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DEPARTMENT OF THE INTERIOR - - UNITED STATES GEOLOGICAL SURVEY
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BULLETIN 594 - - -

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SOME MINING DISTRICTS IN NORTHEASTERN CALIFORNIA AND NORTHWESTERN NEVADA.
By James M. Hill.

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## AURORA (ESMERALDA) DISTRICT, MINERAL COUNTY, NEVADA.

### Location and Accessability.

The old Esmeralda mining district at Aurora, Nev. (No. 14, Pl. 1, p.18), is 28 miles in an air line southwest of Thorne, a town on the Hazen-Tonopah branch of the Southern Pacific and its nearest railroad point. The town of Aurora is 3 miles east of the California-Nevada boundary, 16 miles north of Mono Lake and 1½ miles east of Bodie Canyon. The region is shown near the center of the west side of the Hawthorne topographic sheet of the United States Geological Survey.

The district is most easily reachedby the automobile stage which runs daily between Hawthorne, Nev., and Bodie, Cal. It is possible to enter this part of Nevada by way of Minden, the southern terminus of the Virginia & Truckee Railway. Stages operate between that town and Wellington and thence south to Bodie, Cal., but the trip requires three days in contrast to the half-day run from Hawthorne.

### History and Production.

The Old Esmeralda, near the southern limit of the productive area (see Pl. XIV, A, p. 148), was the first vein discovered in the Aurora district. According to Wasson, James M. Brawley, J.M.Cory, and E.R.Hicks made the discovery on August 22, 1860, and immediately located four claims. The town of Esmeralda was built in the gulch just east of the discovery, but later in the year the present town site of Aurora, 1½ miles north, was laid out. The first mill, owned by Edmund Green, was put in operation in 1861, and was followed shortly by several arrastres and mills. In 1864 there were 17 amalgamation mills in the district, the largest, which had 30 stamps, being the Real Del Monte in Bodie Canyon. Up to the year 1864 the camp was very prosperous. Aurora had a population of about 10,000 and was the county seat of Mono County, Cal. During the year 1864, however, misfortunes befell the camp. The California-Nevada boundary was run and showed that the Esmeralda district lay in Nevada; the rich bonanzas in the Wide
Page 142. West vein on Last Chance Hill became exhausted and bitter litigation over the ownership of the veins on Last Chance Hill developed. The camp, however, continued to prosper until 1882, though the supply of $75 ore, which in earlier times could not be mined, was then becoming depleted. In 1880 an English company acquired possession of the main group of claims on Last Chance Hill. It began operations in 1887, starting the Real Del Monte shaft and connections with the Durant vein on Middle Hill, but suspended work in 1892 after a vain effort to keep the lower workings of the 800-foot shaft free from water.

Most of the claims in the Exmeralda district were owned in July, 1913, by two companies, the Cain Consolidated Co. and the Aurora Mines Co. The Aurora

Mines Co.'s chief group, containing 11 claims, lies on Silver Hill, though they own 5 claims on Aurora Hill. The Cain Consolidated Co. controls about 40 claims, among which are some of the famous producers of the district. In the summer of 1912 these holdings were under option to certain financiers of Tonopah, Nev., who have, according to reports of the mining journals, taken up the ground and started operations.

Most of the productive ground of the district has now been acquired by the Goldfield Consolidated Mining Co. A 500-ton cyanide mill has been built, and there is every prospect that Aurora will again be a producing camp.

The records of production are incomplete. According to a statement of Wells, Fargo & Co. the bullion shipped through them up to 1869 had a value of $27,000,000. Mr. Wasson gives the following table of gold bullion shipped without insurance:

Bullion shipped from Aurora without insurance from 1861 to 1869, inclusive.

| | | | |
|---|---|---|---|
| 1861 | $ 43,417.28 | 1867 | $ 130,656.89 |
| 1862 | 173,148.82 | 1868 | 98,188.88 |
| 1863 | 546,019.16 | 1869 | 28,166.50 |
| 1864 | 952,023.29 | | |
| 1865 | 237,185.23 | | |
| 1866 | 158,162.77 | | $ 2,365,968.82 |

He further says that between seven and eight million dollars' worth of bullion was shipped by express in 1864 and about $12,000,000 prior to the year 1869. If the reports of production of some of the stopes are taken into consideration, even so large a sum as $27,000,000 seems a small showing for the camp.

## Topography.

There are four rather low hills south and east of the town of Aurora (see pl. XIV), known as Silver, Middle, Last Chance and Humboldt. The town has an elevation
Page 143. of 7,415 feet above sea level. Silver and Middle hills are seperated by Esmeralda Gulch. They are long, northward-sloping spurs from the Brawley Peaks, which rise to a height of 9,557 feet about 2½ miles south of the town. Last Chance Hill, east of Aurora, is a low divide, less than 150 feet above the valley, which seperates Willow Creek from the Gregory Flat drainage basin. Humboldt Hill, a low rounded knob about three-fourths of a mile northeast of Aurora, rises to a height of a little over 7,600 feet. The mines of the Aurora district are located on these four hills, though at the east end of the flat north of town and about 150 feet higher than are a few veins near Humboldt and Last Chance hills.

## Geology.

The rocks exposed in the Esmeralda district are, with a single exception, of volcanic origin. In the bottom of Willow Gulch, about 2 miles southwest of Aurora (see Pl. XIV), there is a small, indistinct exposure of a rock that appears to be the basement on which the flows were extruded. It is a coursely porphyritic, granular rock, and is probably to be correlated with the granodiorite and associated rocks of the Sierra Nevada. At least three series of flows overlie this granular rock. The oldest of these flows consists of grayish-green altered rocks that are largely biotite-quartz latites, together with some andesites. This series is exposed on Silver, Middle, Last Chance, and Humboldt hills, and extends southeast up Willow Gulch for an unknown distance. These rocks, which are at least 900 feet thick, inclosed all the veins of the district, none being found in the younger rocks.

Above these flows of intermediate chemical composition lies a series of light-gray to brownish-gray rhyolites that are particularly well exposed on the flats north and northwest of Aurora along Bodie Creek, where they are 1,000 feet thick, and also on Granite Mountain, about 1 mile southeast of town, where there is a remnant of the series about 300 feet thick. Above both the andesites and rhyolites lies a black vesicular basalt that forms Aurora Crater (see pl. XIV) and covers

a large expanse of country to the west of Granite Mountain. It ranges from about 10 to over 600 feet in thickness. Itsweathered surfaces are brown.

All these flows appear to have a gentle dip to the north-northwest. It seems probable that there was a time or erosion between the andestre and rhyolite eruptions, as the rhyolite flows rest on an uneven surface that looks like an erosion surface.

There was unquestionably an interval of considerable length between the rhyolite and basalt eruptions, for the base of the later flows rest in the bottoms of
Page 144. gulches in some places and on the tops of ridges at other places.

The latites and associated andesites seem to have been exposed by the erosion of the capping rhyolite along the Willow Creek drainage basin, and Granite Mountain seems to be a remnant of this capping which escaped erosion. It does not seem probable that the basalt ever extended much beyond its present limits, as shown on Plate XIV, for the edges of the flows are fresh and in some places along the gulch northeast of Gregory Flats show the piled-up, overturned marginal portions of quickly cooled lava sheets.

## Topographic Expression Of The Different Rocks.

The oldest flow rocks are all much altered and are rather easily eroded, except where they have been silicified near the veins. As a consequence the mineralized hills have, as a rule, even and rather gentle slopes, as is shown in the view of Last Chance Hill (Pl.XV). At the southern end of Silver Hill, where the rock is much silicified near the Bald Eagle, Spotted Tiger, and Radical veins, the generally smooth andesite surfaces are interrupted by steep cliffs, as shown in plate XIV, A.

The rhyolite series weathers in rough cliffs and the surfaces of the flows are marked by small steep-sided gullies. On the long ridge northwest of Aurora, near Bodie Creed, the topography suggests the badland forms at many points, especially on the northwest side of the ridge.

The surface of the basalt flows is very rough, making the crossing of these areas difficult, even on foot. Aurora Crater is a basaltic vent, the northwest rim of which has been cut through by erosion. It is a beautiful example of a small volcano, with the successive flows clearly traceable on its rough scarred sides.

## Petrography.

Porphyritic granite. - The single exposure of porphyritic granite in the district lies in the bottom of Willow Gulch, about 1½ miles southwest of Aurora. Its boundaries are not well shown on account of the wash, but the andesitic flows clearly rest on this basement. The outcrop is small and deeply weathered, practically no fresh rock being visible. Numerous large pink orthoclase crystals, the maximum length being 2 inches, are present in the residual sand covering part of the area. The weathered surfaces have a light greenish-gray color, owing to the alteration of the constituents, The rock is rather coarsely granular throughout and contains very large, zonally built, pink orthoclase phenocrysts.

Page 145. In thin sections the groundmass of this coarse porphyry is seen to be inequigranular. None of the minerals, except the phenocrysts and accessory minerals, show any crystal form. The minerals present in this rock, named in the order of their abundance, are orthoclase, quartz, microperthite, green hornblende, brown biotite, microcline, muscovite, and oligoclase. The accessory minerals are titanite, magnetite and apatite. The ferromagnesian minerals are somewhat chloritized, and the feldspars are more or less kaolinized. Some of the muscovite appears to be primary, but part, at least, is bleached biotite. The titanite and magnetite are closely associated and inter-growths of these two minerals are common.

Biotite-quartz latite.- The general country rock on the hills in the vicinity of Aurora, in which the veins are found, is a greenish-gray to gray altered porphyry which ranges from rather fine to medium grain. Few of the phenocrysts are more than an eighth of an inch in diameter, and most of them are less. The most widely distributed type of rock has a fine-grained greenish-gray groundmass, thickly studded with small white lath-shaped phenocrysts. All the rock of this type carries some disseminated pyrite, which is particularly abundant near the veins.

The thin sections show that this rock originally consisted of phenocrysts of andesine, biotite, and possibly pyroxene, set in a fine-grained matrix of andesine, with some ferromangnesian minerals. Some interstices of the groundmass contain intergrowths of quartz and orthoclase. The rock is a biotite-quartz latite. All the rocks are very much altered, presumably by the hot calcereous solutions which deposited the veins. The andesine phenocrysts are altered to calcite, sericite, some quartz, and some of them show a little green epidote. The ferromagnesian minerals are completely altered to chlorite and some magnetite. The ground mass is altered to an aggregate of sericite, chlorite and quartz. Near the veins the alteration has been much more intense than at a distance of 150 to 200 feet from them. In these highly altered zones quartz has been added to the body of the rock, which is also abundant in the rock near the veins, whereas chlorite is more commonly developed in the rock at a distance from the veins.

Andesite.- Near the bottom of Esmeralda Gulch, 1 mile south of Aurora, there is a fine-grained light-green porphyry apparently intrusive into the biotite-quartz latite, though it may be an underlying flow. This fine-grained dark rock is exposed in several other localities in the district, and it is probably rather widewpread in distribution.

Page 146. This rock is much altered and contains disseminated pyrite in small quantities and is cut by quartz and calcite stringers.

Thin sections of this rock show that its groundmass is composed of microscopic lath-shaped crystals of andesine and augite, the latter mineral altered to chlorite. In this groundmass are set small well-developed phenocrysts of zonally built andesine and of augite, both of which are altered, the augite to green chlorite and the feldspars to grayish aggregates of sericite and chlorite.

Rhyolites. - The rhyolite series is made up of a number of relatively thin flows, all of which are glassy. They range in color from gray through green to purple. Some of them appear to be tuffaceous, but the majority are typical flow rhyolites. On the flat north of Aurora some pearl-gray perlitic rhyolites are seen near the top of the series. Flakes of biotite are seen in all of these rocks, and quartz can usually be detected with the unaided eye. Thin sections show that the rock consists of a glassy base having, as a rule, distinct flow structure, which contains a few phenocrysts of quartz, orthoclase and biotite. Some of the slides show that the groundmass suffered some devitrification, accompanied by the development fo chlorite and sericite.

About one-fourth of a mile southeast of the Old Esmeralda Tunnel a small, indistinct body of rhyolite has been altered to a soft white mass by hydrothermal action, but the flows at other places show no alteration by hot waters.

Basalt. - The basalt of Aurora Crater is a very fresh vesicular black rock showing a few small green olivine crystals to the unaided eye. Under the microscope the groundmass is seen to be composed of microscopic labradorite laths and grains of nearly colorless augite set in a black glass paste. The flow structure is well shown by the rough parallel orientation of the long dimensions of the plagioclase laths, many of which bend around the vesicular openings.

## Quaternary Gravels.

The Quaternary deposits on lower Bodie Creek, shown at the top of plate XIV, consist of unconsolidated sands, gravels and silts, which a little north of the area shown on the map are quite thick and extensive. The surface is covered by

fine sandy loam, which under irrigation has produced excellent crops.

On Last Chance Hill there is a small area underlain by roughly stratified volcanic material, shown in the caved Chihuahua stope. (See PL. XIV, B. p. 148.) This material ranges from a few feet to a maximum of 20 feet in thickness and appears to have been reworked by streams.

In the canyon northwest of Gregory Flats and about 1½ miles due north of Aurora a warm spring issues from beneath the basalt of Aurora Crater. This spring
Page 147. deposits limonite and aragonite. The aragonite forms crusts from one-fourth inch to4 inches in thickness, though most of the crusts are less than 2 inches thick. The entire deposit covers an area of about 150 feet square to a maximum depth of 15 feet.

## Ore Deposits.

Distribution of the veins. - The ore deposits of the Esmeralda district occur as veins that cut the biotite-quartz latite and associated andesite over an area extending in a northeast-southwest direction, about 2 miles in length by 1½ miles in width. Aurora is near the center of the northwest side of the productive area. On Silver and Middle hills the veins are rather closely spaced and have, with one exception, a persistent strike of about N. 45 degrees E., though strikes between N. 40 degrees E. and N. 50 degrees E. are seen in many places, even along veins whose average course is N. 45 degrees E. These veins all dip to the southeast but at different angles. The largest and apparently the strongest veins - that is, the Eureka, the Antelope and Lady Jane, the Cortez and Utah, and the Spotted Tiger and Bald Eagle veins - all dip between 45 degrees and 60 degrees SE. into the hill, but some of the smaller veins slope southeast at much flatter angles. An exceptional vein system on Silver Hill is represented by the Old Esmeralda and Radical veins, which strike about N. 10 degrees E. and stand nearly vertical. The outcrops of these veins are wider than any of the northeast-southwest system, the Old Esmeralda being 80 feet wide and the Radical between 20 and 30 feet in maximum width.

On Last Chance and Humboldt hills the veins strike more nearly east and west ranging between N. 60 degrees E. and N. 80 degrees E., and with the exception of the Humboldt and Prospectus veins, which dip 80 degrees N., they dip to the west-southwest at angles ranging between 65 degrees and 75 degrees. Some of the smaller veins have flatter dips, but the strong, well-defined ones stand more nearly vertical. The veins on these two hills have been displaced by a nearly vertical fault, whose strike ranges from N. 20 degrees E. at the Humboldt vein to N. 30 degrees W. at the Real Del Monte vein. The horizontal displacement along this fault has amounted to over 600 feet, the veins west of the fault being at least that far north of their continuation on the eastern side. Thus the Humboldt vein on the east side of the fault along the crest of Humboldt Hill is the Prospectus west of the fault. (See Pl.XIV, p. 142.)

It is said that about 6 miles northeast of Aurora lies a small area of andesite in which there are some veins, but the locality was not visited.

Character of the veins. - The veins of the Esmeralda district range from a fraction of an inch to 70 or even 80 feet in width. They are as a rule between 18 inches
Page 148. and 4 feet wide, and can generally be traced for several hundred feet along the strike. They are not simple, clean-cut veins, but send off numerous small interlacing branches into the walls, particularly on the footwall side. This tendency of the veins is well seen on the edge of the Old Chihuahua stope on Last Chance Hill. (See Pl. XIV, B.)

Along some of the veins there has been postmineral movement. This movement has usually taken place along the hanging wall and has been slight, producing in most places a thin clay parting between the country rock and quartz.

The vines consist in great part of finely granular, white, barren-looking quartz. In some places the quartz is so fine grained that it has a milky-white

porcelain-like appearance. The veins are banded by crustification, the different bands being due to the difference in size of the quartz grains. In all the veins there are small druses lined with minute clear quartz crystals. The rich ore is always marked by irregular wavy streaks of what appears to be dark quartz, cutting the white low-grade or barren vein filling.(See Pl. XVII, A.) In reality these rich streaks are made up of quartz, adularia, argentiferous tetrahedrite, and small amounts of pyrite and chalcopyrite, together with a soft bluish-gray mineral supposed to be a combination of gold and possibly silver with selenium. Some free gold is found here and there in the richest ore now mined, and the old stopes are said to have contained large quantities of free gold.

The adularia is notably absent from most of the white barren quartz, but was found in soft, narrow kaolinized bands in white quartz ore from the Humboldt shaft. In practically every thin section of the ores studies there is a small amount of sericite in thin flakes cutting the quartz crystals. In all the thin sections of very rich ore adularia is abundant, being associated with the quartz and commonly inclosed in the interlocking quartz grains. As a rule the rhombic forms of adularia are not seen, the mineral occurring in irregular masses.

Qualitative tests of a small piece of rich ore from the 350-foot level of the Durant vein at Aurora show the presence of selenium but no tellurium. It also contains a rather large quantity of iron and copper, smaller quantities of silver and gold, and some antimony. A polished section and thin section of this ore show the undoubted presence of pyrite, chalcopyrite, tetrahedrite, and free gold. There is also a small quantity of a sort bluish-gray mineral, that is distinct from the tetrahedrite, which is thought to be a selenium-gold and possibly silver compound. This mineral occurs in minute specks and could not be seperated from the other constituents.

Page 149. The presence of selenium without tellurium sets these veins apart, for there are only a very few mining districts in the United States where this combination of ores is found.

Spurr says that at Tonopah the veins are chiefly due to replacement of the andesite by quartz and the ore minerals along zones of fracture. Crustified veins clearly due to filling of open spaces are exceptional at Tonopah. The mineralizing agent he considers to be "volcanic waters that were hot and ascending." The primary ores at Tonopah, according to Spurr, contained quartz, adularia, carbonates of lime, iron, magnesia and manganese, silver sulphite, probably polybasite or stephanite, and argentite, silver chloride, chalcopyrite, pyrite, galena, sphalerite, and gold in an undetermined form, and silver selenide.

At Republic the veins which seem to bear more resemblance to those at Aurora, according to Umpleby, occur along fissure fillings that have an average width of 3½ feet. The unalgered vein material is a firm white quartz with wavy ribbons of a bluish-gray cast. The veins are made up of quartz, chalcedony, opal, calcite, and adularia, carrying inconspicuous amounts of pyrite and chalcopyrite, with silver and possibly gold, in association with antimony, sulphur and selenium. The most striking feature of the Republic ores is the extremely barren appearance of the quartz. Fluorite was noted in the slides. The silver is thought to be partly in the form of silver selenide and partly as a component of gray copper. Some gold is free, but most of it is probably combined with selenium and tellurium.

Lindgren says of the Republic veins that the banding is due to the difference is size of the quartz grains; that the ore minerals occur in extremely fine distribution in thin black streaks, generally near the walls. In the rich portion of the veins tetrahedrite and chalcopyrite have been identified, but the principal ore mineral, presumably a selenide of gold and silver, occurs in such fine distribution that it has not yet been isolated.

As it was impossible, on account of the condition of most of the mine workings, to study the veins at Aurora at depth, a satisfactory understanding of the distribution of the good and poor ore was not reached during this reconnaissance. From what could be learned, however, it would seem that the rich ore occurred in
Page 150. relatively small shoots in the large barren veins. There were five such shoots, which were exceptionally large on the Wide West vein on Last Chance Hill.

In the majority of the veins it is understood that the rich ore streaks, ranging from a fraction of an inch to 6 inches in width, were as a rule found near the walls, particularly the hanging wall, and that they were not continuous along the veins for any considerable distance. It is almost certain, however, that the barren-looking white quartz, where it shows even a slight suggestion of the bluish color, carries gold.

The veins are said to have been in general considerably wider in the richer portions. This was particularly the case on the Wide West vein, where some of the stopes were as much as 60 feet wide, though the leaner portion of the vein between the stopes ranged from 6 to 10 feet in width.

As only the surface workings and outcrops of these deposits could be studied it is not possible to give detailed descriptions of the veins.

Tenor of the ore. - The average ore from any vein is probably of low grade. Ore which is taken from rich shoots may run up to $1,000 a ton. The average gross value of the ore is reported to be about $6 to $8 a ton, the ratio of gold to silver being 1 to 2 or 1 to 5. It is said that in the ore mined in the early days from the rich stopes on Last Chance Hill the ratio of gold to silver was as 4 to 2.

Origin of the veins. - The veins of the Esmeralda district were formed in open fissures by hot ascending, very siliceous solutions. These solutions were capable of altering the inclosing biotite-quartz latite for considerable distance from the veins. In one or two small veins cut by the Monarch tunnel on Silver Hill the quartz shows the typical form of replacement after calcite, common to the quartz-adularia type of veins (Pl. XVII, B). Pure white calcite was found on the dump of the Humboldt shaft that was said to come from the 450-foot level, though none was found above the 100-foot level in the mine. This ore seems to show that calcite was deposited before the quartz, which appears to replace the carbonate. It is questionable, however, if any considerable time intervened between the deposition of the calcite and the engrance of the silica-bearing solutions. Certainly in most of the ore there is little suggestion that the quartz shows the drystal forms of this mineral usually seen where it is deposited alone in open fissures.

The age of the formation of these veins is not certainly known, though they were formed after the eruption of the biotite-quartz latite and associated andesite and before the succeeding flows of rhyolite. It is probable that they are representatives of the late Tertiary mineralization common to the Great Basin region.

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Out of 18 assays, 7 averaged twenty-odd dollars. 3000 to 4000 tons on a dump averaged $18.00 - There are 7 tunnels on the property - one 3000 feet long - in good condition.