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Major deform. connected with mineralizn. IM movement.
Veins in 2 sets at 90° - uplift.

CASTO QUADRANGLE, IDAHO.

Geology & Ore Deposits of the Casto Quad.,Idaho.C.P.Ross,USGS Bull.854, 1934.

Tertiary structure: Major structure elongated dome or broad arch N40E, extends far beyond quadrangle. Dips to 5° average.Marked axial and cross faults,axial more pronounced.p.77:"The faulting may well have proceeded concomitantly with the folding and prevented the full development of the arch.Cf.Cloos graben on uplifts.

Core of arch Tert.granite with laccolithic top.

Some graben flts near arch crest;some synthetic normal flts.along NW of the Tertiary granite.

Miocene Deposits: Fine-grained ribbon qtz.,adularia. Along shear zones without well-defined walls;formed in part by replacement,in part by fissure filling. Brecciation yielding angularfragments,was recurrent.

Yellowjacket District:NE corner of Quad. CR Beltian qtzite. Yellowjacket Lode a grea t shatter zone N65-75E,dip very steep NW. Two sets veins,one NW,other NE. 2 N40W PM faults,cross-joints, humping of arch axis. Apparently whole works formed great OB,possibly stockwork,mined in part by opencut.Oxid.Au.

Columbia mine, a mile W of Yellowjacket,CR qtzite also;mineralized zone N60E,dips 30-70 NW.

Y district along crest of Casto arch.

Loon Creek District.SW part of Quad.,on SE flank of arch. In block of Beltian schist,looks like N-S roof pendant in daciteporphyry(Miocene). Schist highly contorted. Lode strikes nearly N-S.

Parker Mt.District.- Parker Mt.Mine,SE corner of quad. On SE flank of arch. 1 mi.NW of two NE,NW-dipping antithetic faults. Lode strikes N20W, 60° ~~perpendicular~~ to axis of arch.In Challis volcanics. HW well-defined.Ribbon banded qtz.

6 mi.NW of Parker Mt.mine,fault N26W roughly parallel to arch axis. Gash veins in this fault zone,fg.banded qtz.

See also J.B.Umpleby:Some Ore Deposits in Northwestern Custer Co.,Idaho. USGS Bull.539,1913.Under Intramineral Movements.

Discussion: The Localization of Values in Ore Bodies and the Occurrence of Shoots in Metalliferous Deposits. H.V.Winchell.EG vol.3,1908,425-428. H.S.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

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THE THUNDER MOUNTAIN MINING DISTRICT VALLEY COUNTY, IDAHO*

By Clyde P. Ross,# Washington, D.C.

(New York Meeting, February, 1933)

The Thunder Mountain mining district is in eastern Valley County, Idaho. It is of undefined extent but nearly all of the development is confined to the ridge between Monumental and Marble creeks in unsurveyed T. 19 N., R. 11 E. (Fig. 1.) The district is still remembered among the mining men of Idaho because of the ill-advised rush there in 1902, but available evidence indicates that optimism regarding the future development of the gold deposits of the district is warranted. The former disappointment arose from the fact that many who took part in the early rush hoped for bonanza deposits, whereas the district is characterized by large masses of low tenor.

In 1926 the writer, assisted by C. H. Behre, Jr., incidental to other work in the region, devoted four days to the detailed examination of the then accessible workings in the district. Tha major workings in the Sunnyside, Venable, Standard and H-Y. mines, most of which were still in good shape, were examined. Surface exposures at the Dewey were studied, but the main workings there have long been caved. The time available did not permit more than a cursory examination of the surface at a distance from the mines. Sufficient data have been gathered, however, from published and unpublished accounts, production records and mine maps so that the major features of this deposit, by far the most productive in the district, can be summarized. The kindness of Messrs. Dan McRae and R. A. Davis in making available information regarding the mines of the district, and of these men and others in recounting early history and their observations in now inaccessible workings, have aided materially in preparing the present paper. A brief summary of the salient characteristics of the district has already been published.1/ Circumstances have contributed to delay in the publication of the full official report, which will contain mine maps and such other detailed data as could be ontained. In view of the present interest in gold deposits it seems desirable to present here a summary of results of the study.

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Geologist, U.S. Geological Survey.

Discussion of This Paper is Invited. It should preferably be presented at the New York Meeting, February, 1933, when an abstract of the paper will be read. If this is impossible, discussion in writing may be sent to the Editor, American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York, N.Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close April 1, 1933. Any discussion offered thereafter should preferably be in the form of a new paper.

HISTORICAL SUMMARY

The first discovery of mineral in the Thunder Mountain district was made by the three Caswell brothers and Huntley in 1895. They sluiced the soft material on the surface of the deposit in which the Dewey mine was later developed, and are reported to have made $6000 to $7000 each summer for 4 or 5 years in this way. Through negotiations conducted by the late Col. W. H. Dewey, their claims were purchased in 1901 by the Thunder Mountain Gold and Silver Mining and Milling Co., which promptly shipped in a 10-stamp mill by pack train and commenced underground development. Exaggerated accounts of the new gold district were widely circulated and resulted in a rush to it in 1902. Bell 2/ estimates that between 2000 and 3000 people visited the district in the spring of that year. The towns of Roosevelt and Belleco sprang up, and claims were staked and prospect holes dug over an area of about 20 square miles. Many of these holes appear to have been dug at random, and most of them were soon abandoned. Present development indicates that most of the mineralization is confined to an area of 5 or 6 square miles. At a few places, such as the Sunnyside, H-Y., Standard, and Venable mines, considerable underground development work was done, but by far the most encouraging results were obtained at the Dewey, the original discovery. The period of active production was brought to a close about 1908 with the termination of company operations at the Dewey mine.

From the incomplete information available3/ it appears that the total production prior to 1901 was roughly $40,000. From then through 1908 the Sunnyside produced about $5,000 and the Dewey not over $350,000. While a number of other properties were worked during this period little production was obtained from them. Since 1908 it appears that little more than $20,000 has been produced in the district.

1/ C. P. Ross: Ore deposits in Tertiary lava in the Salmon River Mountains, Idaho. Idaho Bur. Mines and Geol. Pamphlet 25 (1927) 2, 4, 9, 12-17.

2/ R. N. Bell: Facts about Thunder Mountain: Eng. & Min. Jnl. (1902) 74, 273-275

3/ J. B. Umpleby and D. C. Livingston: A reconnaissance in southcentral Idaho. Idaho Bur. Mines and Geol. Bull. 3 (1920) 6.

Annual Volumes of Mineral Resources of the United States, and the files of the U.S. Bureau of Mines.

The remarkable landslide in May, 1909, completed the discouragement of most of the miners. This landslide started close to the Dewey mine, moved over two miles down Mule Creek and dammed Monumental Creek. The result was that the town of Roosevelt, on Monumental Creek just above the mouth of Mule Creek, was flooded. The lake thus formed remains today, although it is filling with silt. For some time subsequent to this disaster activity in the district was confined to intermittent operations by a few men. The dumps of the Dewey mine have been largely reworked by placer methods and small stringers and pockets of gold close to the surface have occasionally rewarded their discoverers. The neighboring streams have from time to time been prospected for placer gold, but the production from this source has not been encouraging. For some years prior to the writer's visit in 1926 a 10-stamp mill had been operated during the summer on ore obtained by a small force engaged in development work at the Sunnyside mine. It is understood that this limited operation has continued up to the present time. Notices in the press record the fact that the district has recently received some attention from mining scouts, but no increase in activity appears to have resulted as yet.

MEANS OF ACCESS

One of the major disadvantages of the Thunder Mountain district heretofore has been its remoteness from routes of travel. It lies near the center of the rugged Salmon River Mountains. The only road that approached the district until recently was the rough and steep one that extends from Johnston Creek above Yellow Pine along the ridge crests to upper Monumental Creek and thence to Roosevelt with branches to Belleco and the principal mines in the Thunder Mountain district. This road was never good and in 1926 had long been in disrepair although still occasionally used by wagons. Much of it is impracticable for automobiles. The distance along it from Roosevelt to Johnston Creek is nearly 30 miles, and much of it is so elevated as to be snowbound most of the year. From Johnston Creek to Cascade on the Long Valley branch of the Oregon Short Line is about 50 miles over the Forest Service Highway. Within the last few years a road has been built from the former terminus of the highway at Yellow Pine up the East Fork of the South Fork of the Salmon River to serve the mines of the Yellow Pine company on and near Meadow Creek. This road is nearly completed and its terminus will be 12 or 15 miles from Roosevelt and not far from the saddle through which the old road descends into Monumental Creek. The route is somewhat longer than the old one, but in every way superior to it. The high divides between Johnston Creek and Cascade still prohibit use of the road by automobiles in winter, but airplane service during this part of the year has been established between Cascade and the Yellow Pine property on Meadow Creek.4/ Consequently, modern transportation facilities have now been brought so close that their extension into the Thunder Mountain district would be a comparatively easy task.

4/ S. Campbell: 33d Ann. Report of the Mining Industry of Idaho for the year 1931 (1932) 36, 37.

GENERAL GEOLOGY

The entire district and the surrounding region for miles around is underlain by the Challis volcanics. This is a thick sequence of lava flows and pyroclastics which is of early Miocene or late Oligocene age.5/ The surface

5/ C. P. Ross: Geology and ore deposits of the Seafoam, Alder Creek, Little Smoky, and Willow Creek mining districts, Custer and Camas counties, Idaho. Idaho Bur. Mines and Geol. Pamphlet 33 (1930) 2.

Geology and ore deposits of the Casto quadrangle, Idaho. U.S. Geol. Survey Bulletin in preparation.

on which this formation rests is irregular. Older rocks are exposed along Monumental Creek about 7 miles above and 8 miles below the site of Roosevelt. They are probably not far below creek level at Roosevelt. No Tertiary intrusive rocks are known anywhere in the vicinity of the mines, but there is a large intrusion of Miocene granitic rock 6/ along the Middle Fork of the Salmon River somewhat over 11 miles to the east, and related dike rocks are plentiful on Rush Creek about 8 miles to the north.

6/ C. P. Ross: Mesozoic and Tertiary Granitic rocks in Idaho. Jnl of Geol. (1928) 36, 682-686, 692-693.

The Challis volcanics in the Thunder Mountain district are preponderantly rhyolitic. The latitic and andesitic rocks that make up most of the lower part of the formation in other parts of south central Idaho are not exposed here. The lower part of the sequence on the Monumental Creek slope is massive, dark purplish rhyolite several hundred feet thick. Resting on this are the light colored beds of rhyolitic lava, tuff, and conglomerate that contain the mine workings. The lava flows make up a small proportion of the total, and some of them are only a few inches thick. The total thickness of the light colored beds is 500 ft. or more. The upper 200 ft. of this is largely tuffaceous conglomerate with well rounded pebbles 1 to 2 in. in diameter, mainly of light colored rhyolite porphyry. Both the lava and the tuff contain pieces of solicified wood and other fragmentary plant remains. Some of the less silicified fragments are black and look charred. In places there are layers of impure lignite from a few inches up to as much as 2 ft. thick. Large logs were found in the Dewey workings, and some of these contained much free gold.7/ About 200 ft. of dense black basalt, in part vesicular,

7/ J. B. Umpleby and D. C. Livingston: Op. cit., 6.

overlies the light colored beds at the Dewey mine and similar rock crops out in several other places on the Monumental Creek slope of Thunder Mountain. While most of the light colored rock in the district is more or less hydrothermally altered, the basalt is nowhere known to be appreciably affected.

On the Marble Creek slope, where the Sunnyside mine is the only development of consequence, the geology differs in detail. On the lower part of this slope light pinkish and purplish lava with numerous quartz phenocrysts predominates over a vertical range of more than 1000 ft., with cream colored tuff abundant below this. At higher levels, in the vicinity of the Sunnyside mine, there is light colored rhyolitic tuff and lava similar to that on the Monumental Creek side of the ridge. No basalt, conglomerate or lignite are present, however. Many of the light colored rocks are so thoroughly kaolinized that it cannot be positively determined from microscopic study whether they are tuff or lava. Exposures in the Sunnyside mine show that some of this rock contains numerous irregular fragments of similar material. In and near this mine a nearly black rock, probably about 45 ft. thick, overlies the altered light colored rock which constitutes the ore. The dark rock is composed of fragments of silicic lava of irregular size and shape, but generally rather rounded, in a fine-grained matrix, apparently composed of clastic grains of glass and lava. This rock is so thoroughly kaolinized that, when wet, it can be molded to some extent in the fingers. The contact with the light colored bed below is rolling. In places the dark upper rock fills crevices in the light one, which was evidently previously fractured. The filling of the crevices is so irregular as to suggest that it was done by solid fragments rolling over the ground as a volcanic mud flow rather than by fluid lava. The dark rock will consequently be referred to in this report as the mud flow. The light colored rock below is composed of a number of beds of only slightly differing character, aggregating several hundred feet in thickness, of which the mineralized rock in the mine workings makes up somewhat over 50 ft. Differences in color permitted distinction in underground mapping between light and dark phases of this rock, but no diagnostic differences between these varieties are perceptible under the microscope. In some places in the mine they grade into each other. Elsewhere the contacts between them are fairly sharp. Whatever the exact character and mutual relations of the two varieties, both consisted, prior to alteration, mainly of glass and a variable proportion of small quartz grains.

The strata on both flanks of the Thunder Mountain ridge are rolling and vary materially in attitude within short distances, in part because of irregularities in original deposition. In a general way the rocks are flexed into an anticline of northwesterly trend whose axis lies near the crest of the ridge. Dips on either flank rarely exceed 25° and much of the rock lies nearly horizontal. A few hundred feet east of the caved ground above the main Dewey workings there is a nearly vertical fault, which brings the basalt against the tuffaceous conglomerate. It strikes N. 50° W. (somewhat more northerly than the average attitude of the strata) and has a downthrow of roughly 200 ft. to the southwest. The same or a related fault zone was followed by the now inaccessible workings of the Dewey to a depth of about 240 ft. No faults of any magnitude exist in any of the underground workings accessible at the time of visit, although numerous slips resulting from minor adjustments are present.

ORE DEPOSITS

Character of the Mineralization

All the light cream to buff colored strata in the district, both tuff and lava, are altered in a fashion that differs in degree rather than in kind from that which characterizes the developed ore deposits. It appears that tenuous solutions suffused these strata over a wide area and were locally concentrated where condition were favorable. The more intensely mineralized material constituting the orebodies can scarcely be distinguished from the surrounding rock except by assay.

The principal products of the mineralization in so far as determined by the present study are gold, with its associated silver, pyrite, quartz and clay minerals. It appears from the reports of those familiar with the Dewey mine that small amounts of other metallic minerals, supposedly including arsenides, existed there, especially in the deeper workings. Evidence exists that the percentage of recovery by amalgamation in ore from this mine decreased somewhat with depth. Other ore deposits in the Challis volcanics in the surrounding region are now known commonly to contain a selenide resembling naumannite, so fine grained and sparsely disseminated as to be recognized only on the basis of chemical examination. 8/ This

8/ C. P. Ross: Ore deposits in Tertiary lava in the Salmon River Mountains, Idaho. Idaho Bur. Mines and Geol. Pamphlet 25 (1927) 13-16. Also subsequent unpublished data.

mineral is consequently to be expected in some of the ore in the Thunder Mountain district and may account for some of the reported difficulties in recovering the gold from this ore.

Pyrite is the only sulfide that has been recognized, and this is nowhere abundant. Rarely there are nodules of pyrite containing leaf gold in the center. These nodules assay $40 to $80a ton in gold. 9/ The rest of the pyrite, commonly

9/ J. B. Umpleby and D. C. Livingston: Op. cit., 6.

in tiny crystals, is presumably also auriferous, but a large proportion of the gold is in fine flakes of the native metal. Much of it appears to be deposited in cracks in the rock, rather than uniformly distributed through it. The highest annual average recovery in the Dewey mill during the period from 1902 to 1907 inclusive was 0.456 oz. of gold and 0.259 oz. of silver to the ton in 1904, and the lowest was 0.200 oz. of gold and 0.140 oz. of silver to the ton in 1907. The weighted mean for this period was 0.2915 oz. of gold and 0.1884 oz. of silver to the ton.

The loss in milling is unknown. It is reported that the ore mined ranged in value from $6 to $30 a ton, amd the above figures indicate that its average value was somewhat over $8 a ton. Judging By the reported returns from the relatively small proportion of ore so far milled at the Sunnyside and from the results of the owners' sampling, the main orebody there is of similar average tenor. There are considerable masses in which the tenor is $5 a ton or less, and in the Burr Oak tunnel, over 200 ft. below the haulage tunnel, values of $1 and somewhat more are reported. Less information is available regarding other mines in the district, but it appears that, outside of the Dewey and Sunnyside, no orebodies of any magnitude averaging over $5 a ton are known.

The gangue in all the deposits consists of the rhyolitic country rock in which the original feldspar and glassy material has been kaolinized and locally somewhat silicified. In some places, particularly in the Sunnyside, there are irregular seams filled either with white clay or fine-grained quartz. The clay is clearly a fissure filling and similar in mode of origin to the quartz seams. Study by and under the direction of C. S. Ross, U.S. Geological Survey, shows that the clay is made up of two slightly different potassic clay minerals resembling hydro-mica. Embedded in the clay are numerous small, doubly terminated quartz crystals. The definitely crystalline character of the clay, distinctly different from ordinary gouge clay, is well shown in Fig. 2, a photograph of a thin section by C. S. Ross. The chemical character of the clay is indicated by the analyses in Table 1, made on samples from the Sunnyside mine from which the quartz had been removed.

Table 1.- Analyses of Two Specimens of Clay from Sunnyside Mine

Analyst: J. G. Fairchild, U.S. Geological Survey

	Sample 1 Per Cent	Sample 2 Per Cent
SiO_2	57.02	47.50
Al_2O_3	26.10	31.52
Fe_2O_3	0.92	1.18
FeO	0.38	0.50
MgO	0.50	0.72
CaO	tr	0.64
Na_2O	none	0.19
K_2O	6.45	7.90
H_2O -	N.D.	N.D
H_2O +	8.20	9.92
TiO_2	None	tr
	99.57	100.26

STRUCTURAL RELATIONS

In the Dewey mine, so far as can be judged from available information and mine maps, the ore lay largely along a nearly vertical fracture zone, which evidently served as a conduit for the solutions; but mineralization was by no means confined to the brecciated rock. For example, development on No. 1 level penetrated mineralized ground in thoroughly altered rock for a length of over 600 ft. and a width of over 200 ft. although much of this was of a grade below that then being milled. In the extensive surface cuts, made by sluicing and otherwise, mineralization, at least in part hypogene, extends far into unbrecciated rock. This mine contained over 2000 ft. of workings which extended through a vertical range of about 240 ft. Mineralization continues below this depth, but ore of satisfactory grade appears to have been scanty below a depth of 114 ft. Stoping was carring through to the surface. In spite of the difficulty of maintaining openings in the clayey ground, there was one stope 10 square sets high, several sets wide and 46 sets long, showing that the better ore in the fracture zone was in shoots of fair size.

Conditions in the Sunnyside mine are fundamentally different. While, at the time of visit, the main workings totaled about 3600 ft., the stopes were comparatively small. Emphasis had been laid on development rather than production. The better ore is concentrated in irregular, ill defined masses immediately below the volcanic mud flow, which although thoroughly kaolinized appears to contain little or no gold. Both laterally and in depth the limits of the ore are those imposed by decrease in assay value. Most of the rhyolitic rock throughout the workings appears to contain appreciable amounts of gold. There is a progressive decrease downward to the lowest development over 250 ft. below the mud flow.

No fault or breccia zone of consequence is exposed in the workings, but in numerous places the rhyolitic rock is broken by slips and irregular seams, in part gouge-lined. The better defined slips strike north or a little east of north and dip steeply west. They appear to record merely minor movements of readjustment in the kaolinized rock.

The other accessible workings in the district, notably the Venable and Standard mines, expose diffused mineralization more closely resembling that at the Sunnyside than that in the fracture zone at the Dewey. Rock somewhat like the mud flow at the Sunnyside is present in some of the other workings but development is insufficient to show its relation to the ore.

ORIGIN

The relations outlined above suggest that mineralization was occasioned by tenuous solutions which suffused the strata sufficiently porous or easily replaceable to permit penetration. Where conditions were favorable, concentration took place. The fault zone at the Dewey, which provided a relatively easy path for the solutions, and the impervious volcanic mud flow at the Sunnyside, which trapped rising solutions, each in different ways brought about such concentration. The diminution in metallization with depth, the structural relations and the character of the assemblage of minerals deposited, strongly indicate that mineralization was brought about by heated, probably alkaline ascending solutions, rather than by the cool, acid solutions characteristic of descending circulation. At first glance the abundance of clay minerals might suggest an alteration process similar to that of weathering, but the principal resemblance is in superficial appearance. Where the clay fills fissures these pinch out upward rather than downward. The clay minerals are in clean-cut crystal flakes (Fig. 2) which is not tru

of clays derived from weathering. They are rich in potash and contain almost no soda. According to C. S. Ross, in clay produced by weathering the reverse is generally true even though many of the rocks weathered contain abundant potash. The presence of quartz crystals in the clay seams and of fresh pyrite in the kaolinized rock also indicates that descending circulation processes have played little part in the formation of the ore containing them.

Obviously supergene processes have had some effect locally, as is evidenced by the presence near the surface of small amounts of such oxidation products as limonite and manganese oxides. The ore originally mined by sluicing was more or less oxidized and probably was locally enriched. At one point on Dewey ground, direct proof of deposition of rich gold stringers by descending solutions was observed during the visit in 1926. Prospectors were working thin, nearly vertical seams in tuff beds that contained gold in flakes and grains, much of which was readily visible to the unaided eye and far coarser than that characteristic of the ore at depth. So much of the gold was concentrated near the upper contact of an irregular lignitic bed as to indicate that it was precipitated from water descending in the seams by the carbonaceous matter in the lignitic bed. So far as the evidence goes, however, processes of this sort were effective for only a short distance below the surface.

The data summarized above imply that the dominant process of mineralization was diffusion of solutions originating in depth and deposition from them. The source of these solutions is not quite so clear. It is possible that Miocene granite or related intrusive rocks are present at depth much closer to the Thunder Mountain district than is evidenced by known exposures. If so, emanations from them may have caused the mineralization. Another possible source is in the volcanic strata themselves. Lava is not commonly thought of as giving off large quantities of aqueous emanations, yet there is abundant evidence that a certain amount of such material is present in many lavas. Hydrothermal alteration sufficient to decompose ferromagnesian minerals and sericitize feldspars is common. The filling of vesicles with such minerals as quartz and zeolites is generally considered to be occasioned in part at least by aqueous emanations from the cooling lava. It would require but little variation in composition and increase in volume for genetically similar solutions to produce results such as those observed in the ore deposits of the Thunder Mountain district. Such solutions might be derived in part from the very strata now containing the ore deposits, but probably came in large part from more or less similar underlying strata.

These ore deposits differ in numerous features from most of those elsewhere in Idaho. There are even marked differences between them and the more common deposits in Tertiary lava, characterized by ribbon-banded quartz, although, as has been pointed out,[10] there are also important resemblances. These differences

10/ C. P. Ross: Op. cit., 14, 15.

point to some modification at least of the conditions governing the formation of the deposits. The theory that the mineralizing solutions of the Thunder Mountain district were derived from the same sources as the volcanic strata seems more probable than that they came from some granitic mass at depth.

A somewhat different theory has been advanced by Zies [11] to account for

11/ E. G. Zies: The concentration of metallic constituents by volcanic emanations Bull. Nat. Research Council 61,(1927) 263-265.

conditions in the Valley of Ten Thousand Smokes in Alaska, which are, in some respects, similar to those of the Thunder Mountain district. He considers that silver, lead, copper, tin, molybdenum and zinc found in fumarole deposits in the Valley of Ten Thousand Smokes were derived from the surrounding rhyolitic pumice and were concentrated by means of emanations of steam from some fairly deep-seated igneous body. Part of the material deposited, notably the magnetite, he regards as having come from below in combination with halogens. Such a theory would accord with the conditions that appear to have existed during the formation of the orebodies of the Thunder Mountain district, except that there is little indication of the existence of restricted fumarolic vents, and all available evidence suggests that the approximately contemporaneous granitic intrusions lie far east and northeast of this district.

COMMERCIAL OUTLOOK

The comparative neglect that the Thunder Mountain district has suffered since 1908 results in part from its remoteness and in part from lack of clear comprehension of its ore deposits, which differ in material respects from any other in Idaho. Recent developments to the west have greatly reduced the distance from modern roads and the improvement in motor trucks and airplanes has made remoteness from railroads a much less serious factor than was formerly the case. Much more quantitative information as to grade and size of the orebodies is required before an adequate concept of the commercial value of the deposits can be arrived at. The grade of the ore is not high and difficulties in mining in the clayey ground and in recovering the fine and partially refractory gold are to be anticipated. However, modern technique should overcome these disadvantages, and it would seem that the outlook is sufficiently favorable to warrant thorough investigation in the near future by an organization capable of operating on a large scale.

The amount of mineralized rock present is very large. Pockets and stringers of high grade, mainly supergene, ore can still be found here and there by individual prospectors, but the quantity of such ore remaining is probably so small as to be negligible in plans for any large-scale operations in the district. A company reopening any of the mines must expect to handle ore containing $8 to the ton and less. The average tenor of the ore might well prove to be little more than one-half this figure and much of the mineralized material is of even lower grade. In many places ore will be found practically at the surface. Elsewhere the overburden may be considerable. Although the oreshoots developed in the Dewey and Sunnyside mines decreased markedly in grade below a depth of 100 ft., there is no apparent reason why structural conditions favorable to the formation of other oreshoots should not exist at least to the bottom of the local light colored rocks.

The most profitable period in the history of the district appears to have been that in which the Caswell brothers and Huntley operated by sluicing the rock at the surface. This process is of obviously limited application, but some such cheap, nonselective method of mining seems to offer the most hope for future development. Presumably at least 60 per cent of the gold could be recovered by simple amalgamation. Flotation or other processes that could be utilized in a modern mill would doubtless result in a high recovery.

While mineralization exactly like that at Thunder Mountain has not been discovered in amounts sufficient to be of commercial interest anywhere else in Idaho there remains a possibility that prospecting directed specifically to that end might be rewarded. Outcrops of such lodes would be so inconspicuous and differ so much from the quartz ledges commonly sought that they might well escape notice. Mineralization is certainly widespread in the Challis volcanics. This is attested

not only by the famous Yankee Fork district, Custer County, and the less known Parke Mountain and Gravel Range districts, Lemhi County, but by numerous scarcely prospected occurrences scattered over the Salmon River Mountains.12/ Most of the

12/ C. P, Ross: Op. cit., 1-21; also subsequent unpublished observations.

mineralization is in or closely associated with rhyolite and rhyolitic tuff in the upper part of the Challis volcanics. This horizon is easily recognized, since it everywhere consistes largely or entirely of nearly white rocks. Any area in it where there has been intense kaolinization or the dissemination of pyrite or quartz is worthy of investigation.

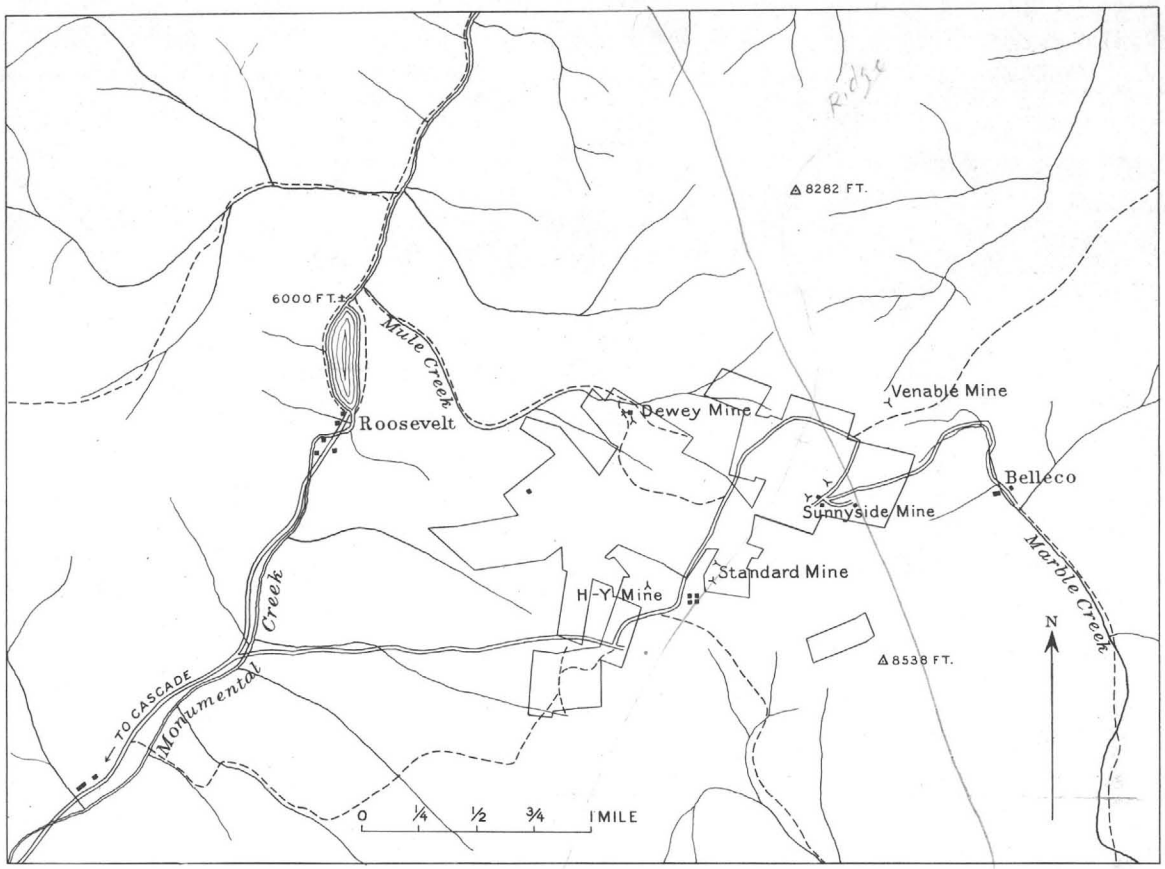

Fig. 1.-Sketch Map of the Thunder Mountain Minimg District, Valley County, Idaho Modified from Forest Service Data. Outlines of Principal Groups of Claims from a Map by Gordon C. Smith

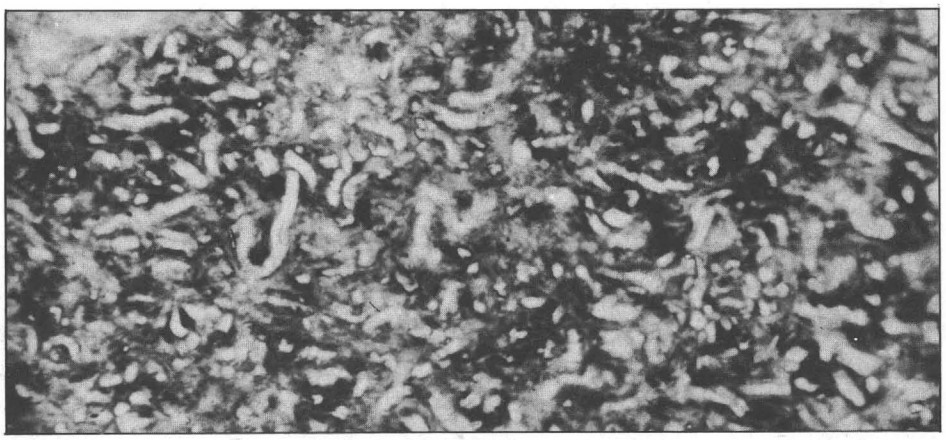

Fig. 2.- Photomicrograph of clay from the Sunnyside mine. Magnification roughly X 50. By C. S. Ross.

It seems reasonable to suppose that the north-south segments of the Ima fractures represents older fractures connected with the regional folding along north-south axes and reopened by younger, northwest arching. Such reopened fissures are less favorably oriented with respect to the tensional pull exerted by arching than are the northwest fissures parallel to the anticlinal axis;this may explain the apparent preference of ore for the northwest segments of the composite Ima fracture system.

Casto Arch, Idaho

Sources.-

C.P.Ross(1934), Geology and ore deposits of the Casto quadrangle, Idaho, U.S.Geol.Survey Bull.854.

Thor H. Kiilsgaard(1948), Unpublished term paper,Graduate School, University of California.

General Description

About 60 miles northwest of the Ima tungsten district a straight northeast belt of granite of Miocene age forms the core of an elongated arch manifested by upfolding of overlying Challis Oligocene(?) volcanics. Granophyre dikes intrude the granite and its cover,striking for the most part with the arch axis and dipping southeast and northwest toward the axial plane. These dikes invaded longitudinal tension fissures formed during the earlier,pre-faulting stage of arching. The faulting stage is represented by a series of antithetic faults oriented like the dike fissures but with downthrows toward the axial plane of the arch. (Ross,1934,p.77;Plate I).

According to Ross(1934,p.77)

"The faulting may well have proceeded concomitantly with the folding and prevented the full development of the arch."

This notion parallels closely the ideas of H.Cloos concerning graben formation on the crests of rising arches.

In the Yankee Fork or Custer district, on the southeast flank of the Casto arch sheeted zones striking parallel to the axis of the arch and dipping noryhwest into the core of the arch carry narrow quartz lenses showing ribbon structure. The district has produced nearly $15,000,000 worth of silver and gold (Ross, 1927; Anderson, 1949).

At the northeast end of the arch, where arch and granite core start to plunge northeast lie the Yellowjacket and Columbia mines. (Ross, 1934, p.110-113). The country rock is Beltian quartzite dipping northeast in the direction of plunge of the arch.

Radial fracturing on the nose of the plunging arch is represented by a fault west of the Yellowjacket mine and striking N30°E, and by the Yellowjacket lode which trends N70°E. Both fractures are nearly vertical.

The Yellowjacket lode is a shatter zone containing numerous stringers a veins separated by altered quartzite. Another set of veins in the area strikes northwest, showing a cross joint arrangement with respect to the Casto arch (Fig.4F). The veins are gold-quartz with sparse galena.

The famous "porphyry belt" within the Idaho batholith lies along the southwest prolongation of the Casto arch, and contains countless porphy dikes of the same age (Miocene) as the Casto granite and granophyre dikes. The dikes of the porphyry belt invaded preexisting fissures and sheeted zo reactivated for their benefit (Ross, 1933, p.329-343; 1934B, p.1933, p.265-272). Important gold-quartz lodes within the porphyry belt parallel the dikes.

El Oro District, Mexico and Michoacan, Mexico

Sources.-

R.T.Hill (1905), El Oro district, Mexico, Engr.& Min.Jour., Mar.2, 1905, p.410-413.

El Oro Mining & Railway Co. (1905, 1908), Reports to shareholders.