All the mines but that near Ojo Caliente are within the area of the Jemez National Forest. The elevations at several points in the mica region, determined by barometer, are: Petaca, 7,500 feet above sea level; camp at Cribbenville mine, 7,800 feet, highest working, 8,000 feet; American mine, 7,750 feet; Globe mine, 7,650 feet; Joseph mine, 6,900 feet; Ojo Caliente, 6,500 feet.

The mica deposits of New Mexico yield some sheet mica of fairly good quality and merchantable size. As usual with mica mines, a large proportion of the output is scrap mica, suitable only for punching into disks or cutting into small sheets and grinding. At some of the mines the principal value lies in this scrap mica. With several of the better mines in active operation, New Mexico would occupy a prominent place among the mica-producing States. By establishing cutting or trimming plants and grinding mills, either in the mica region or at a convenient point on the railroad, the mining industry would be stimulated by a more convenient market and advantage could be taken of the low-priced labor offered in that section. Mr. Leichtle states that miners get from $1.25 to $1.50 a day of eight hours and blacksmiths

$2. It is probable that much of the trimming and splitting of mica could be done by girls and women, and most of such labor would be supplied by Mexicans.

The description of the Cribbenville mine by Holmes gives a good idea of the extent of the work when the mine was in operation. It is here quoted:

> At the Cribben mine, the best known of them all, a considerable amount of work was done between 1884 and 1889, and on a smaller scale since that time. Openings were made on the property at several different locations—(1) the I Excell tunnel, 300 feet long; (2) San Carlos tunnel, 40 feet long, where there are also stopes and drifts under the crest of the hill; (3) an open cut of 100 feet long and a tunnel 40 feet long, near the San Carlos; (4) El Capitan tunnel, shaft, and open cut, some 1,000 or 1,200 feet northwest of Nos. 2 and 3; (5) Columbia tunnel, 40 feet long, with an open cut of 40 feet, in a dike 50 feet thick, located some 200 or 300 yards east of the San Carlos; (6) the Rafugea tunnel, 20 feet long, and open cut, 30 feet long, located some 200 feet east of the last. The larger part of the work at the Cribben mine was done and most of the mica was obtained from the San Carlos and El Capitan openings, and it is in these also that there is the greatest promise of successful future operations. The mica from these openings is all of fairly good quality, generally free from specks, though in places badly ruled.

The several workings described by Holmes are not now readily recognized, as many of them have fallen in badly. The I Excell tunnel is blocked by a cave-in. The San Carlos workings are still open, in part at least, and mica can be obtained by continuing the stopes. The El Capitan workings are nearly all closed. Mr. Leichtle states that the rich deposit of mica encountered in these workings was mined out. A quantity of mica that would yield scrap and small sheet remained around the workings.

The principal work during the last few years has been concentrated on a deposit in a hill about 100 yards southwest of the camp and about 100 feet higher. A tunnel has been started in the hillside toward the "vein" and a shaft 25 feet deep and 12 feet across sunk near the summit of the hill. Massive coarse pegmatite, with feldspar crystals 2 to 3 feet across, was encountered. The principal yield of mica appears to come from a mica-bearing streak about 8 feet across, with a north-south strike and west dip, included in the main mass of the pegmatite. The mica is more plentiful along the sides of this streak, especially in shoots with a pitch to the south. Rough crystals of mica 12 inches across were seen in the shoots and larger ones are reported to have been found. The quality of the mica is fair, and good sheets can be cut from many of the crystals. The thick sheets have a greenish color.

The mine is now owned by the New Mexico Mutual Mining Co., with an office in Milwaukee, Wis. Mr. Leichtle, who owns an interest in the mine, is in charge. But little more than assessment work has been done for several years, and only small shipments of sheet mica

have been made during this time. Two or three hundred tons of scrap mica have accumulated on the dumps and in the storehouses. Small sheet mica could be cut from some of the scrap.

Holmes mentions the following other mines:

> Several other claims have been prospected recently near the Cribben, notably that of the Old Judge claim, probably one-half mile to the north.
>
> The Buckshot and Mica Producer claims, some 3 miles south of the Cribben, and the Petaca, Coyote, The Gulch, Bachelder No. 1, Bachelder No. 2, Summit, Keystone, Mica King, Fleming, Bobtail, and Young America, extending north of the Cribben for some 4 or 5 miles, have been opened up for mica to a small but varying extent and some of them are promising prospects. All yield mica of good quality, except that in many places it is badly ruled. The Old Black Horse (Sandoval or Kentucky) mine, some 3 or 4 miles northwest of the Cribben and on the slope of the canyon, is, next to the Cribben, the best-known and most extensively worked mine in the district, and it may be expected to yield in the future considerable quantities of good mica. The Highland mine, on top of a hill above the Sandoval, and the California, a short distance to the east of the Highland, have both yielded considerable quantities of mica of good quality and can be counted on for further developments in this direction.

Whether the names given include any of the deposits described below was not ascertained. It is possible that the names of some of the claims were changed when the claims changed hands.

The American Mica mine, formerly owned by the American Mica Mining Co., is now reported to have become the property of Moritz Leichtle. The mine is on the brow of a hill facing east. It was first opened by irregular stoping from the surface to a depth of 25 feet and for some 40 feet along the vein. Later a tunnel about 200 feet long and 40 feet lower than the outcrop was run into the hillside to the south of the workings and an air shaft raised to the stopes.

The country rock at the mine is fine-grained gneiss, apparently coarser grained near the pegmatite. The pegmatite as exposed in the workings has a north-south strike and a dip of 20° W. The tunnel cuts through more than 30 feet of pegmatite, which, allowance being made for dip, would give a thickness of over 10 feet. In texture the pegmatite varies from moderately coarse rock to some that is very coarse, with feldspar crystals up to 2 feet thick. In the tunnel the mica was found to be more plentiful near the footwall of the pegmatite, but some occurs in the interior of the mass. The crystals of mica range from those of small size up to one measuring 15 inches in diameter. They are irregularly distributed in the vein zone but are fairly numerous. Some mica crystals occur in pockets or bunches and others in streaks in the pegmatite. The greater part of the mica from the upper workings is suitable for grinding only. It is nearly all small and occurs in mashed lenticular pieces up to 2 or 3 inches across. This mica has been partly hydrated and has a soapy feel. It occurs in a vein 3 to 6 feet thick, with a few irregularities, in the

pegmatite. It can be obtained easily in large quantities and has been shipped to Denver for grinding.

The Globe Mica mine has been opened by three shafts—35, 30, and 25 feet deep—with drifts from them on the vein. The 30-foot shaft is about 200 feet S. 75° E. of the 35-foot shaft, and the 25-foot shaft is about 50 feet farther away in the same direction. The 35-foot shaft has been equipped with a hoist, an air drill, and two 25-horsepower gasoline engines. From the bottom of the shaft a drift was run 12 feet to the east and another 30 feet to the west. At the end of the west drift a crosscut tunnel has been carried 16 feet to the south. The drifts are 6 to 8 feet wide and about 15 feet high, so that they might be called small stopes.

The country rock is quartz-muscovite schist with a variable northwest strike and a prevailing dip of about 25° SW. The schist has minor folds and crumplings that are visible in the mine workings, as well as larger similar regional structures. The pegmatite cuts the schist with a strike of N. 75° W. and a vertical or high north dip. The thickness of the pegmatite is not exposed but is at least 30 feet near the main workings. From the 35-foot shaft an irregular mica streak from 3 to 8 feet thick was followed in the drifts. This streak lies near the north wall of the pegmatite and has an irregular dip of 85° N. The quartz-muscovite schist wall rock is exposed in places in the drifts. The crosscut tunnel from the end of the west drift follows a branch streak of mica. In parts of the main mica streak the mica crystals are plentiful and form nearly solid masses 2 or 3 feet across. Blocks of mica nearly 2 feet in diameter were seen in the vein, but most of the mica is badly ruled and broken, so that only a small proportion of it would be serviceable for cutting into sheets. The feldspar occurs in large masses and crystals and consists of both pink microcline and white albite. Some of the feldspar masses measure 10 feet across. The pink microcline occurs in the largest crystals. The mica streak is separated from the north wall of the pegmatite by an irregular sheet of massive feldspar. Irregular masses and sheets of quartz occur on the south side of the mica streak in massive feldspar.

In the 30-foot and 25-foot shafts relations similar to those in the main workings were found. A mica streak 2 to 4 feet thick, with a high north dip, occurs in massive feldspar. Quartz segregations, some of them 3 or 4 feet thick, lie along the south side of the mica streak. The mica encountered is of about the same quality as that of the main workings.

A 20-foot shaft has been sunk on a mica vein one-fourth mile north of the Globe, on the Peacock claim. The name chosen for this claim is an allusion to the iridescent tarnish on seams of limonite found in

the workings. A mica streak 1½ to 3 feet thick was exposed in the shaft. Nearly all the mica is small, and some of the crystals are bunched together in nearly solid masses.

Two prospects for mica, opened by Antonio Joseph, are in the foothills of the mountains west of Caliente River. One of them is in the walls of a gulch about 1½ miles north of Ojo Caliente and half a mile west of the river. It has been opened by prospects on each side of the gulch. The other prospect, which is the more promising, is about half a mile northwest of this one, in the east end of a ridge between two draws tributary to the same gulch. Here several openings have been made in the hillside on the spur of the ridge and on the south side. The larger opening is a cut 15 feet long, with an 18-foot tunnel from it and a 12-foot shaft at the end of the tunnel.

The country rock of the region is complex and consists of mica, cyanite, quartz, garnet, and hornblende schist and gneiss, with granite, pegmatite, and basalt. The schist and gneiss have been much folded and have received smaller flexures crossing the axes of larger folds. The general strike near the mica deposits is N. 45°–60° E., with a vertical to west dip, but large variations from this attitude occur. Pegmatite is common in the gneiss and schist of this region.

At the best prospect a mass of pegmatite at least 100 feet wide outcrops across the end of the ridge, with a probable northeast strike. This pegmatite has the usual variations of composition and texture, part containing feldspar and quartz, with or without mica, in granular mixtures and part containing segregations of these minerals. The feldspar is of gray and pink to red colors and is chiefly the potassium variety. The mica occurs in pockets and streaks up to 20 feet thick in the pegmatite. The streaks have an approximate northeast strike and are richer in mica in some parts than in others. A large quantity of mica is exposed in the main working. Most of it is in small crystals, but some crystals 12 to 18 inches across and 4 to 12 inches thick were seen. Nearly all were so badly crushed and cut by "ruling" and irregular fractures that only small perfect sheets, not over 2 to 3 inches across, could be obtained from them. The principal values in mica from this deposit would be in material for grinding and small sheets. The mica has a greenish color in sheets one-sixteenth of an inch or more thick and some of it contains magnetite specks. From 50 to 100 tons of scrap and small sheet mica have accumulated on the dumps.

At the other locality a pegmatite mass 8 to 15 feet thick outcrops on each side of the gulch, with a strike of N. 40° E. and a nearly vertical dip. This pegmatite contains streaks of mica gneiss from 1 inch to 2 feet thick. The mica crystals are more plentiful near these inclusions. Only small mica crystals, 1 to 4 inches across, were seen and many of these were crushed and "ruled" into small pieces.

MICA IN MESA COUNTY, COLO.

A deposit of mica was located some 15 to 18 years ago in Ladder Canyon, Mesa County, 8 miles south of Grand Junction, Colo. The discovery is said to have been made by Benton Cannon, but the prospect is now held by S. A. Grady, of Grand Junction. The locality is at present reached by trail only, though a road was once made up the canyon within half a mile of it. The trail leaves the Grand Junction road and enters the canyon about a mile north of the prospect. This part of Ladder Canyon is from 200 to 300 feet deep.

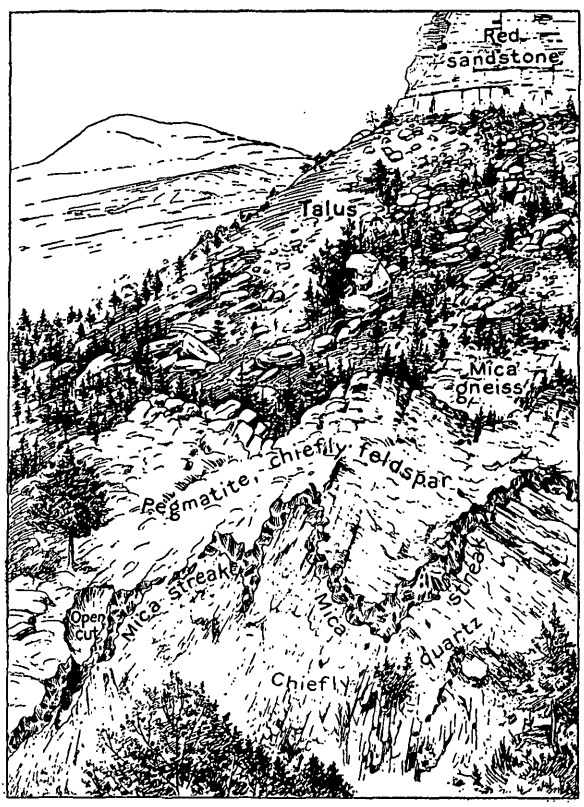

FIGURE 51.—Outcrop of irregular streak of mica between quartz and feldspar, S. A. Grady claim, Mesa County, Colo.

The development consists of a short tunnel about 10 feet long and an open cut about 25 feet long in the side of the canyon. The deposit occurs in a dome of pre-Cambrian rocks exposed in the bottom and lower walls of the canyon. Red sandstone, probably of Carboniferous age, overlies the dome and forms the country rock of the region, even outcropping in the bottom of the canyon one-third of a mile farther north. Near the mica prospect the older rocks outcrop to a height of 100 feet in the canyon walls. They consist of

biotite and muscovite schist and gneiss cut by pegmatite. The pegmatite is over 200 feet wide in the bottom of the canyon and is thinner at the top of the exposure. Apparently it is at the top of an anticline whose axis strikes nearly east and west. The main anticline has smaller folds upon it and the pegmatite exhibits these irregularities. The minerals of the pegmatite are segregated in large masses. The feldspar is chiefly the potassium variety and has a pinkish or flesh color. It occurs in an irregular mass or streak over 10 feet thick in the interior of the pegmatite and grades into material containing considerable quartz or with the composition of ordinary pegmatite. A large segregation of massive quartz, the thickness of which is not exposed, lies below the feldspar mass, and more massive quartz overlies it. A few blocks of translucent rose-colored quartz were observed in the bottom of the canyon, but the quartz is too pale for use as gem material. The upper part of the pegmatite outcrop is concealed by talus from the overlying red sandstone.

The mica occurs principally along the contact between the feldspar and quartz masses, where it forms an almost continuous streak across the face of the pegmatite outcrop. (See fig. 51.) The mica streak ranges from 1 to 3 feet in thickness and is composed of nearly solid masses of mica crystals. These range from less than 1 inch to over 1 foot in length and are more commonly arranged in tufts and radiating groups. In places quartz, feldspar, and black tourmaline are associated with the mica. Rosettes of radiated mica crystals cover the south wall of the open cut for a space 12 feet long by 8 feet high. The exposure here gives an impression of a very thick mica streak, but an examination shows that the cut has opened the "vein" along its wall. The full thickness of the streak of mica is not exposed but is probably 3 feet or more. The mica crystals are much "ruled" and broken and nearly all have either the "A," "wedge," or "herring-bone" structure. It is probable that the entire yield of mica from this deposit will be suitable for grinding only, and that little if any mica valuable for cutting into sheets will be obtained. The quantity of scrap mica for grinding that can be mined near the surface is considerable.

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The following list includes a number of papers, published by the United States Geological Survey or by members of its staff, dealing with various nonmetallic mineral products. The Government publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States 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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