ORE DEPOSITS OF CEDAR MOUNTAIN, MINERAL COUNTY, NEVADA.

By Adolph Knopf.

SUMMARY.

Cedar Mountain, in western Nevada, contains the Simon silver-lead district, which is the chief center of interest, and the Omco gold district.

In 1919 large bodies of silver-bearing lead-zinc ore were discovered below an immense gossan that had been known since 1879 but had not been thoroughly prospected. A rush to the district took place and the country was staked over a radius of many miles. The area soon became known as the Simon district, from the name of the chief mine. The excitement quickly subsided, however, and by the summer of 1920 work was being done only at two places—the Simon mine, in which a large body of ore had been partly blocked out, and the Simon Contact prospect.

The ore deposits are in the northern part of Cedar Mountain. At Simon the rocks that compose the range are divided by a great transverse fault. North of the fault the range consists wholly of Tertiary rocks, mainly rhyolites and andesites; south of the fault it consists of Triassic rocks which have been intruded by granodiorite and allied dikes.

The oldest rocks—those of Triassic age—are chiefly limestones. The volcanic rocks that occur with them in places were erupted contemporaneously with the deposition of the limestones, like the lavas that occur in the Triassic elsewhere in Nevada. The limestones and associated lavas and tuffs were intruded by granodiorite at the end of the Jurassic or early in the Cretaceous period, and the silver-lead ores appear to have been formed as one of the consequences of that intrusion.

In Tertiary time, after erosion had progressed far enough partly to uncover the granite, volcanic activity set in and large volumes of rhyolite and andesite were erupted. Subsequently, approximately late in Miocene time, a great fresh-water lake was formed wherein were deposited the sandstones, shales, limestones, and other rocks of the Esmeralda formation. These lake beds lie on both flanks of Cedar Mountain and have been somewhat folded and considerably faulted.

The ore deposits of main interest are the silver-bearing lead-zinc bodies at the Simon mine. They consist of galena and zinc blende, commonly inclosed in a gangue of jasperoid, and have resulted from the replacement of the Triassic limestone adjoining an alaskite porphyry dike. These ores appear to be of late Jurassic or early Cretaceous age and to have been formed in connection with the intrusion of the granodiorite and the dikes associated with it.

The gold-bearing deposits are quartz veins inclosed in the Tertiary lavas. The veins are of the well-known distinctive Tertiary type, wherein much of the quartz is pseudomorphic after lamellar calcite. The precious metal—probably the gold-silver alloy electrum—is so finely disseminated throughout the quartz as to be invisible, and sulphides are absent. Thus these veins contrast notably in appearance and content with the lead-silver ores. The principal vein is the Olympic, which has yielded somewhat more than $700,000 in gold and silver.

GEOGRAPHY.

Cedar Mountain is in west-central Nevada, in the eastern part of Mineral County. (See fig. 53.) It contains near its north end the two small mining camps of Simon and Omco, which center around the two principal mines—the Simon silver-lead mine and the Olympic gold mine, each of which has its own post office.

The nearest railroad point is Mina, on the Southern Pacific system, 22 miles southwest of Simon. Between Cedar Mountain and the railroad lie the Pilot Mountains, which are crossed by a fairly low pass at an altitude of 6,240 feet; Mina itself is at an altitude of 4,550 feet.

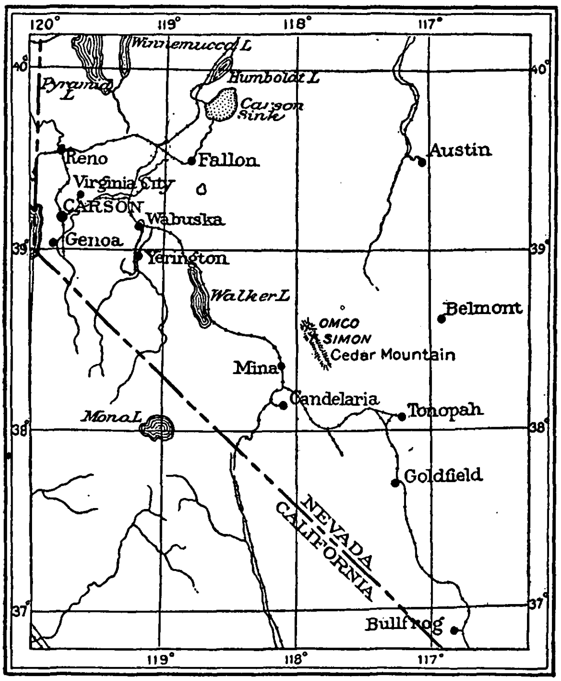

FIGURE 53.—Index map showing the location of Cedar Mountain, Nev.

Cedar Mountain forms a broad, low range of rather subdued relief. It contrasts markedly in this respect with adjacent ranges, especially with the Pilot Mountains, the next range to the west, whose western front exhibits one of the most superb clean-cut triangular-faceted fault scarps that can be seen anywhere in Nevada. The culminating point of Cedar Mountain is Little Pilot Peak, whose elevation is 8,046 feet. Simon is at 6,700 feet and Omco (the post office of the Olympic mine) at 6,000 feet. The topography of the region is shown on the Tonopah map of the United States Geological Survey.

ACKNOWLEDGMENTS.

It is a pleasant duty to acknowledge here the many courtesies extended by Mr. Robert J. Bonnemort, of the Olympic mine, and Messrs. T. P. McNamara and E. W. King, of the Simon mine, and to recall their interest in and appreciation of the work of the geologists of the Federal Survey. In the field work on which the present report is based I was assisted by my wife, Eleanora Bliss Knopf, of the United States Geological Survey.

GEOLOGY.

TRIASSIC ROCKS.

LIMESTONE.

Limestone is the predominant rock in the part of Cedar Mountain near the Simon mine. It is a dark-gray fine-grained rock, except where it has been recrystallized as a result of granitic intrusions. This alteration is specially prominent on Little Pilot Mountain, where the limestone has been transformed to a coarse white marble.

In general it is difficult to detect bedding in the limestone. The dip west of the Simon mine is 45° W., but some distance east of the mine the dip is eastward, so that the major fold in the limestone is a broad anticline. On account of the prevalence of faulting and of the internal deformation to which the limestone has been subjected the thickness could not be measured.

Fossils found in the limestone establish its age as Middle Triassic. T. W. Stanton, to whom they were submitted for identification, reports as follows:

The following report is submitted on a small collection of invertebrate fossils from the Simon district, Cedar Mountain, Nev., referred to in Mr. Adolph Knopf's letter of August 20, 1920:

Lot 1. Collected along pipe line to Wild Rose Spring, 2 miles from Simon mine.

Spiriferina? sp.
Daonella moussoni Merian.
Nucula sp.
Ceratites (Gymnotoceras) beckeri Smith?
Ceratites (Gymnotoceras) russelli Smith?

This lot is assigned without question to the Middle Triassic.

Lot 2. 100 feet in the footwall of the Simon lode, near the Mammoth fault.

Spiriferina? sp. Fragment.

This specimen is not sufficient for determining whether the rock is Triassic or older.

Lot 3. Footwall of Simon lode. Faulted west segment, summit of hill southwest of main shaft.

This fragment of rock contains imperfect specimens of two or more pelecypods and possibly a brachiopod which may be of Triassic age or older.

SIMON QUARTZ KERATOPHYRE.

The name Simon quartz keratophyre is here applied to a series of lavas and breccias that occur in the immediate vicinity of the Simon mine. The lavas are crowded with numerous large crystals of quartz and feldspar and contain a little chloritized biotite. Under the microscope the phenocrysts are seen to be inclosed in an exceedingly cryptocrystalline groundmass, which is clearly a devitrified glass and in the more marked examples has a pronounced flowage structure that swirls around the porphyritic crystals. As the feldspars all prove to be albite ($Ab_{95}An_5$), these lavas are termed quartz keratophyres. They can be considered as rhyolites in which the feldspar, instead of the potassium variety orthoclase, is the sodium analogue albite.

The breccias or tuffs associated with the lavas look much like the lavas themselves, and in practice it is difficult to discriminate them surely enough for geologic mapping. Some of the rocks contain numerous angular bits of limestone and chert (or felsite?) and are probably flow breccias. A coarse breccia, which is well exposed on the 500-foot level of the Simon mine (at survey plug 519), shows numerous inclusions of argillite that range from sharply angular to nicely rounded; it is doubtless an explosion breccia—that is, a breccia formed from fragments blown out from a volcanic vent.

Some quartz monzonite porphyry is intrusive into the quartz keratophyres northwest of the Simon Contact prospect. In the field the porphyry resembles the keratophyres rather closely, the main difference being that it contains a far smaller number of phenocrysts; but under the microscope more marked differences become apparent, as is shown on page 366, where these intrusives are described in some detail.

The structural relations of the Simon quartz keratophyre are obscure, for the difficulty of distinguishing the intercalated beds of tuff nullified attempts to determine the strike and dip. In general the quartz keratophyre is faulted against the adjacent rocks.

The age of these rocks is probably Triassic, and they are believed to have been erupted at about the time the limestones of the range were being deposited. The evidence for thus dating the age of the Simon quartz keratophyre is not entirely conclusive, however, for it rests in part on the fact that some of the ore of the Simon mine is inclosed in the quartz keratophyre, and this ore, as discussed on page 373, is regarded as of pre-Tertiary age. The Triassic was a time of intense volcanic activity in Nevada, and keratophyres, together with andesites and dacites, are abundantly represented in the Triassic section of the Yerington district,[1] which is the nearest district whose geologic details are known. Some of the felsitic volcanic rocks of Cedar Mountain are clearly older than the granodiorite intrusion, as they are cut by innumerable dikelets of aplite and are highly metamorphosed by them. Further, the Simon quartz keratophyre is cut by porphyries that appear to be related to the granodiorite intrusion. In short, all the available evidence points in the same direction and indicates that the Simon quartz keratophyre is Triassic.

[1] Knopf, Adolph, Geology and ore deposits of the Yerington district, Nev.: U. S. Geol. Survey Prof. Paper 114, pp. 13-15, 1918.

LATE JURASSIC OR EARLY CRETACEOUS ROCKS.

GRANODIORITE.

Masses of granitic rock occur in Cedar Mountain, and the margin of one of these lies but a few hundred yards south of the Simon mine. This mass extends southward toward Little Pilot Peak—the summit of which, however, consists of a capping of marbleized limestone—and extends down on the east flank of the range, forming a broad area of subdued relief, in contrast to the bold topography of the encircling limestone. Like many other ranges of Nevada, Cedar Mountain is underlain by a core of granite.

The granitic rock is a moderately coarse grained aggregate of feldspar, quartz, biotite, and hornblende. The feldspar proves under the microscope to be chiefly plagioclase of marked zonal growth, ranging from a core of $Ab_{50}An_{50}$ to an outermost zone of $Ab_{80}An_{20}$, as a whole averaging $Ab_{65}An_{35}$, and as orthoclase is only a minor component the rock falls into the group of granodiorites.

The intrusive nature of the granodiorite is clearly shown. Near the contacts the granodiorite is porphyritic, and tongues and dikes of this facies penetrate the adjacent limestone. Further, the limestone has been marbleized, and small bodies of garnet rock have been formed locally. In addition, aplite, lamprophyre, and diorite porphyry dikes occur in and around the margins of the granodiorite.

As the granodiorite has invaded the Triassic limestones it is clearly of post-Triassic age. Presumably it was intruded at the end of Jurassic time or early in the Cretaceous, like the granitic rocks of the Sierra Nevada not far west.

ALLIED DIKE ROCKS.

Aplite forms dikes in the granodiorite and adjacent limestone. Some of the dikes are less than an inch thick and are so fine grained as to be nearly aphanitic; others are several feet thick and of coarse grain, verging toward alaskite. A large mass of aplite, hundreds of feet in diameter, occurs on the margin of the granodiorite mass where that body crops out nearest the Simon mine. It has intruded and metamorphosed Triassic felsites, so that they closely resemble the aplite itself.

Narrow dikes of hornblende lamprophyre cut the granodiorite and the surrounding limestone as well, but they appear to be more common in the granodiorite. They are dark, heavy rocks, so fine grained that the component minerals are not distinguishable by the unaided eye. Under the microscope they are seen to be composed largely of hornblende in innumerable slender prisms between which lies orthoclase. Apatite is noteworthy because of its relative abundance.

Epidote is common as a secondary mineral. The lamprophyre therefore proves to be a vogesite.

Diorite porphyry and granodiorite porphyry dikes occur in the granodiorite and limestone. They are fresh-looking rocks, conspicuously porphyritic through the presence of numerous crystals of plagioclase—more than half the bulk of the rock. Some of these porphyries contain in addition hornblende, whereas others contain chiefly biotite as the dark mineral. The dike on the east flank of the peak marked by mineral monument No. 301 is a typical granodiorite porphyry that carries phenocrysts of plagioclase (dominant), microperthite, quartz, biotite, and hornblende in a microgranular groundmass of orthoclase and quartz. It is identical with the marginal facies of the granodiorite itself. Dikes of this kind are obviously related to that intrusion.

Other dikes, however, whose origin is not so clear are common in the limestone. They are monzonite porphyries somewhat altered and apparently devoid of dark minerals. They are of interest because they occur nearer the Simon mine than the dikes previously mentioned; in fact, quartz monzonite porphyry occurs in the Simon quartz keratophyre. These dikes may well be contemporaneous with the others, but they have become altered by mineralizing solutions, and the pyrite introduced by these solutions has been oxidized, so that the difference may be more apparent than real.

A dike of this kind is well shown 400 feet west of the northwest end of the Simon lode. It trends parallel to the bedding of the limestone and is possibly 45 feet thick. It is characterized by numerous porphyritic feldspar crystals that average half an inch in length. Quartz phenocrysts, though present, are exceedingly rare. On close inspection it is seen that many of the feldspar phenocrysts contain minute incomplete rosettes of tourmaline, showing that the dike has been altered, most probably by gases that escaped at high temperature from the granodiorite while it was consolidating. The microscope shows that the porphyritic feldspars are orthoclase and oligoclase, indicating that the rock is a monzonite porphyry, or, if we take into account the sporadic quartz phenocrysts, a quartz monzonite porphyry. A similar dike—not tourmalinized, however—occurs 200 feet east of the Simon Contact prospect, and similar rock, except that quartz phenocrysts are more common, occurs in the quartz keratophyre northwest of that prospect. An interesting minor petrographic feature of these dikes is that their common origin, their consanguinity, is indicated by their content of pleochroic apatite.

TERTIARY VOLCANIC ROCKS.

GENERAL FEATURES.

Between the time when the older rocks described in the preceding pages were formed and the time when the next younger group of rocks, which consist chiefly of lavas, were erupted erosion laid bare the granodiorite. As the lavas are overlain unconformably by the lake beds of the Esmeralda formation, of approximately late Miocene age, they must have been erupted during the earlier part of Tertiary time. They are probably not younger than middle Miocene, as suggested by Buwalda.[2]

The Tertiary volcanic rocks form a prominent element in the geology of Cedar Mountain; in fact, the part of the mountain that extends from Simon northward to the Olympic mine consists wholly of these rocks. They are of various types, are much faulted, and evidently are the records of an eventful eruptive and tectonic history, which may not be read by the methods of rapid reconnaissance survey. The detailed studies in recent years of Tonopah, Goldfield, and Yerington show what a complex history may be concealed within an apparently simple accumulation of volcanic rocks. A beginning has been made here in determining the Tertiary volcanic history of Cedar Mountain by the study of the sections at Simon and Omco, but to tie these two sections together would have required an equally detailed examination of the intervening area.

SECTION AT SIMON.

MAMMOTH ANDESITE.

The oldest Tertiary volcanic rock at Simon is the Mammoth andesite, so named because it is well exposed on the Mammoth claim. It is a dull grayish-green porphyritic rock that contains innumerable small tabular phenocrysts of plagioclase. Many of these phenocrysts are honeycombed with inclusions of glass. In places the andesite shows an imperfect columnar structure. Under the microscope the feldspar phenocrysts prove to be sodic labradorite, some hornblende becomes apparent, and a crystal or two of augite is seen. The groundmass is a glass containing microlites of feldspar.

The Mammoth andesite is of uniform character and appears to represent a single flow of lava. Its base was nowhere seen, as the andesite has been faulted down against the older rocks (the Triassic limestone and Simon quartz keratophyre), as shown in figure 54. This fault, which thus forms the lower limit of the Tertiary rocks, strikes transversely to the course of Cedar Mountain and is one of

[2] Buwalda, J. P., Tertiary mammal beds of Stewart and Ione valleys in west-central Nevada: California Univ. Dept. Geology Bull., vol. 8, p. 341, 1914.

the master faults of the region; north of it only Tertiary rocks occur, whereas south of it only Mesozoic rocks occur.

KERATOPHYRE.

A lava of chalk-white color, brilliantly conspicuous in the glare of the desert sun, is the most prominent of the Tertiary volcanics in the vicinity of the Simon mine. It is well exposed on the north side of the main road and extends far to the west of the mine.

This lava overlies the Mammoth andesite and is roughly 200 feet thick. It is an aphanitic white rock devoid of dark minerals. In places it is pitted with irregular gas cavities, now drusy from coatings of minute quartz crystals. Small phenocrysts of glassy striated feldspar are common but are inconspicuous. Spherulites occur irregularly throughout the flow and are especially noticeable in its basal part. Under the microscope this facies is seen to contain many phenocrysts of albite ($Ab_{92}An_8$) in a groundmass that is composed partly of spherulites and partly of devitrified glass, with marked

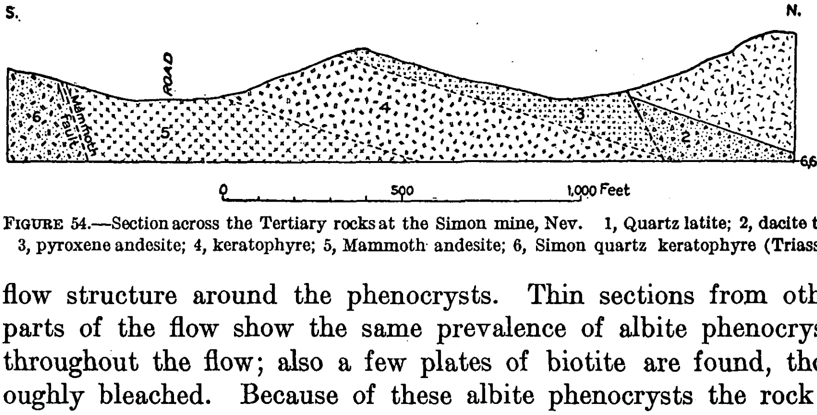

FIGURE 54.—Section across the Tertiary rocks at the Simon mine, Nev. 1, Quartz latite; 2, dacite tuff; 3, pyroxene andesite; 4, keratophyre; 5, Mammoth andesite; 6, Simon quartz keratophyre (Triassic).

flow structure around the phenocrysts. Thin sections from other parts of the flow show the same prevalence of albite phenocrysts throughout the flow; also a few plates of biotite are found, thoroughly bleached. Because of these albite phenocrysts the rock is here termed a keratophyre. A like rock has not heretofore been discovered among the Tertiary lavas of Nevada.

Locally it has been thought that this keratophyre is the extension of the alaskite porphyry dike alongside of which the ore bodies of the Simon mine have formed, but the geologic relations of the keratophyre flow and the dike are alone sufficient to refute this supposition, and the microscope demonstrates that the two rocks, despite a certain superficial resemblance, are petrographically totally unlike.

PYROXENE ANDESITE.

Andesite overlies the keratophyre and forms the summit of the ridge on which the Sterling shaft was sunk. On the north it is cut off by a master fault which dips 60° N., as shown in figure 54, so that its thickness is not known.

This andesite is spotted with numerous plagioclase feldspar phenocrysts, notably larger and more abundant than those in the Mammoth andesite, and, in addition, it shows a considerable quantity of dark minerals in small particles. As a rule the andesite is much altered; the freshest appearing rock, such as that from the Sterling shaft, has a purplish cast. Under the microscope it is seen to be a pyroxene andesite that contains much secondary calcite and chlorite.

DACITE TUFF.

The next youngest volcanic rock is a dacite tuff, which resembles a white porphyritic rhyolite. It is faulted down against the pyroxene andesite and is overlain by a thick sheet of quartz latite. It exceeds 75 feet in thickness.

Under the microscope the tuff is seen to be composed of numerous crystal fragments of labradorite ($Ab_{45}An_{55}$), quartz, and biotite, with sporadic hornblende, set in a compact matrix of minute sherds of glass. The texture is typically vitroclastic. The glass matrix, which carries easily visible particles of feldspar, quartz, and biotite, causes the tuff closely to simulate a porphyritic lava to the unaided eye.

QUARTZ LATITE.

Quartz latite is the most abundant of the Tertiary volcanic rocks and forms a thick sheet that underlies the dissected plateau extending from the Simon mine northward to the Olympic mine. It is more than 200 feet thick and rests upon the dacite tuff, there being commonly several feet, in places as much as 20 feet, of dark porphyritic glass at the base of the quartz latite.

The quartz latite is a gray, highly porphyritic lava rich in biotite; it weathers characteristically to a brownish red. It proves under the microscope to be ideally fresh and shows phenocrysts of oligoclase ($Ab_{70}An_{30}$) and sanidine (these two feldspars being present in equal amounts), quartz, and biotite, with a prism or two of hornblende. The groundmass is seen to be largely made up of glass, which has a marked fluxional structure and in places is spherulitic. Such a lava would generally be termed a rhyolite in the field, but, as shown by the description, it is intermediate between a rhyolite and a dacite, and in order to indicate this character it is called a quartz latite. It contrasts with the rhyolites at the Olympic mine, which are strictly sanidine-bearing rhyolites that contain no plagioclase feldspar.

ESMERALDA FORMATION.

A formation consisting of well-bedded sandstones, shales, limestones, and tuffs laid down in a fresh-water lake extends upward on both flanks of Cedar Mountain and encircles its northern end. Its distribution in the surrounding region has been studied by Buwalda, who has carefully described its general features and shown it to be a part of the Esmeralda formation.[3] His collections of mammal remains from the shore deposits of the ancient lake and from the terrestrial strata intercalated in the general sequence of lake beds have been shown by Merriam[4] to be approximately of late Miocene age.

No special examination of the lake beds was made during the present field work, as the formation is younger than the ore deposits of the region. One fact that appears to have escaped earlier notice is that the lake beds wherever seen, both at the Olympic mine and west of Simon, are faulted against the older rocks and in places let down into them in fault troughs. The evidence of faulting is generally poor or obscure in surface exposures because of the loose, unconsolidated condition of the lake beds, but is impressively shown in the underground workings of the Olympic mine.

ORE DEPOSITS.

SILVER-LEAD LODES.

GENERAL CHARACTER AND OCCURRENCE.

The main ore bodies of the district are replacement deposits in limestone. The ore minerals are galena and zinc blende, which are inclosed in a dark-gray fine-grained aggregate of quartz, a jasperoid, as it is termed, that has resulted from the replacement of the limestone by quartz. Pyrite and arsenopyrite are subordinate metallic minerals, and calcite and limestone occur as gangue materials. The relative proportions of these several constituents differ considerably from place to place, but much of the ore consists largely of galena and sphalerite.

The only notable bodies of ore so far found in the district are those in the Simon mine, where two large irregular chimney-like shoots have been developed. It is said that 500,000 tons of ore, averaging 8 per cent of lead, 9 per cent of zinc, and 5 ounces of silver to the ton, is indicated by the work so far done.

The outstanding geologic feature of the Simon mine is that the two ore shoots so far found are localized along an alaskite porphyry dike. This dike averages 30 feet in thickness, has been injected along the contact of the Simon quartz keratophyre and the Triassic limestone, and dips 70° NE. The contact along which it has been injected appears to be a reverse fault, for the limestone, whose strike is parallel to that of the dike, dips 60° SW. near the dike but flattens away from the dike. Petrographically the dike is an aphanitic

[3] Buwalda, J. P., op. cit., pp. 335–363.

[4] Buwalda, J. P., op. cit., p. 350. Also see Merriam, J. C., Tertiary vertebrate fauna from the Cedar Mountain region of western Nevada: California Univ. Dept. Geology Bull., vol. 9, pp. 162–172, 1916.

white rock that carries scattered small phenocrysts of quartz, which is its only conspicuous constituent, and inconspicuous phenocrysts of orthoclase. Under the microscope the phenocrysts of quartz and orthoclase (orthoclase, not sanidine, as the potassium feldspars in the rhyolites of the district invariably prove to be) are seen to be set in a microgranular groundmass of orthoclase and quartz. Locally this rock has been called both rhyolite and granite porphyry, but because it is barren of any dark minerals it will be here termed alaskite porphyry, which is the variety of granite porphyry that is devoid of dark minerals. It doubtless represents a part of the aplitic differentiate of the granodiorite that was injected farther

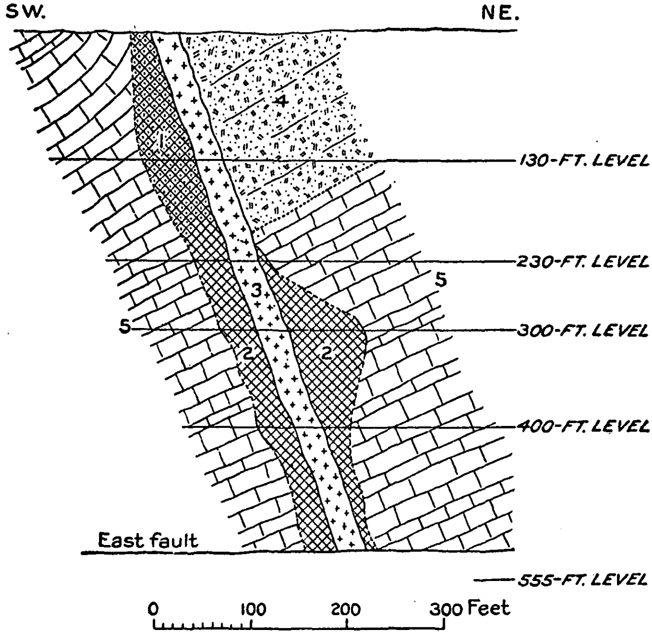

FIGURE 55.—Diagrammatic section through the Simon mine, Nev. 1, Gossan; 2, sulphide ore; 3, alaskite porphyry; 4, Simon quartz keratophyre; 5, Triassic limestone.

from the parent mass and therefore into a colder environment, where it cooled faster and consequently took on a porphyritic-aphanitic texture.

The geologic conditions at the Simon mine are epitomized in figure 55. The ore shoot in the footwall of the dike was discovered first, as it cropped out at the surface. Above the 230-foot level this shoot is composed largely of siliceous gossan, though it contains some galena and cerusite and in places considerable plumbojarosite (a basic sulphate of ferric iron and lead), recognizable by its silky luster and talclike smoothness to the touch. The hanging-wall ore shoot does not extend to the surface, as the keratophyres, which form the hanging wall of the dike near the surface, were evidently not easily replaceable by the ore-forming solutions, as was the limestone.

The contacts of the dike are sheared and reduced to gouge in places; evidently the old fault continued to be a locus of movement. The dike rock has been thoroughly altered by the ascending ore solutions, and it has been silicified, sericitized, and calcitized. Some sulphides also have been introduced, and some quartz veins occur in the porphyry, but the dike has not been highly enough metallized anywhere to constitute ore. The keratophyre that forms the hanging wall of the dike on the upper levels has been similarly altered, and arsenopyrite is relatively common in it, but no ore has formed in it.

A belt of calcium silicate rock lies parallel to the alaskite porphyry dike on the summit of the ridge west of the shaft. It is in the limestone about 100 feet from the dike on the footwall side and comprises both light-colored and dark aphanitic varieties. Under the microscope these rocks are seen to consist of garnet, diopside, actinolite, and calcite. Evidently these rocks represent the outer edge of the contact-metamorphic aureole of the granodiorite intrusion.

One of the problems connected with the Simon ore body is what has become of all the zinc that has been leached out of the gossan. This zinc should have been deposited as smithsonite (zinc carbonate) in the footwall of the lode by reaction with the limestone, but the quantity of secondary zinc minerals so far found is negligible: a little calamine occurs in vugs in the sulphide ore on the 230-foot level, and a small amount of typical iron-stained fine-grained zinc carbonate has been noted in the limestone on that level. Nevertheless the possibility that large bodies of such secondary zinc carbonate should occur ought to be kept steadily in mind.

Of mineralogic interest is the occurrence of adamite in aggregates of small white crystals that line the vugs in the smithsonite. I am indebted to Prof. W. E. Ford, of Yale University, for the identification of this mineral, which is a zinc arsenate—$Zn_3As_2O_8.Zn(OH)_2$—and which has not previously been recorded as occurring in the United States.

ORIGIN.

The contacts of the alaskite porphyry dike served as the pathways of hot ascending metalliferous solutions, which attacked the limestone and dissolved it and simultaneously deposited in the spaces thus made galena, sphalerite, pyrite, and quartz. The solutions also attacked the alaskite porphyry and converted it into an aggregate of quartz, sericite, calcite, and disseminated sulphides. Thus far we are on firm ground, but when we attempt to link up the origin of the ore-forming solutions with a particular period of igneous activity in the district the evidence becomes less secure. The balance of the evidence, however, strongly favors the hypothesis that the ore-forming solutions were one of the postintrusive effects of the granodiorite. Obviously there have been two widely different kinds of mineralization in the district—one that produced the silver-lead ore and the other the gold-quartz ore, which is of a very marked individuality and is known to be of Tertiary age. These differences in kind strongly suggest differences in age, and, furthermore, to assign the silver-lead ores—the heavy basic ores—to an epi-Jurassic age instead of to the Tertiary age of the gold-quartz ores conforms best with the metallogenic history of Nevada.

MINES AND PROSPECTS.

SIMON MINE.

GENERAL FEATURES.

The chief ore bodies in the district are those in the Simon mine, which is owned by the Simon Silver-Lead Mines Co. The company owns the Mammoth, Lillian, Lillian No. 1, and Lillian No. 2 claims. The Mammoth lode, in which the chief ore bodies occur, was discovered as long ago as 1879, for it crops out as a huge ledge that projects 20 feet or more above the ground. A large amount of leached siliceous gossan occurs, and from this material some oxidized lead was shipped, but the possibilities of the mine remained undisclosed for nearly 40 years. Until recently the mine was known as the Nevada mine. In 1916 it came under the control of P. A. Simon, and exploratory work in depth began to be pushed. In 1919 it became evident that a valuable ore body underlies the gossan, and subsequent exploratory work has revealed another large ore body, which, unlike the other, never extended to the surface, owing to the geologic conditions that governed its formation.

The ore of the Simon mine is closely associated with an alaskite porphyry dike that dips 70° NE., which has been intruded along a reverse-fault contact between the Triassic limestone and the Simon quartz keratophyre. On the upper levels of the mine the quartz keratophyre forms the hanging wall of the dike and the limestone forms the footwall, but below the 230-foot level limestone forms both walls. The main body of ore occurs as a pipelike shoot in the footwall of the dike, but in the lower levels another shoot occurs on the hanging-wall side of the dike. The ore is an argentiferous lead-zinc jasperoid, which has resulted from the replacement of the limestone adjacent to the alaskite porphyry dike.

The mine is developed by a shaft which is vertical down to the sixth level, at 400 feet depth, but below that level it inclines steeply northeastward down to the seventh or bottom level. The bottom level is at a depth of 555 feet, but it is sometimes referred to as the

700-foot level. The largest amount of development work has been done on the fifth, sixth, and seventh levels. The mine makes considerable water on the two lower levels. In figure 55, which shows diagrammatically the main geologic features of the mine, the levels are indicated according to their vertical distances below the collar of the shaft. The outlines of the ore bodies between the levels are drawn in dotted lines to indicate that the exploratory work is not yet full enough to show precisely the location of the boundaries of the irregular ore bodies. Similarly, information is lacking as to the precise position of the floor on which the quartz keratophyre lavas rest.

Early in 1921 a milling plant was built at the mine and a flotation unit installed which is capable of treating from 150 to 175 tons a day. It is planned to add another unit as soon as the plant is running smoothly and satisfactorily. Late in the year a power line built by Mineral County from Hawthorne to the Simon district was completed.

DETAILS OF THE GEOLOGY.

The prominent outcrop that naturally attracted attention early in the history of the district consists of silicified alaskite porphyry, the surface exposure of the dike along which the ore bodies of the Simon mine are localized. Adjoining this alaskite porphyry on the northeast side is the outcrop of the lode proper—leached siliceous vein stuff, in places containing sufficient iron oxide to be termed gossan. This gossan continues down to the 230-foot level, where the sulphide ore from which it was derived appears. In places the gossan carries cerusite, and the richer material of this kind was stoped and shipped by the former operators. Locally the rare mineral plumbojarosite occurs in unusually large and solid masses, and it probably formed part of the ore shipped.

The alaskite porphyry dike, which is so important a feature in the geology of the mine, ranges from 15 to 35 feet in width. It has been considerably altered by the primary mineralizing solutions, which have silicified it so thoroughly that the quartz phenocrysts are now the only recognizable traces of its igneous origin. In addition to the newly introduced quartz, some sericite and calcite were formed in the dike, as well as the sulphides sphalerite, pyrite, galena, and arsenopyrite, but these sulphides are nowhere abundant enough in the dike to constitute ore. In the upper levels of the mine the hanging wall of the dike consists of Simon quartz keratophyre and the footwall consists of limestone; but in the lower levels both walls consist of limestone, as shown in figure 55. Because both the alaskite porphyry and the quartz keratophyre have been altered by mineralization it is difficult to distinguish them. The alaskite porphyry, however, is notably white, brittle, and shattered and tends to break into small angular fragments; the quartz keratophyre is far more massive, is characteristically permeated with innumerable manganese dendrites, and is much richer in phenocrysts, of which those of quartz are larger and the feldspars are closely crowded.

Unoxidized ore carrying zinc blende and pyrite appears first on the 230-foot level, although more or less galena persists up to the surface. The typical ore consists of galena and deep-brown zinc blende in a gangue of dark-gray jasperoid, with pyrite as a subordinate constituent. The jasperoid has the usual appearance of the fine-grained quartz aggregate that results from the siliceous replacement of limestone.

The ore body first discovered occurs in the footwall of the dike and forms a shoot in places as much as 60 feet wide and more than 200 feet long, making an irregular chimney that pitches northwest. After this shoot had been extensively developed crosscuts driven through the dike disclosed another fine body of ore on the hanging wall of the dike, replacing the limestone that occurs below the keratophyres, which evidently were unfavorable for the deposition of ore. On the 300-foot level this new shoot attains a width of 80 feet. It is reported that the quantity of ore blocked out in the two shoots aggregates 500,000 tons. Ore on the 230-foot level is reported to average 4½ per cent of lead, 9 per cent of zinc, and $2 in silver and gold to the ton.

The ore zone is cut by faults. The largest of these faults is known as the West fault, because it cuts off the northwestward extension of the ore zone on the upper levels. It is shown on the surface, where it trends northward, making an angle of about 35° with the course of the alaskite porphyry dike, which it has displaced 300 feet. The fault has been cut underground, where the trend of the broad corrugations in the walls indicates that the movement on the fault surface had no lateral component. If this is true the total slip is probably 600 to 700 feet. In conformity with this large slip the Simon quartz keratophyre forms the west wall of the fault as far down at least as the sixth (400-foot) level, much farther down than its normal position elsewhere in the mine. Owing to this fault and to the northwestward pitch of the ore shoot, it is probable, as Mr. O. H. Hershey has pointed out to me, that the downward extension of the ore shoot will be found in the west segment of the ore zone west of the West fault.

A fault known as the East fault cuts the ore zone a few hundred feet southeast of the shaft on the upper levels. It strikes at right angles to the ore zone and dips 60° NW. Because of this northwestward dip it comes successively nearer and nearer the shaft on the lower levels and cuts it between the sixth and seventh (bottom) levels. This fault seemingly terminates the alaskite porphyry dike and the ore shoots along the line of the section shown in figure 55, which is drawn through the shaft and at right angles to the ore zone. The displacement on this fault is small, however, the offset being not over 20 feet, and the ore shoot between the East and West faults has been found on the bottom level. After this segment had been cut further exploratory work was stopped late in 1920, and the energies of the company were turned to the construction of a milling plant.

SIMON CONTACT PROSPECT.

The Simon Contact prospect, owned by the Simon Contact Mines Co., is a few hundred yards northeast of the Simon mine. It is developed by an inclined shaft 350 feet long, which slopes 56° NW. and from the bottom of which a level has been driven for several hundred feet southwestward along the footwall of an alaskite porphyry dike.

The prevailing country rock is limestone of Triassic age, as shown by some *Ceratites* and *Spiriferina* that were found in it. This limestone strikes N. 65° W. and dips 20°–45° SW. It is cut by an alaskite porphyry dike, which is the easterly extension of the same dike on which the Simon mine is developed. In this prospect the dike strikes northeast, dips 50° NW., and is 25 feet thick. The Simon quartz keratophyre appears 200 feet west of the shaft, where it has been faulted down against the limestone. This faulting, however, antedates the injection of the alaskite porphyry dike, which cuts across the contact without offset.

The exploratory work has been done mainly along the footwall contact of the dike on the lowest level. Both the limestone and the alaskite porphyry have been heavily shattered and reduced to gouge along this contact. The alaskite porphyry has obviously been much sericitized, and the microscope shows that calcite also has been introduced. Some slabs of heavy sulphide ore occur in the limestone in the footwall of the dike beyond survey plug 311. The ore minerals are chiefly black zinc blende and galena, with pyrite, arsenopyrite, and chalcopyrite subordinate; the only gangue mineral is calcite.

SIMON STERLING PROSPECT.

The Simon Sterling prospect is a few hundred yards north of the Simon mine. It is developed by an incline of 20° that is sunk on the vein. The vein lies in a sheeted zone on the Simon quartz keratophyre, which appears here to be an explosion breccia rather than lava rock. The vein ranges in thickness from a few inches to 2 feet. It carries silver ore, whose tenor is spotty and reaches a maximum of 90 ounces to the ton. The metallic minerals are galena, arsenopyrite, pyrite, sphalerite, and minor chalcopyrite.

FAGAN PROSPECT.

The Fagan prospect, owned by the Simon Fagan Mines Co., is 5 miles in an air line southwest of the Simon mine. It is on the edge of the west flank of Cedar Mountain. The country rock is a fine-grained white marble, which is intruded a few hundred feet east of the shaft by granodiorite porphyry.

In 1920 a vertical shaft had attained a depth of 190 feet, from which crosscuts had been driven on the 50 and 100 foot levels. The vein is vertical and is irregular in width and on the 100-foot level has pinched down to a few inches. In places there is a highly sericitic gouge, possibly derived from the hydrothermal alteration of some intrusive igneous rock. The ore is chiefly limonite that carries lead carbonate; it probably averages between 5 and 10 per cent of lead and contains an ounce of silver for each per cent of lead. The best assay was obtained at a depth of 35 feet, where across a width of 4.9 feet the ore carried 26 per cent of lead, with 34 ounces of silver and 0.36 ounce of gold to the ton.

GOLD VEINS.

GENERAL FEATURES.

The gold veins occur only in the Tertiary volcanic rocks. They are not numerous, and only two have been worked; the Olympic has produced by far the most gold. The ore consists of fine-grained white quartz, much of it clearly pseudomorphic after platy calcite, containing the precious metal—a gold-silver alloy, so finely divided as to be invisible. Pyrite in traces is the only sulphide present, so that these highly siliceous ores contrast notably with the heavy lead-zinc ores of the earlier period of mineralization in the region.

The Olympic mine presents a number of perplexing problems in structure and faulting, the solution of which is vital to the future of the mine. These problems are discussed in the following description, and a solution is indicated.

THE MINES.

OLYMPIC MINE.

GENERAL FEATURES.

The Olympic mine, owned by the Olympic Mines Co., is at the north end of Cedar Mountain, 4 miles north of the Simon mine. The principal claims were located by J. P. Nelson in January, 1915, but it was not until May, after most careful prospecting, that the gold-quartz vein on which the mine is opened was discovered.[5] The property was shortly afterward promoted by F. J. Siebert, and the new

[5] Siebert, F. J., Nevada's latest gold camp: Min. and Sci. Press, vol. 114, pp. 449–450, 1917.

owners soon brought it to the producing stage. A mill was built to treat the ore by cyanidation. Water was supplied from a spring at an altitude of 7,500 feet not far from Little Pilot Peak through a pipe line 9 miles long. In November, 1919, the original mill burned down, and in the fall of 1920 a new one of 70 tons daily capacity was erected and completed. The ore in sight in the mine was then extracted, and operations were suspended on May 1, 1921, pending the raising of funds to explore for the faulted segment of the vein. Although the mine has produced more than $700,000 from ore of good grade—$16 to $20 a ton in gold and silver—yet the profit has been small, because most of it has been put back into exploratory work and in rebuilding the mill after the fire.

The ore was put first through a ball mill and then through a tube mill, 83 per cent of the ore being then fine enough to pass through

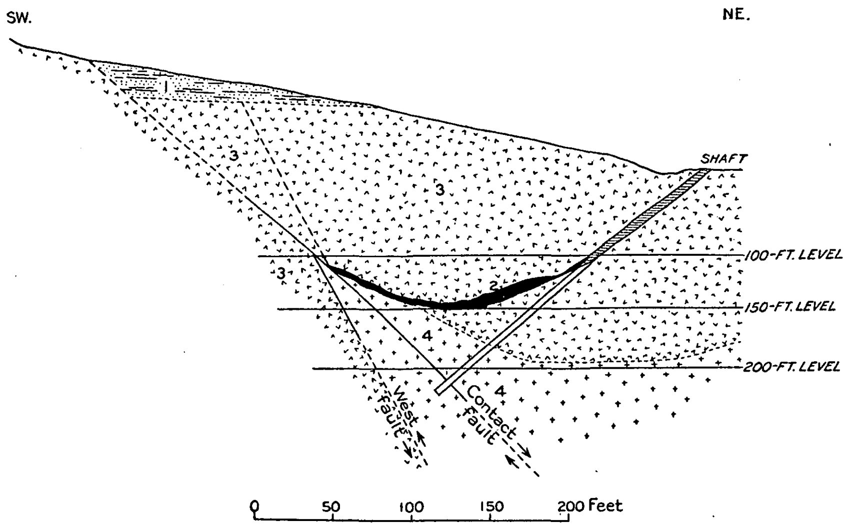

FIGURE 56.—Diagrammatic section through the shaft of the Olympic mine, Nev. 1, Esmeralda formation; 2, gold-quartz vein; 3, upper rhyolite; 4, trachyte.

a 200-mesh screen. The precious metal was then extracted by cyanidation, and a recovery of 90 to 92 per cent was maintained.

The mine is opened by an inclined shaft 225 feet long, which slopes approximately 40° SW. and whose upper portion is sunk on the vein (fig. 56). From this shaft three levels have been turned off—the 100, 150, and 200 foot levels.

AREAL GEOLOGY.

The rocks in the vicinity of the Olympic mine consist of Tertiary lavas, mainly rhyolites, and a series of lake beds, of younger age, the Esmeralda formation, which was laid down probably near the end of Miocene time. The vein itself crops out in a patch of rhyolite that is surrounded by lake and alluvial deposits. Farther from the mine andesites and other types of lavas appear. The lavas at the Olympic mine differ greatly from those near the Simon mine, 4 miles south, and their mutual relations are not known.

There are three important geologic units at the Olympic mine—two flows of rhyolite and between them a trachyte flow and associated tuff. The oldest rhyolite will be referred to as the lower rhyolite. It crops out on the west flank of the ridge southwest of the mine. It is a white rhyolite rich in phenocrysts of quartz and glassy feldspar, the quartz crystals being especially conspicuous. Under the microscope it is seen that the rhyolite once contained in addition plates of biotite, but these are now completely sericitized, and the feldspar, which proves to be sanidine, is also commonly sericitized.

Between the lower rhyolite and the upper rhyolite lies a flow of trachyte with associated tuff, the two together being roughly 150

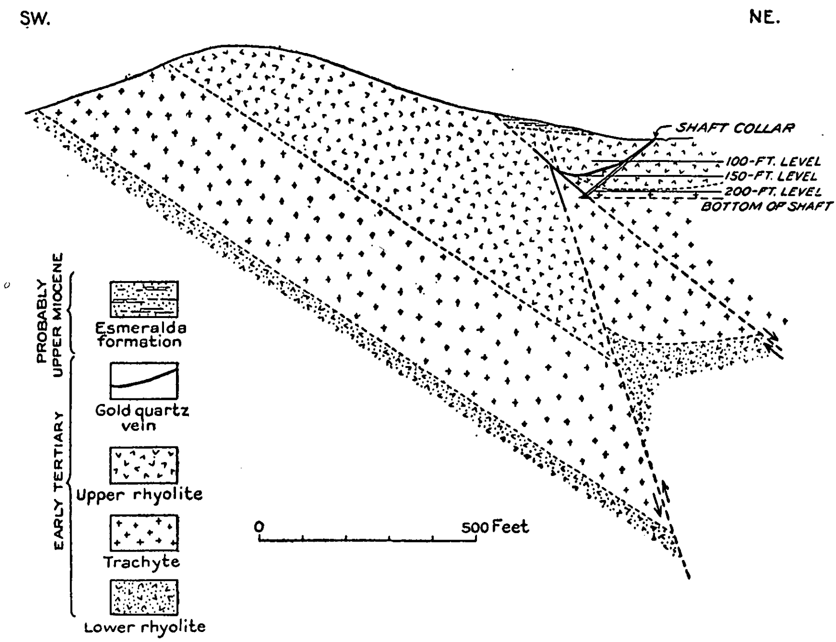

FIGURE 57.—Diagrammatic section through the ridge west of the Olympic mine, Nev., along the line of the shaft.

feet thick. The greater part of the trachyte carries very numerous feldspar phenocrysts, which are much altered (kaolinized or sericitized), some tablets of bleached biotite, and sporadic quartz crystals, in a grayish groundmass that appears rather dark colored in contrast to the rhyolites. It shows fluxion structures, which prove that this rock was a lava. Near the top of the flow the trachyte contains abundant spherulites, the largest the size of a pea, some of which are concentrically banded. This spherulitic facies becomes indistinguishable to the unaided eye from the white tuff that makes up the top of the middle member between the lower and upper rhyolites. Under the microscope the massive trachyte shows numerous phenocrysts of sanidine, much sericitized, surrounded by well-defined fluxion swirls, so that there is no question that this is actually a flow rock. The sanidine phenocrysts are much sericitized, and if any plagioclase was ever present it has been altered beyond recognition. Quartz phenocrysts are exceedingly rare. Thus the rock can be considered to be either a rhyolite in which quartz phenocrysts are exceedingly rare or a trachyte that carries sporadic quartz phenocrysts. The possibility is not wholly ruled out, however, that the rock is a quartz latite whose plagioclase phenocrysts have been wholly sericitized. Provisionally, however, the rock will be here termed trachyte. Different geologists employed by the company have termed it both rhyolite breccia and andesite, and as this rock proves to be the key to the structural puzzle that the mine presents a correct understanding of it must be obtained. For although in principle it makes no difference in working out the structure of an area by what name a rock may be called, yet in practice if a man terms a rock an andesite when in fact it is something else, he will correlate it not only with other masses of the same rock in the area but also with real andesites that may occur elsewhere in the area, and if he names it rhyolite breccia he will be likely to correlate it with undoubted rhyolite breccias that may occur in the area—all of which leads to confusion in interpreting the structure.

Between the trachyte flow proper and the overlying rhyolite is a white tuff or breccia, but whether it is a massive or pyroclastic rock is not everywhere obvious, and it resembles closely the upper part of the trachyte, especially where the spherulites are absent. It is irregular in thickness, but at most does not exceed 50 feet. Under the microscope it is seen to be composed chiefly of minute sherds of glass and is thus clearly of explosive origin.

The upper rhyolite is practically like the lower rhyolite in appearance. The only noticeable difference is that the upper rhyolite generally contains multitudes of rhyolitic fragments, which give it a mottled appearance. The vein crops out in this rhyolite, the upper workings of the mine are chiefly in it, and the east slope of the ridge west of the mine consists of it.

Lake beds of the Esmeralda formation occur in the immediate vicinity of the mine. They partly overlie the upper rhyolite and in part are faulted against it. On account of their soft and unconsolidated character their relation to the rhyolite is poorly shown in the surface exposures, but underground operations have in several places revealed the faults which have let them down against the rhyolite.

THE VEIN.

The vein near the surface strikes N. 20° W. and dips 40° W. It continues at this dip nearly down to the 150-foot level, where it begins to flatten and, becoming horizontal on the level itself, then bends upward until it dips 20° or 25° E. Its farther upward extension is cut off by a fault at 25 feet above the 150-foot level, in the section through the shaft, as shown in figure 56.

The vein ranges from 1 to 7 feet in thickness and averages about 4 feet. The vein filling is dominantly quartz but includes silicified rhyolite and less altered rhyolite. The quartz is white, fine grained, and sugary and in many places shows evidence that it has resulted from the replacement of lamellar calcite. It commonly occurs in a much crushed condition. The gold is not visible, nor does the ore contain any other metallic minerals. The ore first mined carried $20 a ton, and that extracted recently ran $16. The fineness of the bullion was 500 in gold, and the remainder is chiefly silver; evidently the precious metal in the ore is electrum. Prior to the burning of the mill in November, 1919, the mine had yielded 35,000 tons of ore, from which $700,000 was obtained.

FAULTING.

The vein is cut by a number of faults, chief of which are the two known as the Contact fault and the West fault. The Contact fault cuts off the upward extension of the west limb of the vein. The quartz drag found in the gouge of this fault shows it to be a normal fault. The upward bending of the vein has been interpreted by some as the drag effect of this fault; if this interpretation is correct then the segment of the vein that formerly lay in the footwall of the fault must have been removed by erosion, and the mine has practically reached the end of its life. The bending of the vein does not appear ascribable to the fault, however, but to other causes. In the first place, it is significant that the vein begins to flatten as it approaches the underlying formation. In the upper workings it is inclosed wholly in rhyolite; on the 150-foot level the hanging wall is rhyolite and the footwall trachyte. The vein has been deflected parallel to the contact between the upper rhyolite and the trachyte that underlies the rhyolite. Moreover, the rocks inclosing the vein have probably been bent into a syncline (fig. 57), and if this folding occurred after the vein had been formed, as it apparently did, it will account in large part for the structural peculiarity of the vein. On the 150-foot level the bottom of the trough of the vein lies at the shaft, but on the 100-foot level it lies 150 feet north of the shaft. The pitch of the trough is therefore southeastward.

The West fault lies west of the Contact fault; it dips 60° E. and is a reverse fault that brings the underlying trachyte up against the upper rhyolite. Upon the identification of the trachyte depends the interpretation of the structural problem presented by the mine. The trachyte forms the country rock of the mine below the 150-foot level and is unquestionably the same rock that crops out on the west slope of the ridge west of the mine. To account for its position in the mine the hanging wall of the West fault must have moved up at least 300 feet.

The Contact fault, which dips 40° E., is younger than the West fault and is a normal fault. The amount of displacement on this fault is not accurately known but it appears to be small. The interrelations of the two faults are shown in figures 56 and 57. According to the interpretations put on the structure and faulting as shown in those figures, the lost segment of the vein is to be sought in depth, at or near the contact of the upper rhyolite and the trachyte.

The intersection of the two faults at an acute angle has produced a wedge-shaped mass, the apex of which consists of trachyte bounded on each side by rhyolite. This relation is best shown on the 150-foot level.

On the ridge slope southwest of the mine erosion has exposed the apex of the wedge and shows the crushed trachyte inclosed between the rhyolite. This exposure has been considered by some to be an andesite dike.

MINA GOLD MINES CO.'S MINE.

On the edge of the flat 2 miles west of the Simon mine there is an old gold mine that was worked on a small scale about 1912. According to Mr. P. A. Simon, who is a part owner, it produced at that time $4,400 in gold. The operators merely screened the ore—they had no crushers—and cyanided the screenings, using water that they hauled from springs in the mountains. The plant is now in decay, and three tanks, filled with partly pulverized ore, remain as witnesses of former activity.

The vein lies at the contact of the Mammoth andesite and the overlying white lava, the keratophyre. It strikes N. 35° W., dips 15°–25° NE., and ranges from 2 to 4 feet in thickness. It is reported to carry between $7 and $8 a ton in gold. The vein filling consists of calcite, commonly lamellar, or of fine-grained sugary quartz, which has replaced the calcite; thus it resembles the ore of the Olympic mine.

It has recently been reported [6] that plans are being made to reopen the mine, ore of a good grade having been found in the faces.

[6] Personal letter under date of Apr. 11, 1921, from Mr. Robert J. Bonnemort.