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THE R AND S MOLYBDENUM MINE, TOAS COUNTY, NEW MEXICO.

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While engaged in geologic reconnaissance in the southern part of the San Luis Valley for the United States Geological Survey under the direction of Whitman Cross during the fall of 1919, and incidental to this work the authors visited the interesting molybdenum mine near Questa in the north part of New Mexico. The following brief description of the mine and its geology is a result of this visit. Only one day was devoted to the area, and for this reason it was not found possible to study all of the important details and many problems concerning the origin of the ore remain unsolved.

LOCATION AND TOPOGRAPHY.

The R and S molybdenum mine is located in the western part of the Culebra Range in Toas County, New Mexico, on Sulphur Gulch, a northern branch of Red River, a stream that flows in a westerly direction until it empties into the Rio Grande. It lies about 8 miles up the river from Questa, N. Mex., and about 27 miles from Jarosa, Colo., on the San Luis Southern Railway. The mine lies at an elevation of about 8,700 feet above the sea level. The topography is sharp and near the mine the slopes on either side of Sulphur Gulch form almost shear cliffs. The streams have steep grades and erosion is proceeding at a rapid rate in the soft, altered rocks.

HISTORY.

The yellow molybdic ocher that formed as an alteration product at the outcrop of the veins was long regarded as sulphur and gave

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the name to the gulch on which the mine is situated. About the time of the entry of the United States into the war it was realized that the black substance associated with the "sulphur" was not "graphite" but molybdenite, and the Western Molybdenum Company of La Jara, Colorado, was organized to develop the prospect. No systematic development work was done by this company and no ore was produced. In November, 1918, the R and S Molybdenum Company of Denver was formed and took over seven claims from the Western Molybdenum Company and the new company has filed additional claims to increase the total holdings to about 300 acres. Development work was prosecuted throughout the winter, production began in the spring and was continuing at the time of the visit.

EQUIPMENT AND DEVELOPMENT.

The buildings at the mine were an office, bunk house, ore sorting shed, and a blacksmith shop. The company has built a mile of good road to connect the mine with the main road on Red River. A remodeled gold mill operated by water power, situated five miles from the mine, is being used at the present time, involving a haul of ore by auto truck. The equipment at the mill consists of a jaw crusher, ball mill, classifier, and flotation plant.

A tunnel has been driven for 300 feet along one of the southernmost of the group of veins exposed on the property, and in places this has been stoped to a height of 60 feet. Only enough ore has been withdrawn to allow the work to proceed and considerable broken ore was still in the mine in September. The ore as it comes from the stopes is said to average about 2 per cent of MoS_2. This material is run over the grizzly and the fines go directly to the ore bins. The coarse material is hand sorted and the tenor of the ore raised to about 4 per cent. Concentrates run from 80 to 91 per cent. MoS_2 and no trouble is experienced in producing 90 per cent. concentrates. The concentrates are said to be low in copper and phosphorus.

GEOLOGY.

The rocks of the region are a soda-potash alaskite porphyry in which the ore occurs, a dark gray granodiorite porphyry, and volcanic tuffs and flows.

The alaskite porphyry at the mine is a pale flesh pink rock of medium grain having phenocrysts with a maximum diameter of about 4 mm. The following is the approximate mineral composition:

Quartz	32.00
Orthoclase	20.00
Albite	47.00
Magnetite	0.50
Chlorite	0.20

Insignificant amounts of apatite and zircon were observed. This is a rather unusual granite in that felsic minerals form fully 99 per cent. of the rock mass, and since it is composed almost entirely of quartz and alkalic feldspars it should be classified as an alaskite. The orthoclase occurs in large anhedral grains, and contains a few lenses of microperthitic albite. The albite occurs in euhedral gains and has approximately the composition $Ab_{88}An_{12}$. Both feldspars contain many flakes of secondary mica and chlorite, the latter of which is especially abundant near the magnetite grains. Secondary calcite and pyrite occur in tiny veinlets which were evidently introduced after the final crystallization of the rock. Another specimen of alaskite collected at the mine has approximately the same mineral composition given above, but it is composed of phenocrysts of partially resorbed quartz, orthoclase and albite in a fine-grained ground mass of microperthitic quartz and albite. This alaskite appears to form a considerable body as similar rock, with somewhat larger phenocrysts and more and fresher biotite forms the lower canyon of Red River.

In general the alaskite of the area is only moderately altered to sericite even in the immediate vicinity of the system of veins, but one-fourth mile up the gulch there is a large area of alaskite more than a mile across which is decomposed to a soft easily eroded rock. The water of the north branch of the creek which crosses this area is highly impregnated with alum and iron sulphates.

The dark gray granodiorite porphyry occurs in large masses which appear to be included near the top of the alaskite, and it is clearly intruded by the alaskite. This rock is everywhere considerably altered. It is made up about half of stout crystals of plagioclase about a millimeter in length that are now changed to albite with much sericite, imbedded in a finer grained matrix of quartz and orthoclase. There is considerable chlorite and sulphides. Silicification has occurred throughout the rock and small bands are present where all the minerals composing it have been changed to a mass of interlocking quartz grains. Veinlets of calcite and pyrite are even more common than in the alaskite.

The alaskite and the granodiorite are overlain by volcanic tuffs and flows, which are much altered to sericite where seen. They were mostly rocks with large quartz and feldspar phenocrysts, probably quartz latite and andesite. The rapid erosion in these sericitized areas has exposed large patches of white and iron-stained rock that can be seen on the mountain sides for many miles.

VEINS.

The alaskite has been sheeted for about a thousand feet in a north south direction along Sulphur Gulch and this sheeting is said to extend for several thousand feet in an east–west direction. There are a number of main fractures which are approximately parallel and strike about N. 79° W. The veins are all the result of mineralization along these fracture and shear zones. The larger ones follow the main shear zones, but smaller veins and flats branch, intersect, and reunite forming a very complex network. Yellow molybdic ocher makes the outcrop of the veins conspicuous and easily traced. Development work has been confined almost entirely to one vein near the southern border of the group, but its surface indications were no more promising than those of several other veins. In the 300-foot tunnel the mineralized zone has been rather constant in its characteristics, varying in width from 4 to 6 feet. The ore zone is shattered and sheeted alaskite with the ore filling the fracture. Small veins and films of ore penetrate the wall rock but there is almost no replacement of the alaskite and so very little molybdenite is found disseminated in it.

The large persistent veins do not appear to extend far into the granodiorite porphyry, although small veins and stringers of ore are common in that rock. This is at least partly due to the fact that the granodiorite is closely fractured resulting in a greater dissemination of the ore-bearing solutions entering it. No mineralization of the volcanic rocks of the region was observed.

In general mineralized shear zones do not result in ore bodies that are remarkable for their persistence. In the R and S mine, however, one vein at least has been rather uniform throughout the 300 feet of its development, but in spite of this it seems doubtful if single ore shoots can be expected to continue for long distances. It seems likely that there will be more or less lenticular ore bodies that will pinch out, possibly to be followed by other similar ones farther along the shear zone. If this is the case these succeeding lenses might be found either on the strike of the first lens or offset from it, and small veins or stringers would be likely to connect them. One would not expect marked changes in the character of the ore with increasing depth, but there would probably be that same lack of marked continuity in vertical as in lateral extent.

THE ORE.

The mineralized zone which is being stoped contains a comparatively small porportion of vein-filling, as sericitized alaskite lies between the small branching veins. This vein-filling is made up mostly of quartz with a large proportion of molybdenite, some pyrite, a little chalcopyrite, fluorite, sericite, apatite, biotite, chlorite, and calcite. The relationships show that the alaskite was thoroughly sheeted before the introduction of the vein minerals, but that minor movements continued up to the time of the deposition of calcite, the last mineral to form.

Quartz occurs as scattered grains in the sericitized alaskite and as vein-like masses four or more inches in width. In the larger vein masses the less abundant minerals occur in zones in the quartz giving it a banded structure. Fluorite is common in parts of the mine, but does not form an important gangue mineral. The color varies from brownish red to pale green, and zonal color variations are common in the larger grains. A vein of fluorite several inches thick crosses Sulphur Creek about 200 yards above the mine. Pyrite is not abundant but is present in the veins and all the country rocks of the region that have been studied. Biotite which occurs in large masses is normally dark brown in the hand specimen and pale brown in the thin section. Some of it is bleached and other portions are partly altered to green chlorite. It forms layers near the borders of the veins with the plates which are commonly a centimeter across arranged perpendicular to the layers. It appears to be clearly associated with the molybdenite. Apatite forms large irregular masses and is rather common in many of the thin sections examined. Calcite occurs in veinlets filling fractures in the older vein minerals. Molybdenite constitutes the only mineral of value in the veins. It is found in bodies varying in size from the smallest films and flakes up to irregular lens-shaped masses 5 or more inches in thickness. These masses all have a distinctly lamellar structure and the molybdenite occurs in distinct flakes. The larger bodies which are commonly found at the intersection of veins, appear on casual examination to be composed of very pure molybdenite, but a study of polished surfaces shows them to be made up of molybdenite disseminated in masses of quartz or sericite and only subordinately of pure flake molybdenite. The larger masses are commonly slickensided.

Erosion in the region has been so rapid that the oxidized mantle at the outcrop of the veins is very thin varying in thickness from a few inches to a maximum of a few feet. The only oxidation minerals observed were molybdic ocher ($Fe_2O_3.3Mo_3.7\frac{1}{2}H_2O$) resulting from the alteration of molybdenite, and small amounts of limonite derived from pyrite.

ORIGIN OF THE ORES.

Molybdenite is generally regarded as a primary mineral deposited by magmatic waters, but it has been described from deposits that have been formed at vastly different depths and at very different temperatures. In the R and S mine its association with pyrite, fluorite, sericite, biotite, and quartz in a mineralized shear zone indicates that the ore has been formed by ascending magmatic waters, probably at a moderate temperature.

CONCLUSION.

As yet molybdenum ore has been found in only a comparatively small area in Sulphur Gulch. The veins are in a zone of shearing in an alaskite and there appears to be a number of veins that promise to be of sufficient width for economical mining, and many smaller stringers. The veins are of a kind that not uncommonly lack persistence and it is not safe to assume a continuation of the ore bodies much beyond the developed areas. However, the 300-foot tunnel exposes several thousand tons of ore and the chance of considerable more ore in the vein prospected by the tunnel and in some of the other veins seems good. The ore exposed in the main tunnel is of very good and of rather uniform grade.

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