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NOTES ON THE BLUE BIRD MINE.

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Peculiar interest attaches to the Blue Bird Mine and the adjoining property called the Penn Yan, because of the mineralogical association, which is not common, and the presence of a great abundance of tourmaline. The following account is based upon examinations made at various times during 1911 by the authors. The particulars relative to the physical appearance of the property, the general geology and past history are contributed by the senior author, while the more technical mineralogical and petrographical descriptions were furnished by the junior author.

The Blue Bird Mine is situated three and one half miles directly west from the town of Wickes, Montana. The mining claims occupy the central portion of Section 13, Township 7 North, Range 5 West, Jefferson County, Montana. The elevation at the mine is about 7,000 feet above the sea, and from the summit of the property an uninterrupted view is had of the Missouri River basin upon the north, the Elkhorn Mountain upon the east and a large stretch of territory to the southwest.

This mine and the Penn Yan have been known and intermittently operated for many years. Ore has been taken from them at different points and upon different occasions by various former owners and lessees. The aggregate value of the ore thus produced probably exceeds a quarter of a million dollars. Between 1887 and 1893 the mine produced about one thousand tons of ore containing an average value of about 0.56 oz. of gold and 65 oz. of silver per ton. There is a marked difference in the metallic content of different ore shoots. The Blue Bird ore proper contains excellent silver values but only a fraction of the amount of gold contained in the Penn Yan ore. To how great an extent this apparent difference is explained by the greater depth of the workings upon the Blue Bird is uncertain.

It should perhaps be mentioned that these properties are in a district which was formerly famous as the home of several important mines. The Alta Mine near Corbin has been idle for many years, but is again being put into condition for operation. Several other properties in the immediate vicinity have at one time or another made important contributions to the precious metal production of Montana.

The particular development through which the mine can be studied at the present time is in the nature of a tunnel cross-cutting the country rock for a distance of nearly 600 feet to the vein which it then follows more or less closely throughout the length of the Blue Bird and into the Penn Yan claim. Just west of the middle of the Blue Bird claim is a shaft about 200 feet deep from the tunnel level, thus reaching a depth of about 600 feet from surface. Here there is developed an ore shoot which appears to have a pitch or rake in the vein to the west. In mining parlance the ground is heavy and requires unusually strong timber support. The ore from this mine is hauled to the railroad and then shipped to the smelter in Butte. A second ore shoot has been developed in the Penn Yan farther to the west.

The rocks which occur in the vicinity of this mine are granite, dacite (and latite), and andesite-porphyry and slate. The principal vein appears to follow closely the contact between the granite and slate. This vein varies in thickness from a few feet to more than thirty feet. It evidently marks the plane of considerable faulting movement and has been much crushed. There has also been a faulting within the vein since the deposition of the ore. The vein strikes easterly and westerly and has a nearly vertical dip. The ore is frequently found within the vein at some little distance from the actual contact. At such times it has slate upon both walls.

The vein minerals include quartz, tourmaline, pyrite, tetrahedrite, rhodochrosite, galena, sphalerite, chalcopyrite, arsenopyrite, malachite. In places the vein is almost wholly filled by tourmaline; elsewhere this mineral is intimately intergrown in large amounts with quartz, pyrite, and other sulphides. The tourmaline also extends into the granite in places; more rarely it extends into the slate.

Occasionally there is a rich segregation of galena ore carrying excellent silver values, but normally the ore mined contains its principal values in silver and copper. In respect to the valuable metallic contents, therefore, this vein is different from the ordinary tourmaline gold-copper veins mentioned by Lindgren,[1] although in general the origin of the mineralization must be similar.

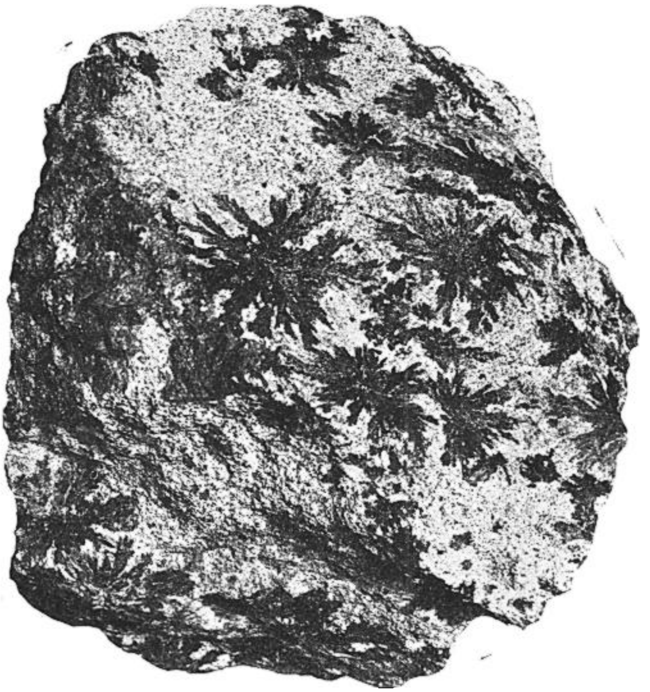

FIG. 37. Photograph of sample of tourmaline-bearing ore from the Blue Bird mine, Jefferson Co., Mont. The tourmaline is in coarsely radiated aggregates in a matrix of euhedral pyrite and anhedral quartz. About one half natural size.

The occurrence of the tourmaline is quite striking, particularly where it contains a portion of the vein material or is mingled with the ore. This is well illustrated by Fig. 37. On the other

[1] "Metasomatic Processes in Fissure Veins," *Transactions A. I. M. E.*, Vol. XXX., 1900, p. 626.

hand, where it occurs in fractures in the country rock and in the unmineralized portion of the vein, it is frequently in the form of delicate spicules or hair-like aggregates, lying criss-cross in the usual manner of tourmaline needles and apparently of later origin than the fracturing and crushing of the rocks. There are also instances in which the tourmaline has been much crushed and the resultant product is a black, pulpy mass in which the individual tourmaline needles have been disguised or completely lost so far as can be seen by the naked eye.

The distribution of the ore in the vein is sporadic and cannot be seen to have an immediate connection with the presence or absence of tourmaline. There is not upon the other hand any distinct evidence of different periods of deposition for the sulphide minerals and for the tourmaline. The evidence tends generally to support the theory that the period of tourmalinization was also the period of the sulphide mineralization. In this respect it does not seem to correspond precisely to the gold-bearing lode of Passagem described by Derby.[1]

Although there is not sufficient development at the Blue Bird Mine to justify any conclusions as to the depth to which ore deposits are likely to extend, and although the ore shoots are no more irregular here than in many other mines, yet the impression made upon the mind of the geologist by the phenomena observed here and elsewhere is not distinctly favorable to tourmaline as an associated vein mineral. It would appear that possibly conditions of deep mineralization are not so favorable for the deposition of large and important deposits of valuable ore as conditions nearer the surface. It may be also true that such deposits which have been formed at great depth may not be so accessible to the influences and forces which bring about secondary enrichment and deposition as ore deposits which were primarily formed above the zone of tourmalinization.

These rocks and ores deserve somewhat detailed description. The granite is presumably a local phase of the Boulder quartz monzonite batholith. It contains dominant orthoclase with some

[1] *American Journal of Science,* September, 1911, p. 185.

plagioclase. Quartz occurs in abundant micrographic intergrowth with orthoclase. The ferromagnesian minerals present include biotite, hornblende and magnetite, with secondary chlorite and epidote. The other minerals present include muscovite, titanite, zircon, and apatite.

Some samples of granite differ considerably from the normal type. They are much more siliceous, containing abundant free quartz. They also contain abundant orthoclase and some plagioclase, partly altered to sericite and calcite. A few phenocrysts, apparently of plagioclase, are now almost wholly altered to sericite. Such samples also contain tourmaline and pyrite. In containing tourmaline these rocks are related to pegmatites, while the presence of the phenocrysts relates them to granite porphyries. The pyrite is apparently a later introduction due to mineralization.

The dacites contain phenocrysts of quartz, plagioclase, biotite, and orthoclase in a ground-mass of about the same composition. There are also a few small phenocrysts of hornblende and small crystals and anhedra of titanite. The quartz phenocrysts are all rounded and have indistinct embayments. The plagioclase is a zonal andesine. Some of the biotite lamellæ are distinctly bent. Well-formed crystals of zircon, apatite needles, and very small magnetites are distributed through the rock. Some samples show fewer phenocrysts, more magnetite, and more alteration to calcite, chlorite, sericite, rutile, etc. In some cases the quartz is rounded by partial resorption.

One sample approaches a rhyolite in composition, but is probably better described as a latite. It contains phenocrysts of plagioclase and orthoclase and rarely of quartz. The rock has been notably altered by hot solutions, but shows very little alteration due to cold solutions. It is impossible to state the original nature of the ferromagnesian constituent as it is now entirely replaced by chlorite, but the indications of form point toward hornblende. A remarkable feature is the apparent partial alteration of chlorite to sericite. The feldspars are also considerably altered to sericite and calcite. Other constituents include ilmenite, titanite, leucoxene, rutile and small grains of secondary quartz.

The andesite porphyry contains large phenocrysts of plagioclase with smaller ones of biotite, in a granitic groundmass. Orthoclase is present in rare phenocrysts and more abundant smaller crystals. Biotite is largely, and another mineral (hornblende?) wholly altered to chlorite. The accessory minerals include magnetite, apatite, and titanite. Epidote is remarkable for its freshness in a rock considerably altered. Minute alteration products seem to include sericite, chlorite, epidote, and magnetite.

The slate of the region is highly metamorphosed and has been regarded locally as a modified andesite. Its character as a slate is believed to be established by the following considerations:

1. The rock varies radically in composition, from a basic rock resulting from the contact metamorphism of an ordinary clay slate to a highly quartzose rock produced by recrystallization of a sandy shale.

2. The texture also varies from that of a metamorphosed slate to the globulitic[1] or "contact" type.

3. Even in the basic phases of the slate quartz occurs sparingly.

4. In rare instances the quartz grains, although enlarged by secondary growth during metamorphism, show the rounded outlines of the sedimentary state by dust-like particles still in position on the former surface of the grain.

5. In spite of the presence of large crystals (pseudophenocrysts) of plagioclase and irregular patches of hornblende enclosing magnetite, the rock shows no true igneous texture. It is believed that both the plagioclase and the hornblende are of metamorphic origin like the garnets produced in schists. Experiments at the Geophysical Laboratory recently have shown that magnesian amphibole may be produced from suitable materials in the presence of water under pressure at temperatures below those of rock fusion.[2]

6. Zircon, on account of early crystallization, is nearly always in well-defined crystals in igneous rocks. When igneous rocks break down zircon crystals become rounded and lusterless. When

[1] A. N. Winchell: *Bull. Geol. Soc. Amer.*, XX., 1908, p. 666.

[2] *Amer. Jour. Sc.*, XXII., 1906, p. 403.

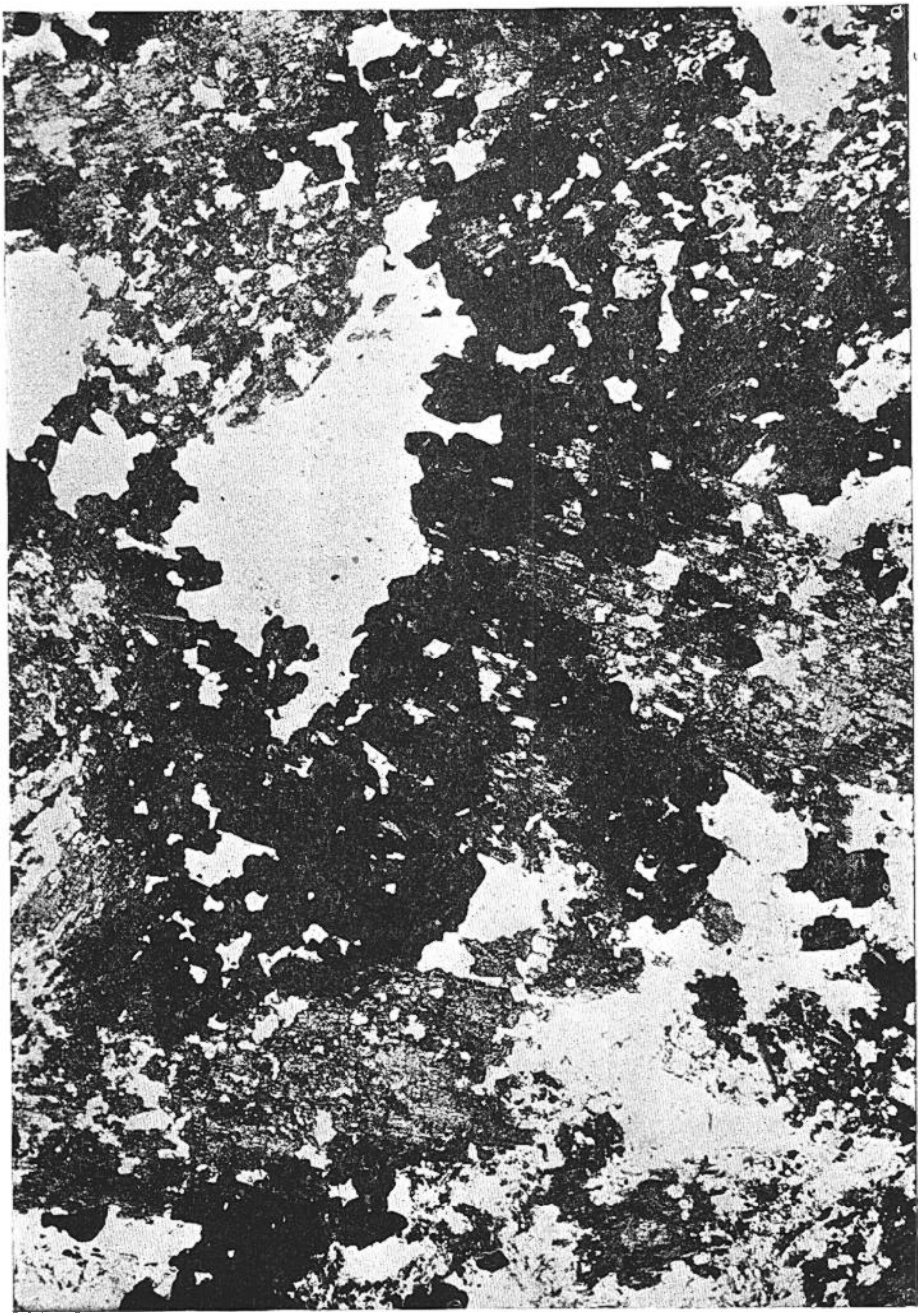

FIG. 38. Photomicrograph of thin section of tourmaline-bearing ore from the Blue Bird mine, Jefferson Co., Mont. The white mineral is quartz; the gray mineral is tourmaline; the opaque mineral is pyrite. Note the intimate intergrowth of the three. One nicol. × 38.

either igneous or sedimentary rocks are anamorphosed the zircon crystals are so small and so stable that their forms remain unmodified in nearly all cases.[1] Zircon is too heavy to be abundant in muds and shales; nevertheless a few crystals are present in these slates, and they are well rounded and lusterless in every case.

The ores commonly consist of tourmaline, quartz and pyrite in varying amounts with or without subordinate quantities of other sulphides such as sphalerite, chalcopyrite, galena. The vein-filling is nearly pure tourmaline in places; elsewhere it is highly quartzose, or composed largely of sulphides; in some places these constituents are intimately intergrown in approximately equal amounts. Sericite occurs in some samples, but in general it is not abundant. Part of the pyrite is of later formation than the tourmaline, but in part also the two are so intergrown as to appear to have been contemporary in crystallization. This is distinctly shown in Fig. 483.

The development of radiated aggregates of tourmaline on a large scale in the midst of sulphide ore is shown in Fig. 484.

In hand samples the tourmaline seems to be all of one type, black and nearly opaque. But in thin section it is readily seen that two types are present with gradations between them. These two types differ in color, pleochroism and birefringence as follows:

	Blue.	Brown.
$Z(O)$ =	slate blue	to dark brown.
$X(E)$ =	pale yellow	to brownish yellow.
$n_g - n_p$ =	0.020 ±	to 0.030 ±.

[1] J. D. Trueman: Thesis for doctor's degree, University of Wisconsin, 1911.