Report on the Geology of

THE BETTY O'NEAL MINE

Near Battle Mountain, Lander Co., Nevada.

By

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Page No.

SITUATION.. 1

HISTORY.. 1

EQUIPMENT.. 1

GEOLOGY

SEDIMENTARY ROCKS................................ 3

IGNEOUS ROCKS.................................... 3

A-PORPHYRY....................................... 3

B-PORPHYRY....................................... 6

RHYOLITE DIKE.................................... 7

GRANO-DIORITE PORPHYRY........................... 7

FAULTING... 8

VEINS.. 9

ESTELLA VEIN................................. 11

BETTY VEIN................................... 14

PORPHYRY OR FLAT VEIN........................ 15

INFLUENCE OF WALL ROCKS ON THE ORESHOOTS.......... 16

GETCHELL TUNNEL.................................. 17

RECOMMENDATIONS FOR DEVELOPMENT.................. 21

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Report on the Geology of

THE BETTY O'NEAL MINE

SITUATION.

The Betty O'Neal Mine is situated about twelve miles south of Battle Mountain, at the base of the mountains that form the eastern side of the Reese River Valley.

HISTORY.

The original discovery was made about 1880, on the Betty O'Neal vein. In 1882, the mine was being worked as a prospect, and was producing $28,000 per month, when an accident resulted in the shutting down of the mine. No other work of importance was done on the property until it was reopened by the present owners in 1920. Since that time the mine has been worked continuously.

The Star Grove, Morning Star, Pittsburg, and Dean were other early day mines in the vicinity.

EQUIPMENT.

The mine is worked mostly through tunnels, but the old Betty O'Neal shaft is used as a service shaft for the 150 and 260 levels. These features are fully illustrated on the accompanying maps.

The mine is fully equipped with air compressors, electric haulage motors, and the usual machinery required for a mine of its kind.

The mill is thoroughly well built, modern plant operating under the oil flotation principle. Power is generated by Semi-Diesel engines. By reason of an ore unusually amenable to treatment by flotation, and good milling practice, the excellent recovery is made of 98% of the values.

The following table gives the production since the mill was started in 1922:

	Tons Milled	Heads Silver	Conc. Content Silver	Smelter Net
1922	4,812	14.10 oz.	63,749 oz.	$ 54,066
1923	38,150	19.05 oz.	665,040 oz.	438,057
1924	28,982	19.66 oz.	483,263 oz.	271,477
1925	23,290	23.49 oz.	506,500 oz.	313,502
1926 (10 mos.)	23,486	25.65 oz.	593,307 oz.	351,148
Totals	118,720		2,311,859 oz.	$1,428,250

Average grade of concentrate January-October 1926: 429.02 oz. per ton

GEOLOGY

SEDIMENTARY ROCKS.

The country consists of a tilted block of Paleozoic sedimentary rocks, intruded by igneous dikes. The general strike of the strata is N 45 degrees W and the dip 35 degrees to 45 degrees northeast.

The sedimentary rocks are well bedded shale, sandstone, chert, quartzite, and limestone. Most of them are colored black with graphite. The entire west side of the mountain, and the entire exposure in Lewis Canyon to the east are made up of these rocks, so that without having made any attempt to measure them, it is still safe to say that they are several thousand feet thick.

IGNEOUS ROCKS.

The igneous rocks are in the form of dikes, that cut across the sedimentary strata in a northeasterly direction. For convenience of reference, they are hereafter mentioned as A-porphyry, B-porphyry, rhyolite dike, and grano-diorite dike.

A-Porphyry.

The A-porphyry is an exceedingly fine-grained igneous rock that is exposed in the form of dikes in the 5th level footwall crosscut, on the 150 level west of the Estella vein, in the Getchell tunnel, and in numerous other places. On the surface the rock is found as a dike some 500 ft. wide, crossing the upper part of the Betty O'Neal gulch, below the prominent chert bluffs near the summit. This dike has probably not yet been cut by the Getchell tunnel.

The rock is usually altered to a gray or brown color in which condition it can easily be mistaken for dense limestone. In the 5th level footwall crosscut, it occurs in places in a less altered form, as a black rock with light-colored spots. Specimen 33 represents the commonest altered form of the rock underground. Specimen 34 is less common, and specimen 38 is the least altered form seen. Specimen 33 closely resembles specimen 35, which is a fine grained limestone containing a large proportion of fine quartz sand. The distinction between these two can be made by examining the wetted surface of fresh fractures with the aid of a good hand lens, and also by observing the bedding planes in the sedimentary rock. The A-porphyry is massive, and is, of course, free from bedding. The comparison of doubtful specimens with known specimens in daylight will be found useful. In some specimens the crystalline structure can be seen with a lens.

Under the microscope, specimen 38 shows a fine felted mass of feldspars, ferro-magnesian minerals, and magnetite. An exact determination of the species was not made, but the rock has approximately the composition of andesite. Specimens 33 and 34 are decomposed forms of specimen 38.

Specimen 32, is from the surface between the outcrop of the Estella vein and the chert bluffs at the summit. The rock looks black and fresh, but shows considerable decomposition under the microscope. This rock has the same general composition as 38, but there are sufficient differences to suggest that it is from a different dike.

Specimen 21, from the 150 level about 200 ft. southeast of the Betty shaft, is an igneous rock, too highly altered for exact identification, but it is thought to be a form of the A-porphyry and has been so mapped. Specimen 8 is a light brown semi-glassy rock with a distinctive ropy flow structure. It is found in the southerly workings on the 4th and 150 levels. The rock was mapped with the A-porphyry, with the idea that it may be a phase of the A-porphyry that was in motion while still in a partly cooled, pasty condition; but it is recognized that the rock may be a separate dike. These two rocks, No. 8 and No. 21, are included in the area mapped as A-porphyry, but the area that they represent forms a very small proportion of the unquestionable A-porphyry, so that even if the identification is wrong, the error thereby introduced will have no bearing on the interpretation of the geology.

The close resemblance between specimens 21 and 23 should be noted. Twenty-one is A-porphyry and 23 is sandstone, although in the hand specimen, specimen 23 looks much like altered andesite.

The A-porphyry is the most difficult of all the rocks to distinquish, because of its fine grain, and because of the close resemblance of some of its altered phases to dense limestone. It is for this reason, and to assist in mapping the geology of new development work, that the characteristics of the rock have been thus fully discussed.

Specimens 8, 21, 32, 33, 34, 38 are from the A-porphyry. Microscopic thin sections of these specimens were made and examined.

<u>B-Porphyry</u>.

The B-porphyry is exposed in the crosscut near the portal of No. 4 tunnel, and in No. 1 north crosscut of the Getchell tunnel. It is so highly altered that its original character cannot be determined. In its present state the rock consists entirely of alteration products. It can usually be distinquished by the presence of light brown, bleached, micaceous remnants of what was originally biotite. It has no quartz phenocrysts.

A surface outcrop of the rock can be seen in the form of a northeasterly dike, at a point about 200 ft. N 10 degrees E from the portal of No. 4 tunnel.

Rhyolite Dike.

The rhyolite is exposed on all levels except the 75 level. It is in the form of a dike on the hanging wall side of the vein; almost parallel to the vein but not in direct contact with it. The rock is of a white, or in some places, of a faint greenish color. It consists largely of alteration products, but contains numerous quartz phenocrysts. Originally it was a rhyolite containing quartz phenocrysts in a felsitic groundmass. It is an easy rock to identify. The alteration processes have so softened the rock it is very unstable and caves readily.

Grano-diorite Porphyry.

This rock is represented by specimens 36 and 5. It occurs in the form of narrow dikes, seen on the 5th and 75 levels. The rock contains phenocrysts of quartz, feldspar, and biotite in a finely crystalline groundmass. It is the rock that forms the long northeasterly dike with the outstanding outcrop in the Betty O'Neal Canyon above the mine.

FAULTING.

No faults of major importance have occurred subsequent to the formation of the veins, within the area mapped; but pre-mineral faults are common. The main Estella vein-fissure is a fault that was formed by forces attendant upon the intrusion and contraction of the igneous dikes. This fissure faults the A-porphyry dike, but does not fault the rhyolite dike. It was formed in the interval between these two intrusions. Most of the faults and gouge seams of low angle and nearly horizontal dip were formed by the "crowding aside" and pushing forces of the intrusions.

The heavy gouges, so common above and below the rhyolite dike and intersecting the dike, are due to the brittle and easily decomposed character of the dike rock. These breaks are both pre-mineral, and post-mineral. Their pre-mineral character is shown by their having been cemented with quartz veins. Their post-mineral components have resulted in the common breaking and crushing of the veins. The heavy gouges found around the old "Porphyry workings" of the 150 level are the result first of attrition by movement, and next by decomposition of the crushed rocks. The formation of these "greasy" gouges, and the contraction of the rhyolite mass through leaching, induced still farther movement of the already shattered rhyolite; so that the ground in the vicinity of this intrusion is in most places a muddy gouge.

The rhyolite itself is thoroughly crushed and the seams are filled with clay and micaceous decomposition products. The result of this condition and the faulting is that the rock forms very unstable walls for mine workings, and must be timbered.

The low-angle fault that appears to cut off the Estella vein in the northerly workings is probably a gouge near the bottom of the rhyolite dike and parallel to it.

Altogether the gouges and faults in and near the rhyolite appear to be local, and confined to the vicinity of the dike. It is the decomposition of the dike and the nearby crushed material that makes them seem large.

VEINS.

The orebearing veins were formed in two stages. The earliest stage was marked by the formation of barite, carrying little or no silver, and the second stage by the introduction of orebearing quartz.

The barite is far less in volume than the quartz. It is most noticeable as lenses, sometimes two or three feet thick. In general, it is a common constituent of the ore, though not in large proportion. It sometimes carries small bunches of tetrahedrite, but does not often form ore. The barite usually occurs in the same fissure with quartz, the quartz overlapping the barite or surrounding broken fragments of it.

The veins are made up principally of quartz, with a small amount of calcite. The quartz is white and much of it is of "sugary" texture. The calcite is sometimes pink with intercrystallized rhodochrosite.

The ore minerals are argentiferous tetrahedrite and galena, and sphalerite. Little is known about the silver content of the sphalerite, but it probably contains silver. The three minerals are closely associated and usually occur together, although the tetrahedrite sometimes forms in seams and masses up to 2 or 3 ft. thick. On close inspection specimens of these tetrahedrite masses are seen to contain considerable included quartz. Pyrite occurs in the ore only in small quantity.

The principal value of the ore is in its silver content. The gold value is very low. A typical shipment of 39 tons of concentrate assayed:

Gold	.03 oz. per ton
Silver	427.95 oz.
Copper	2.3 %
Lead	8.35%
Zinc	10.5 %
Iron	13.65%
Sulphur	22.6 %
Insoluble	24.6 %

ESTELLA VEIN.

The Estella vein was formed by the introduction of quartz along compound fissure or narrow zone of fissuring. There is usually a gouge wall on the hanging wall, and often also on the footwall, and frequently where the vein is wide there are one or more intermediate gouges or "false walls".

The vein maintains a straight course of about S 30 W for 800 ft. on the 4th-5th level, and is of milling grade for practically all of this distance. At the southerly end of this stretch of ore, the rhyolite dike, or possibly only a branch of it, swings directly to the south, cuts across the normal line of the Estella vein. As the vein approaches the rhyolite, the fissure, instead of cutting through the intrusive rock, splits into two branches, both of which turn parallel to the rhyolite and continue in that direction, leaving the rhyolite on the hanging wall side. Shortly after making the turn to the south the two branches enter the A-porphyry dike, and have the igneous rock on one or both walls. This seems to be an unfavorable condition, and the orebodies do not persist in these branches of the vein. Conditions are similar on the south ends of the winze level, 75 level and 150 level, as far as they have been driven, in that the vein weakens where it gets into the A-porphyry. It will be seen on the maps that on each successively deeper level, the vein encounters the A-porphyry farther to the north and that this circumstance marks approximately the southern limits of the important orebodies.

To the north, a caved drift prevented the inspection of the end of the ore in that direction, but as far as could be ascertained, the vein and the ore became weaker north of the cave. On the surface, a series of open cuts on the outcrop expose the vein at about the north edge of the map. They show the vein, tooweak and low in silver to mine, but there are some streaks of good silver ore. While the chances of finding profitable ore to the north on the 5th level are none too good, some further work in that direction would be advisable and a recommendation for this purpose is made.

In the north end of the winze level, the vein and orebodies are strong and of good grade, but they terminate against a strong gouge of 20 degrees dip. This is probably the footwall gouge of the rhyolite dike, and the rhyolite could doubtless be found a short distance above it. The termination of the vein against the gouge is not such as to indicate faulting of the vein, but rather the termination of the vein against a pre-mineral gouge. As the quartz approaches the cross-wall, it turns and follows under the interrupting gouge for a short distance and gradually thins out to nothing. There is no crushing of the vein at the cross-wall, nor any line of broken and dragged vein fragments leading away from the interruption, such as would be found if the vein itself were broken off by a fault.

The same low-angle gouge appears below the rhyolite at the north end of the 75 level, but the oreshoot terminates before reaching it. On this level the orebody meets and turns northwest along a southwesterly dipping crosswall, on which some very good ore occurs, but no ore is found farther north. This same northwest crosswall terminates the oreshoot on the 150 level; while it does not carry much ore on the 150 level, it does show some good ore on the 75 level, and it is on this wall that the high grade orebody occurs that is now being mined on the winze level. On the 150 level this crosswall becomes longer and is fairly well aligned in a long arc, with the footwall fracture of the Estella vein-fracture system.

No work has been done on the 260 level to find the Estella oreshoot, and such work as has been done in the Getchell tunnel has failed to find it.

BETTY VEIN.

The Betty vein strikes southeast and dips to the northeast. It is the vein on which the earliest discovery was made, and on which work was done in the '80's. There is so much caving in the old-time workings that the vein can now be seen in only a few spots. In the Powder Tunnel, the vein varies from small stringers to widths of 2 and 3 ft., with varying dips to the north. A small stope is exposed. The tunnel is caved about 250 ft. from the portal, but the maps show that it extended over the old "Porphyry workings" to where there are old stopes above the flat vein of the 150 level. The indications are that the Betty vein is a steep vein that rises out of the flat

"Porphyry vein", and passes up through the rhyolite dike into the sedimentary rocks. With the present limited knowledge of the old workings, it is impossible to correlate all the ore of the old mine with the Betty vein as seen in the Powder tunnel, and it seems likely that there are several veins that rise from the flat "Porphyry vein". The vein stoped above the south drift from the shaft on the 150 level seems too far north to be the vein mined in the Powder Tunnel.

The work recommended under 150-2 is for the purpose of developing the possibility of another vein to the northeast. It is probable that the old Betty vein is pretty well worked out.

PORPHYRY or FLAT VEIN.

The "Porphyry vein", is in the main a flat or rolling vein below the rhyolite dike. The vein is considerably faulted by heavy gouges, along many of which veins have been formed. As far as known, the vein exists within a horizontal area of 175 ft. by 250 ft., but it may be more extensive. The vein was clearly formed in two periods, in the earliest of which barite predominated. No silver ore was seen in the vein of this period. In several places a sheet of later orebearing quartz, 2 inches to 8 inches thick can be seen immediately below the earlier vein, and also in stringers up to 1 ft. in width, cutting up through the barite, or filling cracks in the shattered earlier vein. All of the ore minerals, tetrahedrite, galena and sphalerite can be found in this quartz, and it is on local concentrations of this kind that the small stopes of the porphyry workings were mined. These orebodies were bunchy and not extensive, but they carried good ore. The orebodies of the 260 level are downward extensions of the porphyry orebodies, associated with a lower sheet of porphyry, and probably connected with the porphyry vein of the 150 level.

This "porphyry vein" is worth further development, especially in respect to its possible extensions in the form of steeper veins. The chances for finding ore would seem to be best in veins breaking away from the flat vein, if such can be found. The Betty vein was of this nature.

INFLUENCE OF WALL ROCKS ON THE ORESHOOTS.

Quartzite and sandy limestone form the walls of the larger orebodies, and these rocks appear to be by far the most favorable for ore. The ore has deposited less freely in the shales and cherts, and there is practically no ore in the porphyries. The fissures leading into the A-porphyry show streaks and small bunches of ore but practically no ore that can be mined.

The quartzite is a brittle rock that shatters readily, but does not decompose into mud. The material that cements the sand grains is not entirely quartz, so that the rock is the more readily attacked by the vein forming solutions, and replaced by vein quartz and ore. As a result of these properties, when the course of the vein passed through shattered quartzite it permeated the mass and formed wide orebodies. Where the No. 5 tunnel cuts the vein, the orebody, formed under these conditions was stoped 60 ft. wide, and other wide orebodies were formed in this way on the winze level and the 75 level.

GETCHELL TUNNEL.

After the Getchell tunnel passes through the porphyry dike, it continues through 100 ft. of crushed black graphitic shale, 50 ft. of B-porphyry on the north side, and then into the A-porphyry. Between No. 1 and No. 2 crosscuts, the A-porphyry seems to lie flat, with black shale above, and the contact marked by a flat barite vein 6 to 12 inches thick. Bedded limestone appears for a short distance at No. 2 crosscut, and then the tunnel enters the main mass of the A-porphyry and continues in it for 250 ft. From No. 3 crosscut to the face, the tunnel is in carbonaceous cherts and shale.

The Estella vein, had it continued downward should have appeared between crosscuts No. 1 and No. 3, but no fissure was found corresponding to the vein. A flatly dipping lens of ore was found under the rhyolite in crosscut 1-S, which yielded about 300 tons of 22 oz. ore. Northerly striking stringers of quartz carrying some silver value were found for the next 300 ft., and one of these at the foot of the orepass shows a good though bunchy mineralization of tetrahedrite and sphalerite. In No. 3 crosscut north, at station S16 an irregular body of vein-type quartz was found, with some small bunches of silver ore. In the face of the short crosscut southeast from station S17 there is a flat lying vein 8 inches thick, 1 ft. above the floor, that carries some goodlooking ore. No veins were found southeast of No. 3 crosscut.

The type of quartz in these small exposures is no different from that in similar exposures in higher levels; and the ore that was found is of the same type and contains no more base metals than on higher levels.

The main geological problem in the mine at the present time is to find the downward continuation of the Estella orebody, if there is one, on the Getchell tunnel level. There are two methods of attacking the problem: first, to trace the 150 level oreshoot downward by first finding it by driving a crosscut north from the "wet raise" midway between the 150 level and the Getchell tunnel; and second, by exploratory work from the Getchell tunnel.

The crosscut from the raise should have no difficulty in finding the vein. When the position and direction of the vein are found on the intermediate level, it should be possible to form some idea of where to look for it on the Getchell tunnel level. If the strike and dip of the 150 level is maintained the vein should reach the Getchell level somewhere north of No. 3 crosscut N, where it would be encountered by Rec. G-3, possibly terminating to the south against 1800 fault; but search for the vein in this vicinity will have to be guided by the work on the intermediate level. Whether or not, the Estella oreshoot can be traced to the Getchell tunnel level, a general exploration of the region north of the tunnel should be made. The importance of the orebodies if found will justify the work.

The orebodies of the higher levels were situated mostly below the rhyolite and in or near the

the quartzite. The main quartzite strata if projected downward on the general strike and dip of the formation, would reach the Getchell level about 500 ft. north of the Getchell tunnel, as shown on the level map. The general plan of work should be to crosscut north until the quartzite is found, and then crosscut for about 500 ft. northwesterly and southeasterly below the rhyolite. The favorable ground may be east or west of the A-porphyry, but not in the porphyry. Even if the Estelle fissure does not persist to this depth, some other ore channel may be found. It is not practicable to lay out this campaign in detail to be followed on given lines. Such conditions as the position of the dikes, stringers, faults, etc. will have their influence on the plan as the new work reveals the details of the geology. The directions specified in the recommendations will do to outline the general plan.

The theory that guides recommendation G-1 is that the zone of stringers on both sides of the Betty Shaft may continue northerly until they encounter sedimentary rocks and then may consolidate and enlarge, and make orebodies when they reach the quartzite. G-3 is to be driven northeast until it reaches quartzite. It should be mentioned that quartzite is not confined to one horizon. There are numerous small beds of quartzite, but the quartzite in which the orebodies are deposited forms the main body of the rock for a considerable thickness. It has not been possible to measure it.

RECOMMENDATIONS FOR DEVELOPMENT

4th-5th Level

5th Level-1

Reopen caved drift northeast of station S161. Drive northeast to 120 ft. from station S165 and crosscut northwest for vein. The amount of drifting on the vein will depend on the showing made.

5th Level-2

At a point 65 ft. southwest from station S111 drive a crosscut N65W, 50 ft. into hanging wall.

5th Level-3

At a point 20 ft. southwest of station S136 drive a crosscut 20 ft. into the footwall.

Winze Level

Winze Level-1

Resume work in face of crosscut 35 ft. from S116. Drive N40W, 190 ft. then turn N25E, and drive 120 ft. from turn, looking for a northwesterly vein.

75 Level

75-1

Resume work in face of crosscut near station S84, and drive northwest about 190 ft. farther. This is purely exploratory work to see what is above the "flat fault".

150 Level

150-1

Start a crosscut from the "wet raise" near station D46, at a point 80 ft. below 150 level. Drive N25E 120 ft., and then crosscut N65W about 50 ft., looking for downward continuation of main oreshoot.

150-2

Start a crosscut at D27, 30 ft. south of Betty Shaft. Drive N80E 60 ft., and then drive about N10E on best looking quartz, as far as showing justifies the exploration. Probably 100 ft. from turn would be the minimum requirement.

150-3

At point S70E from station D31, start a drift on stringer zone and drive northwest. This may open some ore below old Betty stopes.

260 Level

260-1

Resume drifting at face 60 ft. south of point S26. Drive S25W 180 ft. and then turn S65E. Crosscut 200 ft. in this S65E direction. Also from face of present drift drive a 35 ft. crosscut southeasterly.

260-2

Drift northeasterly on vein, starting on northwest side of Betty Shaft. Turn a crosscut southeast from a point 120 ft. northeast of shaft.

Getchell Tunnel Level

G-1

This work consists of crosscutting about N13E from crosscut 2N, as indicated on the level map. The purpose is to open up and explore the country to the north in the direction of the small "pointer-veins" that are now exposed near the Betty Shaft; and eventually to search for veins in the quartzite that should be found to the north. If a good lead of quartz, or gouge with vein, can be found pointing north it should be followed into the quartzite.

If the crosscut gets into the A-porphyry for any considerable distance, branch crosscuts should be driven right and left to expose both sides of the dike, and also driven well into the sediments on both sides of it. The continuation of this work and the details will depend on conditions exposed as the work progresses.

G-2

This is a crosscut to be driven southeasterly from crosscut 2N, for a distance of 60 ft. to expose the border of the A-porphyry again, and to give further data regarding its direction.

G-3

This is crosscutting to the north from crosscut 3N. It is in the region where the Estella vein may reach the level, and if quartz is found, the work may have to be continued much farther than is indicated by arrows on the map. If quartz like the irregular bunches near station S16 is found further exploration should be done to determine the relationship of these quartz bodies to the orebodies above.

Crosscut 1-S

The ore previously mined from this crosscut is similar in its occurrence to that of the "porphyry workings" on the 150 level. Some further work would be advisable here. A steep raise should be driven near station 83 to again cut the gouge exposed in the raise in crosscut 1N.

The ore lies closely under the rhyolite, which is exposed in the roof of crosscut 1-S. This contact should be cut again to the north from Rec. G-1.

It is significant that all the ore (excepting the Betty Vein) of the mine has occurred below the rhyolite, and for this reason exploration on the Getchell level should be kept below the rhyolite.

In making these recommendations, it is understood that circumstances as they arise may alter the details of the development, and that those in charge of the work must use their judgment in carrying out the work. A study of the geological maps will probably suggest other possibilities to your management that have not been noted here.

I regard the country north of the Getchell tunnel, where the veins should enter the quartzite, and below the rhyolite dike, as having good possibilities, and it is to develop that situation that work on this level has been recommended.

Respectfully submitted,

John A Burgess