THE GOLDEN ARROW, CLIFFORD, AND ELLENDALE DISTRICTS, NYE COUNTY, NEVADA.

By Henry G. Ferguson.

INTRODUCTION.

In connection with other work in central Nevada an opportunity arose for brief visits to the three small mining camps here described. Such observations as could be made in the short time available are presented as a minor contribution to information concerning the ore deposits of Nevada.

Golden Arrow and Clifford are situated at the western base of the Kawich Range in Nye County, Nev., and are reached by automobile from Tonopah. The Clifford district is on the main road between Tonopah and Ely, about 35 miles east of Tonopah, and Golden Arrow is 12 miles southwest of Clifford. Neither district has yet produced much ore. At the time of visit one man was working at Clifford and three at Golden Arrow. Ellendale, a few miles east of Tonopah and a short distance south of the Tonopah and Ely road, is now abandoned. The opportunity of visiting these districts was due to the kindness of Capt. W. G. Cotter and Mr. D. Johnson, of Goldfield.

The Kawich Range and its northern continuation, the Hot Creek Range, were visited by Spurr during his reconnaissance of southern Nevada in 1899, and the following description of the Kawich Range[1] is quoted from his report:

> The Kawich Range forms the southern continuation of the Hot Creek Range, from which it is separated at its northern end by a narrow transverse pass. From this point it extends due south about 60 miles, where its southern end runs out into the desert valley. The range is high and is deeply eroded into bold, craggy mountains. On both sides the slope of the mountains is steep, especially on the west, where there are almost impassable cliffs. On the flanks of the range on both sides of the rugged backbone are smooth mesa-like forms.

In 1905 Ball[2] made a more detailed study of the part of the range south of the thirtieth parallel. The accompanying map (fig. 13) is taken from the geologic map in his report. In the southern part

[1] Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel: U. S. Geol. Survey Bull. 208, p. 181, 1903.

[2] Ball, S. H., A geologic reconnaissance in southwestern Nevada and eastern California: U. S. Geol. Survey Bull. 308, pp. 99–114, 1907.

of the range are areas of Paleozoic sedimentary rocks which are correlated with the Pogonip limestone and Eureka quartzite of the Eureka section. The section (fig. 14) given in Ball's report[1] shows eastward-dipping monoclinal structure.

A considerable thickness of Silurian sediments is exposed on the eastern flank of the Hot Creek Range,[2] and rhyolite forms the western side of the range. The sedimentary series is cut by two normal faults striking north, with downthrows to the east of 1,000 and 300 feet. Spurr considers that these faults are pre-Tertiary, and his map indicates that they do not continue into the area covered by Tertiary volcanic rocks.

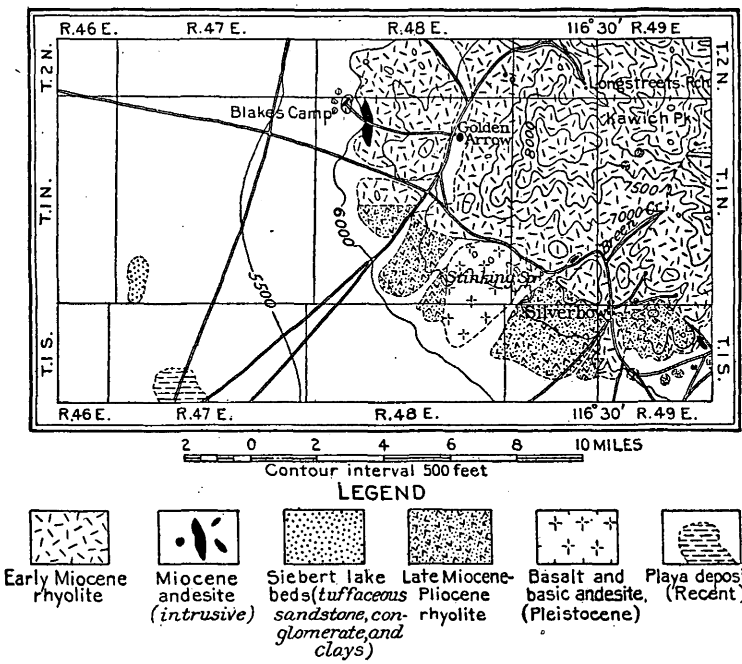

FIGURE 13.—Geologic map of Golden Arrow, Nev., and vicinity. The area without pattern is occupied by Quaternary gravels and sand. (After S. H. Ball.)

The Reveille Range, the next range of the Kawich, has westward-dipping Cambrian strata on its east side,[3] and Ball[4] states that the eastern slope of the range is the more precipitous.

West of the Kawich Range, midway between it and Tonopah, are the Stone Cabin Hills, the southern extension of the Monitor Range. These are a group of low irregular hills which, so far as could be observed, consist of rhyolite and tuff with small masses of intrusive andesite. Gilbert[5] has noted a spur of metamorphic rock

[1] Ball, S. H., op. cit., p. 108.
[2] Spurr, J. E., op. cit., pp. 85–87.
[3] Idem, p. 152.
[4] Ball, S. H., op. cit., p. 113.
[5] Gilbert, G. K., U. S. Geog. and Geol. Surveys W. 100th Mer. Rept., vol. 3, p. 121, 1875.

on the west side of the range at its south end. Ball's map shows Paleozoic sediments and later granitic intrusives on the west side of the Cactus Range, which lies to the south of the Stone Cabin Hills. The northern part of the Monitor Range, according to Spurr,[1] shows a scarp facing westward.

Neither Spurr[2] nor Ball[3] considers that faulting played any important part in the origin of the Basin Ranges, but recent studies by Davis[4] and Louderback[5] have shown that certain of the ranges are undoubtedly due to faulting. As regards many of the ranges, including the Kawich, the evidence is not conclusive in favor of either hypothesis. If the ranges represent tilted fault blocks, erosion has proceeded far enough to remove direct physiographic evidences of faulting. The steeper western front of the Kawich Range, the wall of cliffs on its west side, and its eastward-dipping monoclinal structure constitute evidence favoring the conclusion that the range is a fault block tilted to the east. The monoclinal structure shown in the section is, however, explained by Ball[6] as the western limb of the

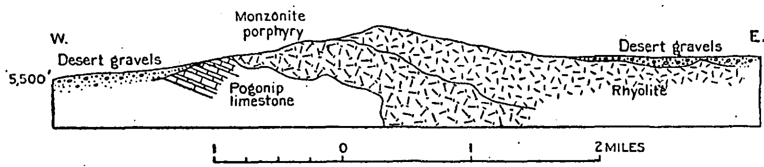

FIGURE 14.—Section across Kawich Range 2½ miles north of Kawich, Nev. (After S. H. Ball.)

Reveille Valley syncline. Evidence against faulting is found in the presence of many small hills, such as Deadhorse Hill, at Golden Arrow, and the andesite hill at Clifford, which form outliers to the east of the range, and the fact that the desert wash does not reach the mountains but is separated by a belt of rock-surfaced plain. These features are not incompatible with faulting, however, if the time since the formation of the range has been sufficient to allow eastward retreat of the fault scarp for a few miles, with consequent loss of regularity.

GOLDEN ARROW DISTRICT.

The Golden Arrow district lies a few miles south of the north end of the Kawich Range and nearly 40 miles east of Tonopah. Although the low Stone Cabin Hills lie between, the lights of the

[1] Spurr, J. E., op. cit., p. 89.

[2] Spurr, J. E., Origin and structure of the Basin Ranges: Geol. Soc. America Bull., vol. 12, pp. 217–270, 1901.

[3] Ball, S. H., op. cit., p. 42.

[4] Davis, W. M., The mountain ranges of the Great Basin: Harvard Coll. Mus. Comp. Zool. Bull. 42, Geol. ser., No. 6, 1906.

[5] Louderback, G. D., Basin Range structure of the Humboldt region: Geol. Soc. America Bull., vol. 15, pp. 219–346, 1904; vol. 18, pp. 663–669, 1906.

[6] Ball, S. H., op. cit., p. 42.

Tonopah-Belmont mill are clearly visible from Golden Arrow. The mines are situated on a narrow strip of rock-cut plain between the mountains and the desert valley to the west. There is no sharp line between desert wash and rock outcrop, and the loose material near the mountains is clearly only a thin veneer on the underlying rock. The region is barren and desolate, supporting only scanty desert vegetation, but the higher hills to the east carry a sparse

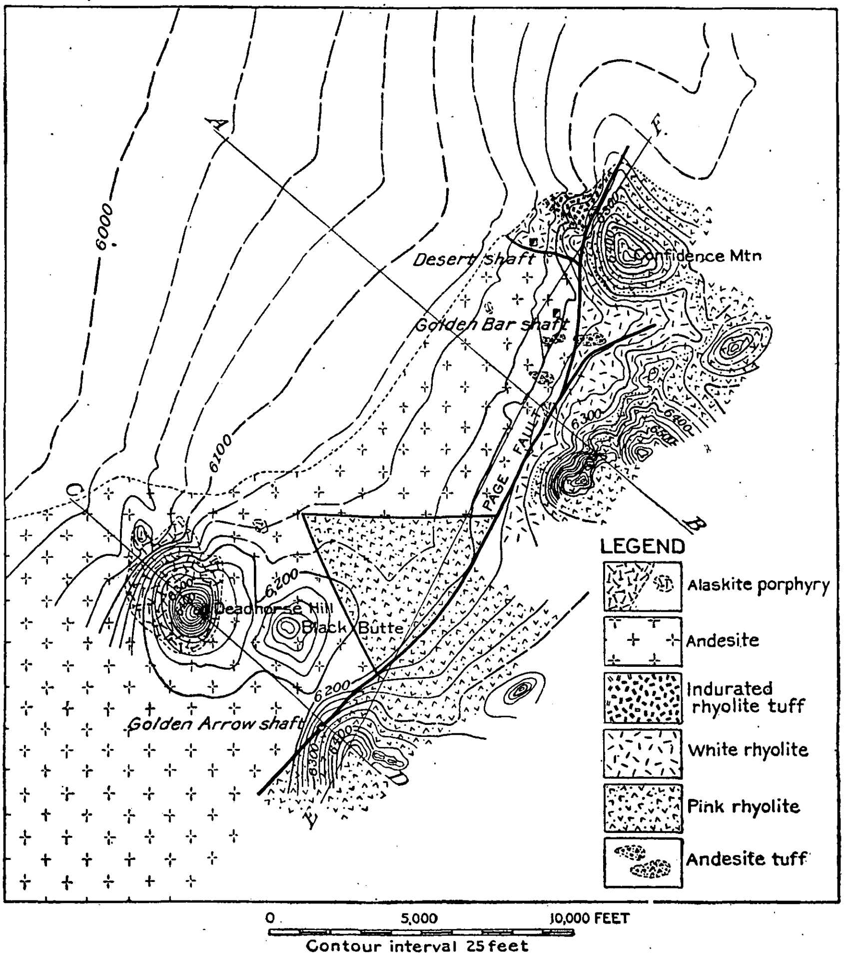

FIGURE 15.—Map showing geologic relations in vicinity of mines at Golden Arrow, Nev. By J. D. Irving.

growth of pine and juniper. Water for domestic purposes is hauled from a spring on the Longstreet ranch, about 7 miles to the northeast.

The geology of the district has been studied in detail by Prof. J. D. Irving in the course of an examination of the property of the Cotter Mines Co., and the accompanying map and sections (figs. 15 and 16) are reproduced by his permission. The rocks exposed are alaskite porphyry (or tordrillite), andesite, rhyolite tuff, and rhyolite.

Deadhorse Hill consists of a mass of light-colored porphyritic rock, shown on Irving's map as granite porphyry (alaskite), presumably the rock called tordrillite by Spurr. The rock is white and almost granitic in appearance, the phenocrysts exceeding the groundmass in volume. The feldspar individuals are large, some of them 6 millimeters in length, and are far more numerous than those of quartz. Both orthoclase and oligoclase are present, the former in greater abundance. The quartz phenocrysts are rounded and show deep magmatic embayments. Other original minerals are very sparingly present and consist of small shreds of muscovite and biotite, the latter now almost completely chloritized. The groundmass is an extremely fine-grained mixture of quartz and feldspar. Although there is nothing in the texture or occurrence of the rock to preclude its being a well-crystallized portion of a rhyolitic flow (tordrillite), it seems more probable, both from its texture and from its mineral composition, that it is allied to the earlier granitic intrusions, or represents a phase of the intrusive activity of early Tertiary time, which produced masses of various porphyries, chiefly silicic types, in several parts of southern Nevada.[1] If this is the case, the mass crowning Deadhorse Hill and the small areas in the flat to the north must be considered as remnants of the original roof of the andesite intrusion or less probably, in view of the size of the Deadhorse mass, included blocks in the andesite.

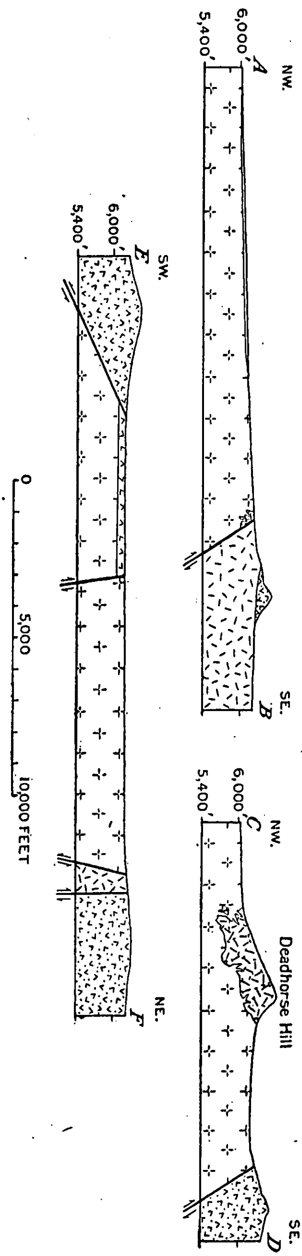

FIGURE 16.—Geologic sections on lines indicated in figure 15. By J. D. Irving.

Rhyolite forms the mountain range immediately east of the district. Irving has mapped a white rhyolite and a later pink rhyolite,

[1] Ball, S. H., op. cit., p. 32.

but there seems to be little other than color to distinguish the two. The rhyolite contains abundant quartz phenocrysts, feldspar in smaller amounts, and a little biotite in prominent small crystals. The feldspar are albite and orthoclase.

On a low ridge north of the Cotter property there is an outcrop of thin-bedded tuffaceous sandstone, which consists principally of quartz with a few grains of feldspar. In the single slide examined orthoclase was the only feldspar observed. The matrix appears to be composed chiefly of minute quartz grains. Small specks of dark slate and minute fragments of slightly sericitized rhyolite are to be seen in the coarse-grained layers, but no trace of andesitic material was found. Ball noted similar rocks in other parts of the Kawich Range and correlated them with the Siebert tuff.

The rock plain between the rhyolite hills on the east and the desert valley on the west and north is for the most part composed of andesite. The andesite is a rather fine-grained porphyritic rock, with numerous small feldspar phenocrysts, mostly under 3 millimeters in length. Microscopic determination of the feldspars indicates andesite (An_2Ab_1). The feldspars are largely replaced by calcite, but no sericite has been developed. Indefinite dark specks represent original ferromagnesian minerals. Under the microscope it is seen that the ferromagnesian minerals are entirely altered to a mixture of chlorite, calcite, a little quartz, and, rarely, zoisite. From the shape of these pseudomorphs it appears that hornblende was originally the most prominent of the dark silicates, though augite may also have been present. No flow structure is recognizable, though irregular areas of chlorite suggest the filling of amygdaloids.

The andesite appears to be intrusive into the alaskite porphyry of Deadhorse Hill, though the writer was not able to confirm his impression by the study of actual contacts. The irregular contact of andesite and rhyolite exposed in the workings of the Desert shaft likewise suggests intrusion, but there the relations of the two rocks are masked by the extensive slipping which has taken place. On the other hand, specimens collected on the dump of the Gold Bar shaft and said to come from the 400-foot level show a decidedly andesitic tuff in close association with the andesite, and outcrops of a similar tuff are shown on the map (fig. 15).

Faulting has affected all the rocks exposed in the district. The principal fault, called the Page fault on Irving's map, follows the line of the hills in a general northeasterly direction and dips to the southeast at an average angle of about 60°. It is probably a normal fault, and the downthrow is therefore to the east. It forms the boundary between the andesite and rhyolite over the greater part of its known length. Between the Golden Arrow and Cotter mines, however, east of the fault, there is a triangular area of rhyolite that is itself bounded by faults. This seems to represent a sunken block on the upthrow side of the main fault, bounded by minor faults contemporaneous with the larger one. A similar subsidiary fault separates the rhyolite and andesite on the Desert and Gold Bar claims of the Cotter property. The throw of the faults is unknown but is probably not more than a few hundred feet.

The mineralization is believed to have followed the faulting closely and to belong to the same general period. The Page fault appears to be mineralized at the Golden Arrow mine and in the prospects to the southwest, although so far as can be judged from specimens collected on the dump, the main ore body was within the rhyolite. Most of the veins in the Cotter prospects appear to branch out from the fault nearly at right angles and have not been found to continue for any great distance from it. The arrangement of the vein system here suggests that the fissures now filled by vein matter are subsidiary to the main fault. North of the Desert fault the ore is in the rhyolite, and here the fracturing is less distinct than in the andesite area. East of the Page fault ore is likewise found in the rhyolite but in less well-defined veins than where the andesite forms the country rock.

Some faulting probably took place after the deposition of the ore, for the vein at the Desert shaft appears to be cut off by a later fault parallel to the Desert fault, but the work done is insufficient to determine this point with any certainty.

Although considerable work has been done on the two principal groups of the district, there has been almost no production. In October, 1915, a little work was going on at the Cotter property, and two prospectors were at work on some claims to the west.

The shaft at the Golden Arrow mine appears to follow the Page fault, which here strikes about northeast and dips 60° SE., and both andesite and rhyolite are found on the dump. The ore, however, seems to lie entirely within the rhyolite and to consist of small quartz-filled fissures carrying a few specks of sulphides. The wall rock close to these fissures is silicified, but does not appear to be sericitized.

Pyrite is the principal metallic mineral present, but here and there throughout the quartz are very minute specks of a dark cleavable mineral, probably zinc blende. The quartz is glassy, and in most specimens distinctly vuggy. Slender crystals as much as an inch in length project outward from the walls or radially from included fragments of silicified rhyolite or from pyrite. In the vugs small quartz crystals of a second generation line the faces of the larger crystals. More rarely quartz is seen in small plates studded with minute crystals. In this position it appears to replace lamellar calcite. Silver is said to be the principal valuable constituent of the ore, gold being present only in very small quantity. A 10-stamp mill has been set up but was never used, and the production of the mine is unknown.

The principal working of the Cotter Mines Co. is on the Gold Bar claim, where a vein has been developed by an inclined shaft 500 feet in length. Only the upper 140 feet, however, was accessible at the time of the writer's visit. The vein has a northwesterly course and a southwesterly dip. The angle of dip varies in different parts of the shaft between 43° and 60°. At points where the vein could be seen it consists of a series of closely spaced parallel quartz veinlets with pyrite. In places a small quantity of very light colored gold, said to have approximately the composition of electrum, is present in the ore but is so finely divided as to be visible only in the pan. Two ore shoots have been developed, one on the northwest and the other on the southeast side of the shaft. The northwestern shoot has been lost on the 400-foot level, but the other continues as far as development work has progressed. The ore averages about $25 a ton, chiefly in gold, but ore with an average tenor of $100 a ton can be obtained by sorting. The fineness of the gold appears to be highest close to the surface, the proportion of silver increasing with depth. Pyrite is the only other metallic mineral found associated with the best ore. Outside of the ore shoots marcasite is present as well as pyrite.

The Desert shaft is in rhyolite a few feet north of the Desert fault. The best ore occurs in an irregular crushed zone approximately parallel to the fault and about 20 feet to the north. In contrast to the better-defined veins within the andesite area, the ore here is spotty and irregular and occurs in poorly defined zones of crushed rock within the rhyolite. The ore shoot that is followed down from the surface in the shaft appears to be cut off by a later fault, though the evidence is not entirely clear. This is the only case of post-mineral faulting found in the district. The deepest level, 130 feet on the incline, has been most fully developed and shows a fairly definite though narrow eastward-trending mineralized zone, paralleling the Desert fault and from 10 to 25 feet to the north. Exploratory work farther north has shown a band of andesite about 50 feet wide whose northern and southern contacts strike on the average N. 75° E. and N. 70° E. and dip 45° N. and 70° S., respectively. The level above, 88 feet on the incline, shows only rhyolite. Intense crushing on the contacts has obscured the relations of the two rocks. The andesite is beneath the rhyolite and may be intrusive, but it is possibly the older of the two and represents an irregular surface on which the rhyolite was laid down.

There are several prospects in the rhyolite east of the Page fault, but only one was being worked at the time of the writer's visit. The Hot Tamale claim adjoins the Cotter group on the east, and the workings lie about 100 feet to the east of the fault. The mineralization appears in fissured zones in the rhyolite that carry minute seams of iron-stained quartz. The crushed ore when panned shows extremely minute colors of gold.

CLIFFORD DISTRICT.

The Clifford district is about 12 miles northeast of Golden Arrow, on the western flank of the Kawich Range, near the pass that separates the Kawich and Hot Creek ranges. About midway between Clifford and Golden Arrow is the deserted district of Bellehelen, which was not visited. The main road between Tonopah and Ely passes close to the mine workings, which occupy a low hill that juts out into the desert valley. The region, like the Golden Arrow district, is barren and desolate, as it is below the zone of tree growth.

The greater part of the small hill is composed of thin-bedded rhyolitic sandstone and pyroclastic rocks, rhyolitic tuff, and breccia. Andesite similar to that of Golden Arrow occupies the extreme western point of the hill. Although no clear contact was seen, it seems most probable that the andesite is not intrusive into the pyroclastic rocks, for in some of the specimens collected there are pebbles of a much altered andesitic lava inclosed in a matrix of fine-grained quartz fragments.

Most of the work in the district has been done by James Clifford in the oxidized ores near the surface. The hill is covered with small shafts and irregular inclines where rich streaks have been followed for short distances. Few, however, have been found profitable for more than a few feet below the surface. A 200-foot shaft on the western point of the hill reached the sulphide zone but disclosed no definite ore bodies, and the writer was informed that this shaft had been abandoned by the lessee who sank it.

The ore of the shallow workings consists of heavily iron-stained tuff cut by small quartz veins that contain small irregular masses of limonite. Close examination of the richer ore reveals cerargyrite, mostly stained brown by iron oxide but in part light green, and a few minute threads of native silver. In the specimens examined microscopically the cerargyrite grains occur in minute veinlets of light-brown jarosite. Rare specks of a silver sulphide mineral and pyrite, the latter surrounded and partly replaced by jarosite, were seen in the oxidized ore. A small amount of free gold of a light-yellow color is present in concentrates obtained by panning the richer ore.

The sulphide ore was seen in place on the 200-foot level of the shaft at the western point of the hill. The shaft itself is sunk entirely in andesite, but the drift enters rhyolitic agglomerate a few feet east of the shaft. Along the line of junction both rocks are much sheared and heavily pyritized. The contact is approximately vertical, and this fact, together with the presence of andesitic material in the agglomerate, makes it probable that the andesite is here older than the agglomerate and faulted against it. From the smallness and irregularity of the stopes it may be inferred that the ore is spotty in its occurrence. Most of the stopes are less than 6 feet in width by 20 feet in length. Although the andesite is pyritized near the contact, the ore appears to be entirely within the agglomerate. The greater part of the material shows heavily pyritized agglomerate, in places almost completely converted into pyrite, the matrix and pebbles being equally affected. The richer ore consists of agglomerate with less pyrite but cut by small drusy quartz veins. The vugs of these veins contain small crystals of stephanite, pyrargyrite, and proustite, as well as pyrite and more rarely marcasite, resting on the projecting quartz crystals, and the silver sulphide minerals also occur in minute streaks between quartz and wall rock. No gold or native silver was found in the concentrates. The presence of marcasite is taken to indicate that this ore does not represent the original ore as deposited but is to a large extent, at least, the product of enrichment by downward-migrating surface waters.

ELLENDALE DISTRICT.

The deserted district of Ellendale lies on the road between Tonopah and Stone Cabin, a few miles east of Tonopah. The claims were located a few years ago, and the rich surface showings started a rush which was a miniature repetition of those following the discovery of such camps as Tonopah, Goldfield, and Manhattan. A town was laid out and houses were built, but to-day a single empty house marks the site of the town. The extent of the older workings is considerable, but apparently only a very small amount of ore was of sufficiently high grade to be shipped. In 1909, according to Mr. F. M. Chambers,[1] a shipment of 5 tons assaying 205.68 ounces of gold and 145.7 ounces of silver was made, in addition to other shipments with a gross value of about $40,000. In 1910 there was shipped from the district 26 tons of ore containing $18,349 in gold and 718 ounces of silver, valued in all at $18,737, or $720.65 a ton.[2] In 1911, 94 tons was shipped, carrying $54,702 in gold and 1,823 ounces of silver, with a total value of $55,668, or $592.21 a ton.[3]

[1] Letter, Dec. 9, 1916.
[2] U. S. Geol. Survey Mineral Resources, 1910, pt. 1, p. 525, 1911.
[3] Idem, 1911, pt. 1, p. 689, 1912.

Most of the workings are in rhyolite, near the contact of andesite porphyry. The rhyolite is fine grained and rather siliceous and carries small phenocrysts of quartz and feldspar. Biotite in rare and minute plates is the only ferromagnesian mineral present. The andesite is similar to that of Clifford and Golden Arrow, but the relations of the two rocks could not be determined.

So far as a very hasty inspection showed, no mining of any importance had been undertaken in the andesite area.

The mineralization consists in the irregular veining of the rhyolite by numerous little fissures filled with iron-stained quartz and the silicification and to a less degree the sericitization of the adjacent rock. The rhyolite in the mineralized zone also shows numerous brown specks, resulting from the alteration of pyrite. Microscopic examination of the ore shows that these rusty specks are composed in part of jarosite. The silicified rhyolite is also cut by minute veinlets of jarosite, few of which exceed 0.1 millimeter in width. It appears that the oxidation of the pyrite in conjunction with the weathering of a potassic rock has resulted in the formation of the sulphate jarosite instead of merely the hydrous oxide limonite.

CONCLUSIONS.

The three districts here described, although varying in the nature of their ore, show certain features in common. The deposits belong to the class of shallow vein deposits in which the mineralization followed closely the extrusion of lavas, or the welling up of intrusives that reached close to the surface. In each case the occurrence of the ores in close association with andesite is significant. It may be that one of the principal periods of Tertiary mineralization is to be associated with an epoch of andesitic volcanism. In the Manhattan and Tonopah districts there are masses of similar andesite, intrusive at Manhattan and occurring both as flows and intrusions at Tonopah, but in the Manhattan district the relations of the andesite and ore are not clear, and at Tonopah, according to Spurr,[1] the ores of the different periods of vein formation are associated with rhyolite rather than with andesite.

At Clifford and Ellendale jarosite, a sulphate of iron and potassium, takes the place of part of the limonite as a result of the oxidation of pyrite. It is believed that the potash necessary to form this mineral has been obtained from the rhyolite.

[1] Spurr, J. E., Geology and ore deposition at Tonopah, Nev.: Econ. Geology, vol. 10, p. 764, 1916.