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Unpublished report on the Carson Sink area, Nevada.

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CARSON SINK AREA, NEVADA

By

Frank
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1860-1944

(Field work 1911-1920)

General Geology

1935 ?

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Carson Sink Area

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Geology

General statement

The region lies in an area of primarily sedimentary rocks which are principally Mesozoic and are tilted, folded, and faulted and cut by granular intrusives, and flooded by Tertiary lavas as shown on Figure 4. The Mesozoic sediments were strongly folded and invaded by granular intrusives at or about the time of the intrusion of the great Sierra Nevada batholith. The rocks are exposed chiefly in the mountain ranges and hills.

The mountain ranges are mostly fault ranges with much of their structure monoclinal. Faulting in many instances has been prominent since the deposition of the Tertiary lavas and continues down to the present, as shown by fresh scarps and recent earthquake disturbances in the Stillwater and Augusta ranges and in general along the flanks of the various ranges by the tilted attitude of the lava flows and lake beds, and by the older lavas in general being tilted at steeper angles than the overlying lake beds. The faulting may be normal or overthrust.

The faulting shown in the various mining districts as Fairview and Wonder may be regarded as indicating that of the region in general.

In some parts of the region faulting is so young that it is still shown in the topographic forms as by trunctated gulches in the east base of the Stillwater range in Dixie Valley.

As the writer in the present work had but small opportunity to examine the rocks excepting in the various mining districts many of which are located far apart, the accompanying geologic map (Fig. 4) is largely compiled from earlier reports of various authors in order to here present a geologic picture of the region. The portion to the north of Latitude 39°30' is largely adapted from the 40th Parallel Survey and that to the south of the 39th parallel from papers and reports by Buwalda, Clark, Merriam, Hill, Spurr, and the unpublished work of H. G. Ferguson of the U. S. Geological Survey on the Hawthorne and Tonopah quadrangles.

Triassic and Jurassic rocks

The pre-Cambrian basement complex and Paleozoic rocks are not known to outcrop in the region. According to the 40th Parallel Survey the Paleozoic rocks rest directly on the eroded Archaean complex. The oldest rocks seen are Triassic whose sediments and also those of the Jurassic rocks during Mesozoic time were derived from an uplifted Paleozoic landmass in eastern Nevada and vicinity. Their distribution in the region here treated is shown on the accompanying map, fig. 4. They occur chiefly in the Stillwater Range and its southward continuation, the Sand Springs and Gabbs Valley ranges and Lodi Hills, and are important in that they, particularly their limestone members, are hosts to a considerable portion of the ore deposits of the region. The Triassic period was also one of volcanic activity along the whole Pacific Coast.

In their areas situated respectively just north and south of the Carson Sink region, Louderback and Buwalda describe the geological conditions as being in general similar from the beginning of Triassic on, and both compare them to those of the Sierra Nevada.

The Mesozoic rocks are best displayed to the north of the region in the Humboldt Range, which in the report of the Fortieth Parallel Survey, Hague[1]

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[1] Hague, Arnold, and Emmons, S. F., Descriptive geology of U. S. Geological Exploration of 40th Parallel, Vol. 2, p. 714, 1877.

described the Humboldt Range as consisting of an Archaean nucleus, surrounded and unconformably overlain by Triassic strata of great thickness, these in turn being overlain by Jurassic beds, which, along the base of the range and locally elsewhere, are steeply tilted, broken, and associated with masses of Tertiary rhyolite and basalt, and with poorly exposed Miocene beds called the Truckee group. The Archean and Triassic rocks were described as sparingly cut by Mesozoic dikes, chiefly diabase. The Triassic rocks which, in ascending order Hague designated the Koipato and Star Peak "series", are here termed respectively formations.

The Koipato formation was supposed by Hague to consist chiefly of metamorphosed silicified sedimentary rocks, beds of quartzite overlain by interstratified beds of limestone, quartzite, and "felsitic porphyroids". It was referred to the Triassic and regarded as of the same geologic age as the lower members of the "Red Beds" of the Rocky Mountain region. Its thickness was estimated at 6,000 feet.

The Star Peak formation, shown by Gabb, Meek, and others to be of middle and upper Triassic age, occupies somewhat more than the northern fourth, and the northern half of the eastern half of the Humboldt Range. was estimated by Hague to be 10,000 feet in thickness.

According to the section compiled by Ransome from Hague's description it consists of the following members:

Section of the Star Peak formation, Star Peak Range, Nev.

[Compiled from the description by Arnold Hague.]

	Feet.
Quartzite and overlying limestone..............................	4,000-5,000
Massive limestone...	1,800-2,000
Black arenaceous slates...	200- 300
Slaty quartzites alternating with greenish schistose rocks...	1,500
Limestones, dark, almost black at the base, passing up into gray and blue varieties................................	1,200-1,500

Ransome also writes:

The Star Peak formation is noted for its abundant Middle Triassic vertebrate and invertebrate fossils, which have been described by Gabb, Meek, Hyatt and Smith, and J. C. Merrian. * * * Hyatt and Smith [and Smith] state that the Upper Triassic is also represented in the Humboldt Range, and list half a dozen fossils. The beds containing them are said to be unconformably overlain by limestone containing Jurassic forms.

Later and more detailed work than that of the Fortieth Parallel Survey has shed more light on the geology of the range and led to certain revisions in the interpretation of the geologic phenomena and classification of the rocks. Of these revisions the following are the more important:

According to Louderback, the supposed Archean nucleus exposed in Rocky Canyon, 7 miles north of Nixon, is post-Triassic intrusive granite with associated contact-metamorphic phenomena in both the granite and the host rocks.

According to Ransome, the Koipato formation as a whole is a volcanic complex, consisting chiefly of rhyolitic flows, in which non-volcanic sediments, including limestones, form only a subordinate part. With this view, the determinations of the rocks in the Rochester district near the middle part of the range by Jones,[1] Knopf,[2] and others, including the

1/ Jones, J. C., Geology of Rochester, Nev.: Min. and Sci. Press, vol. 106, pp. 737-738, 1913.

2/ Knopf, Adolph, Geology and ore deposits of the Rochester District, Nev.: U.S.G.S. Bull. 762, 1924.

present writer,[3] are essentially in accord. Also on the south in the Hawthorne

3/ Schrader, Frank C., The Rochester Mining District, Nev.: U.S.G.S. Bull. 580, pp. 325-372, 1915.

and Tonopah quadrangles "The Mesozoic is represented by sedimentary and volcanic rocks of Triassic and Jurassic age and by plutonic rocks of Jurassic or Cretaceous age. The plutonic rocks are believed to represent a single epoch of intrusion."[4]

4/ Ferguson, H. G., and Cathcart, S. H., Major structural features of some western Nevada Ranges: Jour. Wash. Acad. Sciences: Vol. 14, No. 15, p. 377, Sept. 19, 1924.

Here according to the same authors the lowest group of the Triassic consists largely of volcanic materials.[5]

5/ Foshag, W. F., U. S. G. S. Bull. 795-E, 1927.

According to the Report of the Rortieth Parallel Survey,[6] the Stillwater Range just to the north of the region here treated in its larger features

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6/ Vol. I, p. 278.

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repeats the structure of the Humboldt Range in the same latitude. The range consists of a granite nucleus unconformably overlain by an immense but obscure series of dark varied siliceous and argillaceous schists, considered to correspond with the Koipato formation of the Humboldt Range. The orographical structure, however, is far more complicated and the relations of the beds are never as well defined as in the Humboldt Range. The Koipato group, which here forms the eastern member of the anticlinal, dips east and is overlaid by the heavy basal limestone of the Star Peak formation. The whole northern part of the range has been subjected to severe local disturbances and dislocations.

Essentially with the characteristics above described, the Triassic rocks extend southwestward into the Carson Sink region, with the granite inclusions, however, supposed to be Archean being post-Triassic and intrusive as afore noted. They are especially prominent in the Stillwater Range which they largely compose, and with modifications they continue interruptedly on southward through the region, being prominent in the Sand Springs, Gabbs Valley, Gillis, and Paradise ranges and the Lodi Hills.

As Mr. Ferguson, who has studied in detail the formations of the Hawthorne and Tonopah quadrangles in and to the south of the southern part of the present region, reports that in lithology and subdivisions ~~that~~ the Triassic and Jurassic differ markedly from the Triassic and Jurassic of the 40th Parallel Survey on the north, it is inferred that in their extension southward through the middle part of the region these formations must undergo a considerable transition. According to Ferguson the Triassic on the south consists of at least three main subdivisions instead of two, the Koipato and Star Peak on the north. Also the Jurassic consists of two or more distinct subdivisions. Moreover, the Mesozoic formations as a whole on the south form a transition or connecting link between those of the Grand Canyon on the southeast and those of the Sierra Nevada and California on the northwest. The work of Ferguson in this part of the field, which is far too elaborate for presentation in the present sketch, will appear in a later report.

In the middle part of the Stillwater Range the rocks are largely compressed into a single high narrow ridge only about 5 miles wide. Here in the latitude of Cox and I X L Canyons they are folded, faulted, and upturned with the prevailing dip to the northeast, in places as high as 60° or more, with the slaty-shaly Koipato formation of great thickness on the west overlain by the Star Peak limestone on the east.

Just northeast of Sand Springs the mountains consist essentially of these Jura-Trias sediments here mostly dark shale and limestone, and about 2 miles east of Sand Springs the Lincoln highway for some distances follows a syncline in these rocks.

One of the most conspicuous occurrences of the supposed Triassic rocks is at Chalk Mountain near the middle of the eastern border of the map. Chalk Mountain is a foothill outlier of the Augusta Range. It is about 3 miles long by 2 miles wide and 1,000 feet high and consists chiefly of whitish dolomitic limestone which has been intruded by granodiorite porphyry and arched up into an anticlinal fault block, fig. 41, map. Much of the limestone is more or less marmorized.

No fossils indicative of its age have yet been found in the limestone of Chalk Mountain, but because of Jurassic fossils found in limestone in the foothills to the south and in the adjacent part of the Westgate Range, and because of the more highly metamorphosed character and dynamically shattered condition of the limestone in Chalk Mountain, it is thought to be probably of Triassic age and to belong to the Star Peak formation.

The Spurr map shows a 5-mile wide belt of Triassic extending from Downeyville 5 miles eastward and about 12 miles each northward and southward and occupying almost the entire Paradise Range.7/

7/ Spurr, Josiah Edward, Descriptive geology of Nevada south of the 40th Parallel and adjacent portions of California: U.S.G.S. Bull. 208, Pl. I, 1903.

It is probable that some of the areas shown as Triassic on the map in the southern part of the region may contain also Jurassic rocks which have not been differentiated.

Jurassic-Triassic

The term and pattern Jurassic-Triassic are used on the accompanying map to designate areas which in the southern part of the region on the Hawthorne and Tonopah quadrangles consist of rocks known from fossil evidence to belong to both the Triassic and Jurassic periods, as determined by Ferguson at various points, by Buwalda and by Clark in the San Francisco district near Luning, but have not yet been differentiated. To the north of these quadrangles the rocks are those represented on the basis of their continuity, geographic position and lithologic similarity. Some of them doubtless contain fossils as reported at several points by residents. In the southern end of the Sand Springs Range, at Big Kasock Mountain, near Rawhide and at Slate Mountain in the south end of the Fairview Range the formations include a large quantity of dark slate.

Jurassic

The Jurassic, which consists chiefly of dark gray limestone and shale and is of considerable thickness, occurs chiefly in the east, central, and southern parts of the region. Some is also present in the north margin of the map in the Trinity Mountains, a few miles west of Humboldt Lake.

According to the Report of the 40th Parallel Survey, the Jurassic in the Nevada Province of that survey consists of a heavy dark gray limestone about 1,800 feet thick and about 4,000 feet of overlying argillaceous slates and shales.[8/]

8/ 40th Parallel Survey, Vol. 1, p. 295.

The best exposures of the formation seen in the present work are in the mid-eastern part of the region in the Chalk Mountain district and vicinity, particularly in the west slope of the Augusta Range, here called the Westgate Range. Here at about 2 miles east of Chalk Mountain the west slope of the range beginning at a point a little north of Westgate and extending northward for several miles is largely underlain by dark gray to bluish Jurassic limestone, which in general dips about 30° eastward into the range, denoting that the range here has probably been upfaulted along its western front. The limestone is intruded and in part flooded by Tertiary volcanic rocks. Interruptedly, at least, it extends several miles farther northward to a point 4 miles south of Wonder, and it is also exposed in the foothills near the Lincoln Highway about 2 miles south of Chalk Mountain. At all three of these localities it is fossiliferous and from them collectively has yielded the following forms which are referred by Dr. T. W. Stanton, Paleontologist, to the lower Jurassic, as well developed in the Hawthorne and Tonopah quadrangles to the south of the region.

From the locality 4 miles south of Wonder and 6 miles north of Westgate in the west slope of the Augusta Mountains (here called Westgate Range), collected by Harry Light:

Pecten sp.	Fragment of a large species of the type often called Neithea.
Pecten sp.	Fragment of a more compressed, more nearly equivalent form.
Arnioceras sp.	Possibly *A.* nevadanum (Gabb).
Arnioceras ? sp.	Good imprints of a species evidently distinct from the above.
Arnioceras ? sp.	Fragment of a large specimen possibly belonging to the last mentioned form.

Locality 2 miles east of Chalk Mountain and 3 miles north of Westgate in the west slope of the Augusta or Westgate Range:

Arnioceras ? sp.	Fragment of an ammonite probably belonging to this genus.
Pecten sp.	A very large species of Vola type.
Aegoceras ? sp.	A fine ammonite apparently belonging to Aegoceras or a related genus.

In places at this general locality the forms are said by mining men to be very abundant and to represent many species. The straight forms, as of the belemnites type, are/said to ~~xxxxxxx~~ occur chiefly, if not solely, in the lower part of the limestone which in part at least is light brown, and the coiled forms or ammonite type occur in great abundance at higher horizons in the dark limestone.

Locality in foothills 1 mile south-southwest of Chalk Mountain, 4 miles west of Westgate, and one-half mile north of the Lincoln Highway:

Arnioceras ? sp.	Two ammonite fragments possibly representing two genera.

In proceeding from Westgate 16 miles southward toward Broken Hills and the Esmeralda County line through a belt of country 10 or more miles wide whose surface is mostly underlain by Tertiary volcanic rocks, limestone is seen to crop out in places, and though it has not been examined it is thought to probably be Jurassic. Similarly to the south of Chalk Mountain limestone outcropping interruptedly through a distance of several miles in the lower west slope of Fairview Mountains may be Jurassic.

Tertiary

Miocene

Truckee group

As no Cretaceous sediments appear in the region, it is inferred that during the Cretaceous period the region was a land area exposed to sub-aerial erosion.

The most important development of the Tertiary sedimentary rocks occur in the northwest part of the region in the Hot Springs Mountains and the valley to the north, separatingthem from the Trinity Range, Fig. I. Here, accofding to the 40th Parallel Survey, 9/ the beds are lacustral and expose a

9/ Vol. I, p. 415.

thickness of about 2,300 feet and consist in descending order of:

(1) 1,200 feet of drab, mauve, gray, pale-buff and white stratified trachytic tuff, mixed with detrital material and all characterized by rapid changes in color and texture.

(2) Coarse, sandy grits, gray and yellow fragments,
partially rounded. . . . . 250 feet

(3) Saccharoidal limestone, rich in fresh-water mollusks. . . 60 "

(4) Marly grits, yellow and drab, rather coarse. . . . . 40 "

(5) Fine-grained friable, buff and gray sandstones, having
a peculiarly sharp gritty feel. . . . . 70 "

(6) Variable gray sandstones. 100 "

(7) A marly grit. . . . . 60 "

(8) White and yellow infusorial silica. . . . . 200-250 "

(9) Palagonite tuff, beds not seen, 250 feet being maximum
exposure.

Here as nearly everywhere the beds dip at angles of 10 to 25°, and they are referred by the 40th Parallel Survey to the Miocene. Similarly in the northeast corner of the region about a mile wide belt of upturned volcanic and sandy sediments of this group extends 10 miles southward along the west base of the Augusta Mountains nearly to the mouth of Shoshone Valley.

Upper Miocene

Esmeralda formation

The next important exposures of the Tertiary sediments are in the southeastern part of the region where they occupy most of Stewart Valley, here the southern part of Ione Valley and a considerable portion of Gabbs Valley and vicinity, in all 50 or more square miles as mapped by Ferguson on the Hawthorne and Tonopah quadrangles, from which they seem to extend northward into the Quartz Mountain District. See map, fig. 4.

The beds are known as the Esmeralda formation from their similarity to and continuity with the Esmeralda formation originally described by Turner[10/]

10/ Turner, H. W., The Esmeralda formation, a fresh-water lake deposit, 21st Ann. Rept. U.S.G.S., Part II, pp. 191-209, 1900.

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in the Silver Peak quadrangle farther south in Esmeralda County.

According to Turner the beds there are composed of sandstones, shales, and lacustral marls with local deposits of breccia on a large scale. They nearly everywhere dip from 5° to 60°, and Turner provisionally assigns to them a thickness of nearly 15,000 feet.

In Stewart and Ione Valleys, according to Buwalda,[11/] the beds consist

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11/ Buwalda, John P., Tertiary mammal beds of Stewart and Ione valleys in west-central Nevada: University of Calif. publications, Bull. of Dept. of Geology, Vol. 8, No. 19, pp. 335-363, 1914.

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mostly of thin-bedded lacustral fine to coarse textured sandstones, shales, generally calcareous and hard, and several types of impure hard compact heavy limestone. They are mostly whitish or light-colored and are composed of quartz and other sediments derived from the rocks in the surrounding mountain ranges and include considerable pyroclastic material, especially fine ash and pumice. Buwalda here places the thickness of the formation at about 1,000 feet. The beds rest unconformably on a deeply eroded surface of the older rocks and wherever they have a covering are overlain unconformably by fanglomerate. They are moderately deformed by open folds parallel with the axis of the mountain ranges, but their dip rarely exceeds 15°.

From fossil remains comprising Mammalian bones, fish bones, fresh-water mollusks and wood, the formation is referred to the Upper Miocene.

Buwalda notes that the Truckee beds afore described are, in general, similar in appearance to the Esmeralda, and that it is not improbable that the correlation of the Esmeralda with the Truckee suggested by Spurr is correct[12].

12/ Op. cit. p. 352.

This correlation is also suggested by Merriam[13] who has specially studied

13/ Merriam, John C., Tertiary vertebrate fauna from the Cedar Mountain region of western Nevada: Univ. of Calif. Publications, Bull. of Dept. of Geol., Vol. 9, No. 13, p. 167, 1916.

the vertebrate paleontology of the Esmeralda formation from the Cedar Mountain region.

It may also be noted that the sediments formerly known as the Siebert Lake beds are now known to be the same as the Esmeralda. The known age and wide distribution of the Esmeralda formations make it a valuable criterion or marker for differentiating the age of the lavas that unconformably underly it from those that intrude and overly it, in places conformably.

Judging from fossil wood reported at several localities, the Esmeralda formation covered by later deposits probably has a much wider extent in Gabbs Valley and vicinity than is at present known. For instance, in the open valley just north of Regent at about 2 miles northwest of Rawhide and also at 2 miles west of Regent, fossil wood, of which good silicified ~~xxxxxxxxx~~ chalcedonized and opalized specimens were seen by the writer at Rawhide, is said to occur plentifully strewn over the surface from which the place is locally referred to as the fossil forest graveyard. As the fossils are similar to the forms described from the Esmeralda of Cedar Mountain, it is inferred that they are probably derived from the same formation which may occur in this vicinity and has since been more or less buried by Quaternary alluvium.

The Regant occurrence of the fossils is at the elevation of about 5,000 feet, the same as that of the Esmeralda beds in the north-central part of Gabbs Valley 20 miles to the southeast with the present intervening barrier standing at an elevation of about only 4,800 feet, that near Dead Horse Well 10 miles south of Rawhide, and which separates Gabbs Valley from the wide open valley on the west extending to the head of Walker Lake.

Pliocene

Humboldt formation

In the northeastern part of the region at about 40 miles east of Fallon in the head of Dixie Valley and adjoining the Wonder District on the north and the Horse Creek area on the east are exposed eroded sedimentary beds of tuffaceous "sandstone" which in turn seem to rest unconformably on the eroded volcanic rocks along the foot of the mountains and outliers of them which they encircle in the open valley, fig. 10. The sandstone beds are well exposed interruptedly through a distance of several miles between the mouth of Hercules Canyon and Horse Creek to the northeast, where they are incised by present gulches to depths of about 30 feet. They were observed to extend up the mountain slope to an elevation of 4,450 feet, than which, however, they probably extend somewhat higher. The beds vary from heavy to thin. They are light colored, and range from gray to whitish. They are composed mainly of porous, light, friable, and almost pumiceous volcanic tuff but include also some kaolin or chalk-like members. They are faulted and upturned and for the most part dip toward the N.W. away from the mountains and toward Dixie Valley. The composition of the beds and their disturbed condition suggests that they probably represent showers of volcanic ash and dust emanating from the eruptions of the volcanic rocks of the Wonder district and vicinity and were deposited in an adjacent lake which may have occupied Dixie Valley or a considerable portion of it. The beds are therefore referred to the Tertiary age. They seem to be correlative with similar deposits found elsewhere in Nevada belonging to the Humboldt formation,[14/] which was deposited in a great lake,

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14/ King, Clarence, 40th Parallel Survey, Vol. I, p. 434.

Emmons, W. H., A reconnaissance of some mining camps in Elko, Lander, and Eureka counties, Nevada: U.S.G.S. Bull. 408, pp. 21-23, 1910.

Schrader, F. C., Bull. 497, pp. 31, 106-107; also Bull. 741, pp. 15, 81.

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named Lake Shoshone by Clarence King, which in Pliocene time occupied almost the whole territory between the Wasatch Range on the east and the Sierra Nevada on the west extending northward into Idaho and southward for an unknown distance.

The beds of the Humboldt formation, or their equivalent, probably have a much wider distribution in the region than the Horse Creek area here described, but they were not observed or recognized as such in the present work. The only occurrence of them shown by the 40th Parallel Survey in the present region is a small belt in the middle of the western border in the north bend of Carson River just west of the old site of Ragtown.

Quaternary deposits

(a) Lacustral deposits

(b) Alluvial deposits

(c) Dune deposits

Lacustral deposits

The Quaternary deposits, areally speaking, consist chiefly of alluvium, but they include also important lacustral deposits as follows:

The several permanent lakes, Carson Sink, Soda Lake, Carson Lake, and Walker Lake, shown on the map, are mere remnants of a much larger lake - Lake Lahontan - which, in the Quaternary period, occupied nearly all of northwestern Nevada and adjacent portions of California and Oregon,[15] a total area of nearly

15/ King, Clarence, U. S. Geol. Exploration of the 40th Parallel, Vol. I, p. 504, 1878.

Russell, I. C., Lake Lahontan: Monograph U.S.G.S., Vol. 11, 1885, p. 28, Pl. XLVI.

9,000 square miles. It had a maximum depth of 886 feet at the present site of Pyramid Lake. It covered nearly all of the western half of the region here treated and extensive lowlands in the northeastern part. Among other places, its shore line records at their most persistent levels, are well marked in the northeastern part of Fallon on Rattlesnake Hill, at Sand Springs 12 miles southeast of Fallon, and practically all along the northwest base of the Stillwater Range where the horizontal lake beds and terraces rise to an average elevation of about 4,500 feet.

At Rattlesnake Hill, which is composed of a remnant of a flow of blackish basalt, the records consist of level shore line incrustations of light-colored calcareous tufa encircling the hill at intervals from its middle slope to the top.

At Sand Springs the steep slope of the mountain just east of the station and north of the Lincoln highway shows very beautifully 5 or 6 well-marked Lahontan Lake shore terraces situated at intervals up to a height of several hundred feet above the base of the mountain. The terraces are plainly visible to the tourist from his passing automobile. They curve conformably around the southwest end of the mountain and extend for a considerable distance northward along its west front. They are built up in large part of coarse bouldery black volcanic talus or rock debris eroded from the higher slopes of the mountain, and since the recession of the lake they have been incised or locally cut through by trenchant hanging gulches, whose upper reaches during Lahontan time supplied much of the constructive material.

In the northeastern part of the area on the western front of the Stillwater Range between Copper Kettle Canyon and White Cloud Canyon, the writer counted seven successive Lahontan terraces. At Cox Canyon what seems to be the two upper of the bench terraces stand about 25 feet apart vertically, and the next pronounced terrace stands at about 50 feet lower than the lower one of the two. Locally the nearly horizontal lake shore gravels composing the terraces meet the face of the mountains in nearly vertical cliffs or fault scarps.

Walker Lake Valley according to Russell is underlain by roughly stratified gravels, sand and silt deposited in an arm of Lake Lahontan.

Elsewhere in the bottom of the lake were deposited in places a great thickness of finer sediments, chiefly clays and sands eroded from the surrounding mountains and uplands, which the Timber lake well sunk by the Government in search of potash near Fallon penetrated to the depth of 985 feet without reaching their lower limits. 16/

16/ Gale, Hoyt S., The search for potash in the Desert Basin region: U.S.G.S. Bull. 530, p. 295, 1913.

Phalen, W. C., Potash salts, summary for 1912, Mineral Resources of the U. S., 1912, Part II, pp. 880-882.

The strata as shown in the log of this well are alternating layers 5 to 30 feet in thickness of clay and sand or quicksand. Many of the latter bear large artesian flows of relatively fresh water. At Rock Springs, 18 miles southeast of Fallon, the spring ~~out~~ in Eightmile Salt Flat issues, artesian-like, several feet above the level of the Flat and is perennial. The water is warm and sulphurous.

Later deep drilling for oil in the Fallon basin seems to indicate that the unconsolidated sediments in the Carson Sink basin may locally be nearly 3,000 feet in maximum thickness as follows:

As a point 9 miles south of Fallon and 1½ miles west of Carson Lake, well No. 5, of the Syndicate Oil and Gas Co., known as the Syndicate well, had in 1922 a depth of 2845 feet "all in unconsolidated material which seems to be largely thin-bedded soft shaly clay which is probably derived from finely divided water-laid tuff. Cuttings from this well (No. 5) contained minute shells in which, on being examined by the W. S. Mountain Museum, the only fossils found were simple Ostracods considered to be derived from fresh water Triassic rocks".

Thus there appears to be present in the basin a maximum thickness of about 3,000 feet of unconsolidated fresh water sediments, Pleistocene and recent, consisting of sands and silts or clays. While the upper portion of this section is probably largely Lake Lahontan sediments the lower part may be Siebert beds of Pliocene age. Thus far there is no evidence of any beds of marine origin in the Tertiary and more recent formations under Carson Sink. 17/

17/ Hewett, D. F., Explorations for oil and gas near Fallon, Nevada: Mss. report Sec. of Geology of Fuels, Sept. 1922.

In the deep well (No. 5) water stands at a depth of 300 feet below the surface and the well shows a slight gas pressure when capped.

There is also said to be a deep well in the northwest part of the basin at White Plains 28 miles north of Fallon on the Southern Pacific Railroad on which the following data were kindly supplied by Mr. John T. Reid of Lovelock in oral communication Oct. 1930. The well is said to be artesian in character, 2,800 feet deep, and all in unconsolidated material - lake beds, Valley fill or wash, with no hard rock, with salt water in the bottom. Water in the well stands at the surface but does not rise any higher.

At the depth of about 1,600 feet was found an 18-foot thick log of a redwood tree perfectly fresh in appearance.

The well was drilled in the year 1886 by the Central Pacific Railroad Co. in whose care the log of the well was lost in the great San Francisco earthquake fire. This may be the same well referred to in the following quotation: "In 1886 gas developed in an artesian well put down on the Freeman Ranch about 20 miles from Fallon and was used to heat water on a small scale". 18/

18/ Salt Lake Mining Review, p. 28, Jan. 15, 1920.

As the White Plains well is in the Lahontan Basin, its collar is at about the same elevation as the Timberlake well, and the surface at each is underlain by about the same Quaternary deposits. Probably a considerable portion of the upper part of the log of the White Plains well is Lahontan Lake beds about the same as the Timberlake well which in depth are probably underlain by deposits belonging to the Humboldt formation or perhaps Truckee beds constituting the lower part of the log which latter formation occurs a few miles to the northeast at Humboldt Lake.

The soils of the Fallon project and vicinity which have been studied and mapped by the U. S. Department of Agriculture [19] consist of sediments formerly

19/ Strahorne, A. T., and Van Duyne, Cornelius, Soil Survey of the Fallon area, Nevada: U. S. Dept. Agriculture, Bureau of Soils, 1911.

deposited in the bottom of Lake Lahontan. They are mostly sandy loams generally deficient in organic matter, and all but the lightest contain alkali.

Jones who has made a study of the lake concludes that "it existed in historic time and can be correlated more closely with the Sequoia curve than with the stages of continental glaciation." [20]

20/ Jones, J. Claude, Age of Lake Lahontan: Bull. Geol. Soc. Amer., Vol. 40, No. 3, Sept. 1929, pp. 533-540.

Dixie Valley separated from the former shore lines of Lake Lahontan only by the narrow steep divide of the Stillwater Range is not known to have been connected with Lake Lahontan, although its bottom lies 400 feet lower than the lowest part of the Carson Sink desert. It has an elevation of only 3,400 feet and is said to be the lowest point in the State of Nevada.

The most of the present lakes and Carson Sink are undrained or without outlet, water being removed from them only by seepage or evaporation, in consequence of which their waters are alkaline or saline, the salts leached from eroded sediments and carried in solution being left behind as the water containing them evaporates or seeps away. To this process is due also the chemical character of the various playas or flats shown on Pl. 3, as alkali, - salt and borax flats, which are no longer permanent lakes but whose surfaces are covered with water only during wet seasons or following heavy rains, and they are then known as playa-lakes.

Alluvial deposits

Of all the Quaternary deposits the most widely distributed and abundant are the Alluvial deposits or valley fill forming the bolson plains. They nearly everywhere cover the broad valleys and lower slopes of the mountains. They consist chiefly of gravel and sand but include also coarse talus along the foot of the mountains and cliffs and silts and clay beside sand and gravel along a few of the streams. Excepting a minor quantity along a few of the streams, as Carson and Walker rivers, the deposits are nearly all sub-areal and were deposited by transitory torrential streams and sheet floods caused by cloudbursts. They were deposited at first mostly in the form of huge fan-cone deltas and sheets or blankets which with gentle slope extend in some ~~xxxxxxxxx~~ instances 10 miles or more from the foot of the mountains out into the valleys and merging with one another form the bolson plains. Locally as at the Stillwater Range and Walker Lake region they include also mud flows.21/

21/ Blackwelder, Eliot, Mud flow as a geologic agent in semi-arid mountains: Bull. Geol. Soc. Amer., vol. 39, pp. 465-484, June 30, 1928.

Aeolian deposits (Dunes)

Dune sand is widely scattered throughout the region, chiefly around the margins of some of the playas and flats where it forms dunes composed of the fine material swept from the surface of the playas by winds during dry periods. It occurs largely as knollys and hills and ridges of more or less prominence, which are usually treeless but covered with a scanty growth of various desert shrubs which retard drifting by the winds and give to the forms a relatively stationary character. The forms are abundant in Carson Sink Valley, especially around Fallon and vicinity. An example of the larger dunes is shown in Fig. 3 and Fig. 4B near Sand Springs. This dune forms a hill 3/4 of a mile long by 3/8 of a mile wide and about 500 feet in maximum height. It has for the most part a sharp sinuous crest at the top and consists mostly of whitish or light-gray sand. The hill is larger and higher toward its northeast, stoss or prevailing windward end, from which point it gradually declines in height and tapers toward its southeast or lee end. From this configuration it is inferred that the material of which the dune is composed was mostly derived from Fairview Valley on the northeast and was blown by the wind southwestward through the low pass near the head of the dune. Under favorable conditions, however, doubtless some material was also derived from Four mile flat on the southwest.

The sand of this dune seems to be composed mainly of small grains of quartz or silica. It is said to have been tested by a mining engineer from Ely and found to be suitable for the manufacture of glass and to contain a trace of gold.[22/] The Indians are said to regard this dune and the crunching and behavior

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22/ Nevada Mining Press, p. 4, May 20, 1927.

of its material under foot somewhat like trampled snow or quicksand with suspicion. Their tradition holds that an Indian mounted on horseback and accompanied by his faithful dog attempted to ride through a pass in the dune, from which, however, only the dog was able to escape; the Indian and his horse becoming engulfed in the treacherous quicksand disappeared beneath the surface and no trace of them has ever been found.

In the northeast corner of the Carson Sink Quadrangle (Fig. 3) a single line of dunes extends from the north edge of the map 12 miles or more southward to Ford Avery Canyon. These dunes are narrow elongated ridges about 100 feet high a few hundred yards wide and range individually up to 5 miles in length. They lie about parallel with the adjacent west front of the Stillwater Range and more or less closely follow the 4,000-foot contour. The stoss or westerly side of the dune is gently sloping while the lee or easterly side is comparatively steep.

The dunes are formed by wind-blown sand and dust swept from the wide-open expanse of the Carson Sink Valley over the West by southwesterly winds. The prevailing winds are said to blow N. 37° E. This direction intersects the axis of the dunes at an angle of about 30°, which is of interest because the dunes are gradually migrating easterly at about right angles to their axis. Their rate of migration, according to Reid[23/] who has been closely observing them

23/ Reid, John T., Oral communication: Oct. 2, 1930.

for many years is about twenty (20) inches per year. The dunes are sparsely clothed with a scattered growth of stunted greenish "sage brush", which seems to find its best foothold in the lee side of the dune where it extends nearly to the crest and seems to be very instrumental in retarding the migration of the dune.

Igneous rocks

The mountain ranges contain also a great variety of igneous rocks. These rocks are abundant, widely distributed and cover large areas. The consist of two main groups:

(a) Granular intrusives

(b) Tertiary volcanics

Granular intrusive rocks

The granular intrusive or plutonic rocks consist chiefly of granitoid types, granodiorite, granodiorite porphyry, diorite, monzonite, quartz monzonite, granite, and aplite, true granite, however, being comparatively rare. The dominant type is granodiorite, which, accofding to Lindgren, is also a normal rock in the neighboring Sierra Nevada and Cascade ranges. The rocks occur as masses, batholiths, stocks and dikes, as shown in the Augusta, Stillwater, and Wassuck ranges. They range from late Jurassic to early Tertiary, and are probably to be correlated as satellites to the batholiths of the Sierra Nevada and California on the west.

They are manifestly younger than the sediments which they intrude and overlie, the oldest of which are Triassic, and older than the Tertiary lavas, which, in turn, intrude and overlie them, and as but few of the many which intrude the late Jurassic and younger formations intrude also the Triassic, it is concluded that in age the rocks mostly range from late Jurassic to early Cretaceous, but some intrusions extended also into the early Tertiary. The principal activities are probably to be correlated with the intrusions of similar rocks which occurred on an extensive scale along the Sierra Nevada Range during this period.

At the close of Jurassic, according to the 40th Parallel Survey, a powerful mountain-building period prevailed in Nevada with the ejection of middle-age eruptive rocks whose post-Jurassic age is clear from their covering and intruding Mesozoic strata in Nevada and California. From a similar study of the relations of these rocks to rocks of known age in various parts of the West described by Lindgren, Ransome and others, it is concluded that the rocks are essentially of Cretaceous age.

According to later work of Nolan they were intruded at two main periods, Late Mesozoic and early Tertiary. Those in the western part of the Nevada batholith are not later than early Cretaceous and those in the eastern part not earlier than Eocene, some being even younger than folded Eocene and those intermediate in area are also intermediate in time. The rocks are of economic importance because the ore deposits found in association with them in the Mesozoic sediments in the region seem to be genetically connected with their intrusion. They are widely distributed throughout the region, the first three named occupying areas of several miles or more in extent which seem to represent batholiths and stocks. Examples of them are the granite area in the Stillwater Range 10 miles east of Stillwater having an extent of about 16 miles, a smaller area in the Sand Springs Range, the diorite area in the northeast corner of the Carson Sink quadrangle, the granodiorite area 20 miles or more in extent in the Wassuck Range, the area of granodiorite porphyry in the Lodi Hills and one at Chalk Mountain, the granite in the Paradise Range, and several smaller though important areas of quartz monzonite and diorite in Gabbs Valley Range and in the Pilot Mountains on the south. In the southern part of the region the plutonic rocks are chiefly quartz monzonite and are believed to represent a single age of intrusion.[24]

24/ Ferguson, H. G., and Cathcart, S. H., op. cit. Jour. Wash. Acad. Sci.

Smaller areas of the intrusives occur at various points throughout the region in nearly all of the ranges. Both diorite and granite occur in the Augusta Range. Commonly associated with the larger areas of the intrusives are smaller areas or bodies and complementary dikes of the granitoids as aplite, quartz monzonite, diorite, and related forms.

The rocks are further described under the various mining camps in which they occur.

Tertiary volcanic rocks

As already noted and shown on the map, Fig. 4, large portions of the region have been flooded by Tertiary lavas. The lavas were erupted throughout the Tertiary period. It was early recognized by the 40th Parallel Survey and other surveys that the Great Basin shows a great variety of Tertiary lavas which are identical over wide areas and were erupted in somewhat the same succession, the order of sequence being in general:

(1) Andesites

(2) Trachytes

(3) Rhyolites

(4) Basalts

With this sequence the lavas of the present region are in general agreement, excepting certain minor variations and complications by repetition. The principal periods of eruption were:

(1) Eocene. Andesite.

(2) Late Miocene. Trachytes. (Their tuffs form Miocene Lake beds several hundred feet in thickness).

(3) Early Pliocene (extending through about the first third of it). Rhyolite.

(4) (Middle to late) Pliocene. Basalt.

In the present region, however, some of the rhyolite seems to have been erupted in the Late Miocene. "The pre-lacustral lavas are younger than Middle Miocene. They show a netted appearance on the weathered surface."

Quantitatively the lavas are present in the following order:

(1) Rhyolite

(2) Basalt

(3) Andesite

As to location, the Tertiary eruptives throughout the world most frequently occur at the angles of powerful flexures or dislocations of earlier rock masses. 25/

25/ King, Clarence, 40th Parallel Survey, Vol. I, p. 606.

The Tertiary lavas shown in the part of the region covered by the 40th Parallel Survey are almost entirely rhyolite and basalt, and these two rocks are present in about the ratio of 2:1.

Andesite

The andesite eruptions took place principally in the Eocene period. Andesite is widely distributed in the region, being present in neafly all of the ranges and mining camps, but nowhere is it abundant or does it constitute large areas of the country rock. In several camps, however, as Fairview, Rand, and Broken Hills, it contains important mineral-bearing veins with whose deposits it is genetically connected.

According to Emmons,[26/] in the central part of the Augusta Range "in the

[26/] Emmons, S. F., Augusta Mountains: 40th Parallel Survey, Vol. II, p. 651.

deep canyons to the east of Crescent Peak, is a great variety of older eruptive rocks associated with limestones and quartzites, apparently wrapped around a body of granite. Through these rocks have poured outbursts of hornblende porphyry which have been succeeded by extensive eruptions of andesite forming the main body of the range which in turn are covered by flows of trachyte and the whole succeeded by rhyolite".

The prevailing andesite in this place and vicinity is a light greenish-gray rock having large black phenocrysts of hornblende in an earthy groundmass.

Trachyte

The trachytes are the least plentiful of the four volcanic groups of rocks. They were erupted chiefly in the late Miocene where their tuffs form lake beds several thousand feet in thickness. In the present region these rocks are widely distributed, but for the most part they are only sparingly present. Several areas of them, each several miles in extent, are shown by the 40th Parallel Survey respectively in the northeast base of Hot Springs Mountains west of Carson Sink; in the east slope of the Stillwater Range, near the north limits of the map opposite Copper Kettle Canyon, and at Crescent Peak and vicinity in the Augusta Range.

Rhyolite

As the trachytic eruptions form the characteristic volcanic feature of the late Miocene, so the rhyolites form the characteristic of early Pliocene, their tuffs also forming voluminous lake beds. Their eruption accompanied or closely followed the orographic disturbances that tilted and dislocated the Miocene beds at the close of that period.

According to King, rhyolite is supefficially the predominant volcanic rock of the 40th Parallal Survey field, and considerably exceeds the basalts which rank next in territorial area. These two families cover ten times as many square miles as all the rest of the volcanic series combined.

The most extensive exposure of the rhyolite shown by the 40th Parallel Survey in the present region is toward the northeast in the Augusta Range, of whose area more than 90 per cent is occupied by a body of rhyolite forming a belt 80 miles long by 12 miles wide, and having a thickness of mostly 2,000 to 7,000 feet. It is the largest single body of rhyolite in the whole 40th Parallel Survey. The edges of the flow beds forming the high summit mass between Shoshone Springs and Antimony Canyon exposes a thickness of fully 6,000 feet. The beds dip gently northeastward, in places at angles of about 15°, all of which dip, however, is probably not due to flow, some of it being attributed to post-depositional tilting, caused chiefly during the period of basalt eruption. The beds are from 50 feet to a few hundred feet in thickness. They are conformably superimposed one upon another and are all of different external character.[27]

27/ Emmons, S. F., 40th Parallel Survey, Vol. II, p. 656.

From a study of the rhyolites as a whole in the Augusta Range by the 40th Parallel Survey, the rule seems to be that the earliest eruptions were of a glassy and brecciated type, and the later ones were more solid and porphyritic. As a rule, the higher and central portions of the range lack the bedding which in places may be seen toward the foothills on either side. A view of the rhyolite beds near Horse Creek is shown in Fig. 4-A (Photo 1644-1645.)

This large belt of rhyolite in the Augusta Range is only the western margin of a much larger northeast-southwest belt, the "Great Central Nevada rhyolite belt" which has a length of about 200 miles, a width of 45 to 80 miles, and comprises a group of six or more adjoining ranges in all of which the predominant rock is rhyolite. This train of rhyolite ranges is said to be the most remarkable volcanic feature in the whole field of the 40th Parallel Survey. 28/

28/ 40th Parallel Survey, Vol. I, p. 615.

Basalt

The basalt eruptions occurred mostly in the middle Pliocene, but they extended also into the late Pliocene, and some are scattered down to the present time. Opal 3

Basalt is commonly widely distributed throughout the present region and in places is more or less abundant. It is generally the youngest of the volcanic rocks and frequently caps them and forms mesas which its flows built upon them. One of the largest occurrences of this rock is on the Stillwater Range at the northeast edge of the map and adjoining territory including Table Mountain of the 40th Parallel Survey, where it covers nearly 100 square miles, and the accumulated thin flows locally aggregate 2,000 to 3,000 feet in thickness. The mass rests on a great thickness of rhyolite through which it has broken. Other extensive occurrences are in the Hot Springs Mountains 20 miles northwest of Fallon, in the west slope of the Stillwater Range 16 miles southeast of Fallon, and in the ~~xxxxxxxxxxxx~~ mountainous ridge about 8 miles west of Sand Springs.

The hard rocks composing the hills that surround the broad flat Fallon basin are basalt or basaltic andesite. They occur in bedded tuffs, breccias and thin flows that dip gently west. As exposed easterly from Salt Well Junction, northeasterly from Salt Well and Sand Springs, the tuffs and breccias occur in considerable thickness and are of variable character. In places they rise nearly to the top of the hills where they are capped by flows. They are mostly whitish or light gray, but in places reddish brown or brick red and mottled with these colors. As these same rocks have been found in almost any deep well drilled in the Fallon Basin, they seem, without doubt, to form the irregular hard bed rock that underlies the great thickness of unconsolidated materials that fill the basin. The greater part of most of the wells drilled is in unconsolidated material, but some wells seem to be wholly in the volcanic rocks.

The wells show that the volcanic flows are very irregularly distributed, which, according to Hewett, the presence of the Rattle Snake Hill residual suggests may be due to the possible presence of eastward dipping north-south pre-Lahontan normal faults such as appear to occur along the eastern edge of the basin and may repeat parts of the section. (On the general geologic map, Fig.4). The Tertiary volcanic rocks have for the most part been mapped as undifferentiated, especially in the northern part of the area, where they could not be adequately examined between widely separated mining districts. In the southern part of the area, however, the more detailed work of Ferguson and Cathcart has separated this group of rocks or the belts representing its southerly continuation into (a) Pliocene ? lavas and sediments and upper Miocene rhyolite and (b) pre-Esmeralda lavas.

That the undifferentiated areas in the northern part of the field may also contain sediments is suggested by the relationship of the lake beds to the lavas in the west front of the Augusta range at Horse Creek north of Wonder (page G-15 and Fig. 4A).

Ore deposits

Mineralization in the region is widespread and took place on a large scale. The ore deposits are mainly of two classes and belong to the two well-known great groups of deposits described by Lindgren, 29/ Ferguson 30/

29/ Lindgren, Waldemar, Mineral deposits: 3rd edition, pp. 516-717, New York, 1928.

30/ Ferguson, H. G., The mining districts of Nevada: Econ. Geol., Vol. XXIV, No. 2, pp. 115-148, 1929.

and others in Nevada and neighboring States. They are (1) Cretaceous or Early Tertiary; (2) middle or late Tertiary.

Cretaceous or Early Tertiary deposits

The Cretaceous, eatly Tertiary, or deep-seated deposits are genetically connected with the intrusions of the granular rocks as granodiorite or quartz monzonite, as at Chalk Mountain, Quartz Mountain, and Bernice. They consist mainly of quartz ~~xxxxxx~~ veins but include also contact metamorphic and replacement deposits in both the intrusive and host rocks. In the temperature classification of Lindgren 31/ they mostly come under the heading of "mesothermal".

31/ Lindgren, W., op. ci., pp. 598-717.

The gangue is mainly quartz with minor quantities of carbonate minerals. The primary sulphides include pyrite, arsenopyrite, tetrahedrite, galena, sphalerite, jamesonite, and ~~xxixixxx~~ stibnite and are argentiferous and slightly auriferous, but they rarely constitute commercial ore. The valuable ore generally contains supergene silver minerals. The principal metals they contain are silver, gold, copper, and lead. In the contact metamorphic type as at Coppereid, copper is the principal mineral. In the vein replacement type as of argentiferous galena in limestone and quartzite at Chalk Mountain and Quartz Mountain, silver and lead are the principal metals. As the deposits have suffered much erosion their now accessible parts were formerly deeply buried.

Tertiary deposits

The Tertiary or younger deposits occur as veins, shear zones, and replacements almost entirely in the Tertiary lavas with which they are genetically connected. They occur near the surface and belong to the epithermal type in the Lindgren classification. Tertiary mineralization occurred on a large scale and with great diversity. It occurred in several epochs but mainly in Miocene time. In places the hypogene mineralizing magmatic solutions widely propylitized the lavas they penetrated.

The deposits are mostly connected with Miocene rhyolite and andesite or their related types as latite and trachyte as at Wonder and Fairview and are of Pre-Esmeralda age. The principal metals are silver or silver and gold which commonly occur together in a quartz-adularia gangue. Silver predominates by weight. Copper, lead and zinc are subordinate. Free gold is common in the oxidized zone but not below groundwater level. However, workable ore in veins generally continuous below the zone of supergene enrichment.

Most of the gold and silver produced in Nevada has come from this class of Tertiary deposits. The chances of making new discoveries are more favorable in this class than in the older deposits.

Distribution

The deposits are widely distributed in the mountainous sections of the region in about 26 mining districts as follows: (1) Wonder, (2) Fairview, (3) Chalk Mountain, (4) Gold Basin, (5) Bell Mountain, (6) Broken Hills, (7) Quartz Mountain, (8) Rawhide, (9) Eagleville (Hot Springs) and King, (10) Rand, (11) Holy Cross (Terrell), (12) Benway, (13) Sand Springs, (14) Mountain Well (Laplata), (15) Job Peak, (16) IXL Canyon, (17) Cox Canyon, (18) Shady Run, (19) Fondaway Canyon, (20) White Cloud Canyon, (21) Copper Kettle Canyon, (22) Cottonwood Canyon, (23) Marvel, (~~25~~ 24) Jessup, (25) Bernice, (26) Alpine.

Those which are, or have been, the most important, are the Wonder, Fairview, Rawhide, Rand and Quartz Mountain districts. The Wonder and Fairview districts are in approximately the same latitude, or east-west trend as Virginia City, Austin, Eureka, Steptoe and Ely.

CARSON SINK AREA, NEVADA

By

F. C. Schrader

Fairview District (2)

Fairview District

Location

The Fairview district is about 35 miles by airline east-southeast of Fallon, just south of the Lincoln Highway and the old Overland Trail. It is in the rugged west slope of the Fairview Mountains, toward their north end, at an elevation of about 5,700 feet. (Fig. 3 and Fig. 27). The country rock is mostly andesite. The principal part of the district is comprised in an area of about 2 square miles shown in figure 28, but during the boom period activity extended several miles northward and 8 miles southward, the south extension being then called South Fairview.

History and production

The first discovery of mineral in the district was made in the autumn of 1905 by F. O. Norton and C. L. Wilson, prospectors of Reno, on the ground which they located as the Cyclone Group. They found rich lode silver ores in place in andesite at or near the surface. Other good indications were soon afterwards found by other parties, and the news of these discoveries attracted mining men from various camps. A stampede began in February 1906, and many persons reached the camp before the date of the San Francisco earthquake and fire, which caused many of the mining deals in the district to be cancelled.

In January 1906 Perley Langdell, of Colorado, on discovering ore in an 18-inch quartz vein in a prominent andesite outcrop along the side of a north-south fault gulch, located the Boulder and Boulder No. 1 claims (fig. 28). This property later became the famous Nevada Hills mine.

The Fairview Eagle property, which adjoins the Nevada Hills on the northeast, soon became the second important producer of the camp. It opened up shipping ore in several places, and on the 200-foot level it had a 15-foot vein consisting mostly of sulphide ore that ran $50 to the ton in silver and gold, and a 2-foot oreshoot running about $700 to the ton. Twenty hoists were being operated early in 1907. In April the population was 2,000, and 300 men were employed in the mines. The boom town of Fairview had sprung up at the foot of the mountains 2 miles northwest of the Nevada Hills mine, with a postoffice, several hotels, two newspapers, and telephone facilities, and for a few years it was the main settlement of the district. Though the town itself has since disappeared, its site, shown in fig. 3 and other maps, is useful as a tie point in describing the location of other features in the district, as is also the site of the Nevada Hills mine.

By July 1906 an indexed claim map covering more than 12 square miles and showing about 400 claims had been prepared and published by United States Deputy Mineral Surveyors. By 1910 the nucleus of population and activity had shifted to a site in the Fairview Canyon, about half a mile northwest of the Nevada Hills mine, where the company built a hotel and other buildings for housing its mine force. This settlement became known as New Fairview, or the Upper Town, and the original Fairview as Old Fairview, or the Lower Town. Water hauled 15 miles from East Gate sold in the camp for $2.50 a barrel of 50 gallons. The miner's wage was about $5 a day. Drifting cost $8 a foot. Freight from Fallon was 1-1/4 cents a pound and ore haulage to Hazen $12.50 a ton.

The Boulder claims, located by Langdell, together with the ore that had then been produced, were sold for $7,500 (IN March 1906 ?) and in June the owners cleared $8,000 on their first ore shipment, which was sent to Salt Lake.

The Cyclone group of claims, including the original discovery in the district, sold for $120,000, the Lena group for $145,000 and the Ohio group for $4,000. The Boulder No. 6 claim sold for $18,000; this claim contained the richest surface showings in the camp, some assays running $2,800 to the ton. The Golden Boulder sold for $2,500. Within a few years after discovery of the camp about twenty properties had been patented. The population, on the other hand, had dwindled by 1910 to only a few hundred, and by 1912 there was but one producing mine, the Nevada Hills, though development work was being done on several other properties. From this date forward the history of the Nevada ~~Hills~~ Hills mine is practically the history of the camp.

History of Nevada Hills mine

Until 1921 the Nevada Hills mine was owned by the Nevada Hills Mining Co. with headquarters at Reno, Nevada, and New York City. The company was organized and incorporated April 19, 1906, under the laws of South Dakota, with an authorized capital stock of $6,250,000. It soon purchased from W. A. Webber for $25,000 the Boulder and Boulder No. 1 claims which formed the nucleus of the property henceforth known as the Nevada Hills mine. By 1912, through the acquisition of adjacent ground, this property had been increased to 107½ acres, all patented. The

Fairview Eagle mine was consolidated with it in 1911. The mine was a steady producer from the time it was purchased by the company until it was closed downin 1917. Its total production up to that time was $3,250,000, of which $2,000,000 was produced before its consolidation with the Fairview Eagle mine, which by that time had produced $30,000.

The following incomplete figures, all that are now available, serve to illustrate roughly how recovery and production were distributed through the years 1911-1916. During this period the property was operated almost continuously, and very efficiently, by the Nevada Hills Mining Co., some of the time with a force of 120 men but most of the time with about 50 men. The company's production during this period is said to have been $2,265,000.

here

Partial production of Nevada Hills mine

For period ending	Value
Dec. 31, 1906	$121,000 1/

Year ending	Tons ore	Gross value	Average value per ton	Percent of recovery
Mar. 31, 1912	10,956	$296,042.90	27.02	89.00
Dec. 31, 1913	41,919	577,458.32	13.78	88.40
Dec. 31, 1914 2/	64,348	505,798.67	7.86	88.8
Dec. 31, 1915 3/				
Dec. 31, 1916	52,436	402,833.29	7.68	80.9

1/ By the end of 1906 there had been shipped from the property a total of $121,000 worth of ore having a net value of $254 to the ton.

2/ Net profit was $67,036.

3/ Net profit was $39,142. Percent of recovery 81.7.

The management says that about $300,000 of unnecessary expense could have been saved if the quantity of ore remaining had been approximately known before the splendid milling plant was built. At that time, both the Nevada Hills and the Eagle veins showed their best values and greatest width on the lowest levels. The part of the Nevada Hills vein to the west of the Main fault had been opened continuously for more than 1,000 feet along its strike; it had produced about $2,000,000 worth of ore and there remained in sight $604,000 worth of ore. In the part of the vein extending east of the Main fault on the 465-foot level, an ore body 8 to 12 feet wide and running about $80 to the ton had been opened for a length of 250 feet, and a 50-foot winze sunk from this level showed was in good ore to the bottom.

Both the Nevada Hills and the Eagle veins, however, passed out of ore at slightly greater depth, without any apparent reason. Later, work on the eastern segment of the Nevada Hills vein disclosed that the ore body gradually narrowed downward, with decreasing values, until at 30 feet below the bottom of the winze it became of no commercial value and at 50 feet below the vein it contained no ore. This part of the mine was further prospected at depths of about 700 feet, but no ore was found. Certain parts of the mine, moreover, said at the time of purchase to contain good ore, were later found to have been worked out.

In April 1913, there was said to be sufficient ore in sight to run the mill for two years. A little later, when it was realized that the mine would soon have to be abandoned, much ore was stoped overhead until it became dangerous to continue. The remainder was then shot down, stulls and all, as cheaply as possible. By this process the ore was mined with a small amount of labor, the cost of mining and milling being only 81 cents a ton.

Later - in 1920 for instance - Fairview was quiet except that several lessees were chloriding ore from deposits in the Nevada Hills mine or associated ground. One lessee is said to have taken out $1,200 from a pocket in the north side of the old glory hole.

In 1921 the Nevada Hills Mining Co. was reorganized on an assessable basis under the name of the Nevada Hills Mining Co. Reorganized, and was operating mining properties elsewhere than in the Fairview District.

Development

The mine was opened to a depth of 935 feet and was developed on 9 levels by more than 43,000 feet of work distributed in shafts, adits, tunnels, drifts, crosscuts, winzes and raises. It is said that work was also done on the 1100-foot level before the mine was closed down, and some still deeper exploration was done with the diamond drill. Drifting and lateral work cost about $11.50 per foot and sinking much of the Webber shaft cost about $63.00 per foot.

In point of time much of the work was performed about as follows:

Year ending	Feet of work
Mar. 31, 1912	4,200
Dec. 31, 1913	6,243
Dec. 31, 1914	5,697
Dec. 3, 1915	1,812

The principal shaft, through which most of the mining was done and the ore delivered to the mill, is the Webber shaft, 935 feet deep (fig. 27, at right). This had three compartments, a concrete collar 25 feet high, and a steel head frame 77 feet high, and it is timbered throughout with 10 by 10 Oregon pine. The Nevada Hills shaft had two compartments and a depth of 580 feet, and the Eagle shaft a depth of 315 feet.

More than 4,000 feet of work was done in the year ending March 31, 1912, for the purpose of connecting the old workings with the Webber shaft, in order that their ores might be conveyed to the mill more economically. The 300-foot level of the Webber shaft was connected with the 200-foot level of the Nevada Hills shaft, this being the suitable depth to recover the ore in the Nevada Hills vein west of the Main fault; the 450-foot level of the Webber shaft was also connected by an 800-foot crosscut with the deepest workings of the Fairview Eagle mine, and the 650-foot level of the Webber shaft was connected with the 565-foot or bottom level of the Nevada Hills shaft, for the economical handling of ore in the Nevada Hills vein east of the Main fault.

Treatment of ore

During the year ending March 31, 1912, the principal construction program of surface equipment, including the mill, was completed at a cost of about $503,000, of which the mill, including machine shop and other related buildings, cost about $354,000. The mill, a 20-stamp cyaniding plant completely equipped with the most modern machinery and improvements, The principal shaft, through which most of the mining was done and the ore delivered to the mill, is the Webber shaft, 935 feet deep (fig. 27, at right). This had three compartments, a concrete collar 25 feet high, and a steel head frame 77 feet high, and it is timbered throughout with 10 by 10 Oregon pine. The Nevada Hills shaft had two compartments and a depth of 580 feet, and the Eagle shaft a depth of 315 feet.

More than 4,000 feet of work was done in the year ending March 31, 1912, for the purpose of connecting the old workings with the Webber shaft, in order that their ores might be conveyed to the mill more economically. The 300-foot level of the Webber shaft was connected with the 200-foot level of the Nevada Hills shaft,this being the suitable depth to recover the ore in the Nevada Hills vein west of the Main fault; the 450-foot level of the Webber shaft was also connected by an 800-foot crosscut with the deepest workings of the Fairview Eagle mine, and the 650-foot level of the Webber shaft was connected with the 565-foot or bottom level of the Nevada Hills shaft, for the economical handling of ore in the Nevada Hills vein east of the Main fault.

Treatment of ore

During the year ending March 31, 1912, the principal construction program of surface equipment, including the mill, was completed at a cost of about $503,000, of which the mill, including machine shop and other related buildings, cost about $354,000. The mill, a 20-stamp cyaniding plant completely equipped with the most modern machinery and improvements, was built at the Webber shaft in the period September 1910 to August 1911, and was operated almost continuously until June 1917, when the mine was closed down for want of ore. The mill, together with its process of ore treatment and flow sheet is described by McGraw. 1/

1/ McGraw, Herbert A., Cyaniding silver at Nevada Hills mill: Eng. & Ming. Jour., Vol. 95, No. 13, pp. 645-648, Mar. 29, 1913.

The cost of mining and milling the ore in 1916 was about $6 per ton, of which $3.30 was for mining and $2.60 for milling.

Some of the ores were easily treated, but some were treated with difficulty. In general they were harder than the usual Nevada silver ores. Their manganous character, especially where oxidized, made them more or less refractory for cyanidation, so that the average extraction of about 90 percent which was obtained was regarded as good. Lower recoveries were obtained from low-grade ores than from high-grade ores. About 50 percent of the ore treated was passed through a tube mill using pebbles of Norway flint. The mill-tailings dump, containing about 260,000 tons, runs about $1.50 in value to the ton, or about .007 oz. gold and 2.3 oz. silver.

About two-thirds of the product was bullion composed of about 100 oz. of silver to 1 oz. of gold, and one-third was concentrate. The bullion was shipped to the Selby smelter at San Francisco, where it was refined and the metals were parted into fine gold and silver. The Company then sold the gold to the mint and the silver to the Merchants National Bank, where it brought a slightly higher price than that quoted in New York. The concentrates were shipped to the International Smelting and Refining Company at Tooele, near Salt Lake City, Utah, where they were treated gratis by reason of their siliceous character. The company also received returns for the small amount of copper in the concentrates. During most of the period of operation about 50% of the production was net earning.

The mine and mill were supplied by the Pacific Power Company with hydro-electric power from near Bodie, California, over a line about 140 miles long. The camp used a total of about 400 continuous horse power, costing about \$7 per horse power per month, or \$1.33 per kilowatt hour.

The mill was equipped for fine grinding and originally had a capacity of 120 tons of ore a day, which, however, had been increased to more than 200 tons by 1914. The average treated in that year was 176 tons a day. In 1916 the ore treated averaged \$7 to the ton.

Tenor of ore

The ore in general ran about 100 oz. silver to 1 oz. of gold. The ratio of gold to silver increased downward, so that in the deeper part of the mine it was about 50 oz. of silver to 1 oz. of gold. In the Wingfield vein east of the main fault on the No. 3 level, and in the Nevada Hills vein on No. 7 level, the ore ran only about 40 oz. of silver to 1 oz. of gold, which, however, is exceptional. During the early history of the camp the ore averaged about \$2 in silver to \$1 in gold.[2]

2/ U. S. Mineral Resources, ~~1910lpx~~ 1901, p. 394.

Water supply

Until 1913 the mill was supplied with water from the mine, the flow from which averaged about 5,000 gallons ~~faddmmx~~ of water a day up to 1916, and rose during a part of 1912 to 30,000 gallons a day. Much of the water came from the Eagle workings. The water occurred, however, only in sporadic pockets or chambers in the rocks at ~~xg~~ places where it was confined by impervious dikes or sheets of gouge, and with increase in depth it was found that the mine was becoming dry. The company accordingly procured in 1913 a more dependable and adequate source of supply by purchasing water rights at Westgate, from which it thereafter pumped the water 8 miles through a 2-inch pipe line, against a static head of 1,300 feet.

Topography

The topography of the district and vicinity is mountainous and in part fugged, as is fairly well expressed in figures 3 and 29.

The Fairview Mountains, on whose west slope the district lies, form a belt about 12 miles long by 5 miles wide extending from the Lincoln highway southward to Slate Mountain near the county line. The belt, as shown in figures 30, 31, and 32, consists of a high axial ridge about 2 miles wide flanked or nearly surrounded by a zone of rugged foothills several miles in width. Toward the northeast the mountains culminate in Fairview Peak, a well-known prominent landmark, which has an altitude of 8,250 feet and rises 4,000 feet above the adjacent Fairview Valley on the west. The ridge is unsymmetrical, its west slope being about 4 miles wide and its east slope only 1 mile wide, and the uniformity of its crest is interrupted by half a dozen peaks and knobs, alternating with saddles or passes. The only pass through which a wagon can cross is occupied by the old Downeyville road, which leads southeastward through the southern half of the range to Bell Flat, Quartz Mountain, Downeyville, and Tonopah. In the northern part of the range the east slope, in part a fault scarp, descends steeply 2,000 feet to a rough mountainous plateau-like belt of volcanic rocks about 6 miles wide, above which the Fairview Mountains have been upfaulted.

Both topographically and geologically the Fairview Mountains apparently represent a southward continuation of the uplift of the Augusta Range, with which they are axially in direct alignment and with which they are loosely connected through Chalk Mountain. Like the Augusta Range, they stand between the Desatoya Mountains on the east and the Stillwater Range or its southward continuation, the Sand Spring Mountains, on the west. (Fig. 3).

The upper slopes of the mountains support a good stand of stunted coniferous trees that are suitable for fuel.

Geology

The Fairview Mountains, especially in their northern part, have a granitic core of intrusive quartz monzonite, flanked on the lower west slope by an overlying complex of Mesozoic sediments. All these are flooded and overlain by Tertiary volcanic rocks, chiefly in superimposed flows, tuffs and breccias (figures 28 and 28a) and it is in certain of the volcanic rocks, or in close association with them, that the ore deposits of the district occur. Alluvium and wash fill the valleys and overlap on low slopes at the feet of the mountains.

Sedimentary rocks

Mesozoic sediments

The oldest sedimentary rocks observed in the present work are quartzitic schist, limestone, shale, and slate.

Seemingly the oldest of these rocks and probably the most extensively exposed in the range is a leaden- to iron-gray fine-grained quartzitic calcareous schist. This rock has a pronounced silver sheen on its foliated surface, and from its laminated or foliated character is commonly called slate. It occurs sparingly near Fairview and at some other places, and it is abundant at the southern end of the Fairview Range, where from report it seems to be the dominant rock of Slate Mountain. Except for a belt about a mile wide, mostly occupied by volcanic rocks, that extends along the south side of Crown Canyon, the schist is exposed at the Crown mine shaft, where it dips gently northward into the mountains. Flattish pebbles of it are abundant in the Crown Canyon gravels, especially in those discharged from McDaniel Gulch, which heads in the north-central part of Slate Mountain. From the abundance of monzonitic aplite associated with the gravel it is inferred that the aplite is probably intrusive into the schist back southward in the mountain. Aplite in place is well exposed in the north end of Slate Mountain, about a third of a mile southwest of the Crown mine.

The schist is believed to belong to the Koipato formation of the 40th Parallel Survey.

Limestone is not abundant. With some associated shale it is exposed a mile south of the old townsite of Fairview in a northwest-southeast belt about a mile long by 1/4 mile wide, and it is also exposed on or near the Dandalo and Badger claims and elsewhere. It is mostly a bluish-gray, heavy-bedded rock of medium grain, only semi-crystalline or but little altered. In general it dips gently westward about parallel with the piedmont slope which it underlies. In places, however, it is folded or contorted and is whitish and crystalline. Just south of the Dandalo claim and near the Badger claim it is cut by an east-west dike 10-feet wide of tuffaceous porphyritic andesite, and a little farther south, just beyond the Badger claim, by a north-south rhyolite dike, which is closely banded and partially mineralized. Still farther south the limestone is exposed at a few places in the sides of gulches. From its general resemblance to the limestone near Chalk Mountain, 3 miles to the north, which contains Jurassic fossils, it is thought to be a southward continuation of the latter and of Jurassic age. Some of the more crystalline limestone, however, that occurs farther to the southeast and nearer the axis of the range may be Triassic, as are probably also the rocks composing Slate Mountain. In this vicinity the limestone does not seem to be more than a few hundred feet in thickness.

Quaternary alluvium

Lapping upon the consolidated rocks along the lower slopes of the mountains is a sheet of alluvium or wash composed of gravel, sand, and angular rock debris eroded from the rocks in the mountains. From a feather dge at the base of the mountains, these deposits increase in thickness o at least 100 feet in the adjacent valleys. Near the middle of the alley, west of the range, at a point 4 miles west of Fairview, a well nown as the Hayes-Monnette well, sunk in search of water at a cost of 15,000, is reported to have attained a depth of 600 feet without reaching edrock. A considerable part of the well's log, however, may represent uried lake beds instead of alluvium. Water was first reached at a depth f 350 feet in gravel with rounded pebbles about 2 inches in diameter, and this gravel extends to the bottom of the well. The deposit above the rounded gravel is described by the driller as "chip" gravel and seems to have been ordinary wash from the hills. It apparently was more or less clayey or impervious, as the water on being reached soon rose 50 feet and permanently stood at the 300-foot level in the well. The water is said to be of fair quality and suitable for domestic use, but there is no record of its every having been used. Perhaps the dying out of the boom discouraged installation of the expensive pumping plant and town reservoir that had been planned for.

Igneous rocks

Mesozoic intrusive rocks

Quartz monzonite

Quartz monzonite, locally called granite, seems to form the core of Fairview Peak and the northern part of the range. It is exposed on the north slope of Fairview Peak and at the foot of the mountains 2 miles south of Fairview, where it occupies an elliptical area north and south about 1/3 mile in diameter. This and the other granular rocks are regarded as intrusive into the Mesozoic sedimentary rocks, and aplite can be seen to cut the slate at the south end of the mountains. They are regarded as late Jurassic or early Cretaceous age, like the granodiorite porphyry of the neighboring Chalk Mountain and Quartz Mountain districts. Fragments and boulders of these rocks, especially the quartz monzonite, are included in most of the overlying volcanic formations.

The quartz monzonite is a medium-grained, granular, sparingly porphyritic gray rock, with a greenish tinge that is due to alteration of its dark minerals. A specimen from the north slope of Fairview Peak is found by microscopic study to consist mainly of plagioclase (oligoclase-andesine) and orthoclase in about equal quantities, together with considerable biotite, quartz, microcline, and hornblende. The feldspars are largely kaolinized and sericitized and the biotite mostly changed to chlorite. With the biotite and hornblende is associated a little secondary magnetite. The rock has been deformed by orographic pressure, as shown by sharply bent prisms of hornblende and foils of biotite.

Diorite porphyry

The diorite porphyry is exposed in the northwest foot of the mountains, about 1-1/4 miles east-northeast of Fairview, at an elevation of about 4,800 feet. Here, cropping through the volcanics on and near the Defiance No. 1 claim, it forms the country rock in an elliptical area about a quarter of a milelong and is cut by a one-foot dike of andesite porphyry. The diorite porphyry is a dull greenish-gray speckled rock fine- to medium-grained and moderately porphyritic. Only weathered specimens, too much altered for accurate determination, are available. The microscope shows the rock to consist largely of oligoclase-andesine, much-altered hornblende and augite, and secondary feldspar, calcite, chlorite, quartz, and epidote.

Aplite

Eastward, up the slope, from the diorite porphyry area on the Bonanza claim group and vicinity the talus contains angular aplitic debris, from which it is inferred that aplitic dikes, probably complementary to the larger masses of quartz monzonite and diorite porphyry, crop out nearby, as they do elsewhere in the range. Aplite is plentiful in the north part of Slate Mountain, south of Crown Canyon, where it seems to be ingruded into the quartzitic schist.

Greenstone

Associated with the limestone and schist in places and seemingly intrusive into them is a dark-green much altered rock which probably represents a basic pre-Tertiary andesite or diabase. This rock is well exposed about a mile northwest of the Nevada Hills mine.

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Tertiary igneous rocks and veins

Introduction

The Tertiary volcanic rocks and veins are all thought to be Miocene. They are listed below in order of increasing age, the oldest at the bottom.

Fairview Peak dacite

Fairview Peak andesite

Pyramid tuff

Rhyolite

Grade formation

Later andesite

Barren quartz veins (Blout)

Ore veins

Faults

Lode andesite porphyry

Dacite tuff

From their relations to the underlying rocks and their similarity to rocks of known age in the surrounding region, the volcanic rocks are regarded as Miocene.

The volcanic rocks are more abundant and have more geologic interest than the others in the district, and they contain all the ore deposits. They form nearly all of the rugged western slope of the range. They have a known thickness of at least 3,000 feet, and their lower limits were not reached in the deepest mine workings. They are almost all fragmental. Oxidation extends in them to a depth of 300 feet, and at the Nevada Hills mine the groundwater table stands at a depth of probably about 2,000 feet below the surface, so tthat it is not likely to be reached in mining operations in that part of the range. The volcanic rocks are structurally and stratigraphically complicated, as they are at Tonopah. At two or more periods they are considerably faulted and in part mineralized by hypergene magmatic solutions, which resulted in the formation of the present deposits.

The rocks are best known in the Nevada Hills mine and vicinity, where they have not only been studied by the present writer but also studied and mapped for the Nevada Hills Mining Co. by Dr. A. C. Lawson, Mr. Oscar H. Hershey, and the Co.'s resident engineers, Charles C. Starr, R. A. Hardy, and James C. Greenan, all of whose reports, together with a report on the microscopic features of the rocks by Dr. Chas. P. Berkey, were kindly placed at the writer's disposal by the company. The geology of an area of about 2 square miles has been mapped in detail (figs. 28 and 4). The mapping is largely adapted, with only minor changes, from the company's map.

The Tertiary volcanic rocks are divisible into eight or more formations listed in columnar order on page ~~21~~ 17, and they represent more than eight eruptions. They rest with marked unconformity on the eroded surface of the older intrusive rocks already described. The formational names that were early introduced by the Nevada Hills Mining Co. or its geologists have locally come into general usage, and some of them appeared in published paper; they are therefore retained as far as possible.

Dacite tuff

The oldest of the volcanic formations consists of a succession of dacitic tuffs, ash beds and ~~xxxxxxxxx~~ agglomerates, several hundred feet in total thickness. Its areal distribution is shown in part on the map (fig. 28), and its relations to other members of the group in the cross sections (fig. 28a). The dacitic rocks are very heterogeneous in structure, texture, and color. They weather mostly to a dirty greenish gray, some of it yellowish or whitish. In some places they are hardened and masked by silicification. Texturally, they range from coarse agglomeratic material containing inclusions up to a foot and a half in diameter, down to dense or extremely finely stratified and laminated waterlaid material which seems to represent the finest volcanic ash. They are coarsest in or near the lower part. The basal layer, consisting chiefly of unstratified tuff, includes also scattered coarse boulders and blocks of the older intrusive rocks. Above it is a layer of still coarser agglomerate with more abundant inclusions of granite, up to a foot and a half in diameter, which in turn is followed by very fine-grained evenly stratified volcanic ash. The granite boulders and blocks were probably derived, during the process of eruption, from eroded sub-aerial surfaces of the underlying granitic rocks and from the walls of vents in those rocks.

The dacite tuff is well exposed at the Keystone tunnel and in the canyon below the Eagle mine, the fine-grained waterlaid phase being well shown at the Junction of Eagle and Dromedary gulches, where it is seen to produce a smoother topography than the other rocks (fig. 33, right foreground).

The dacite tuff has been considerably disturbed and altered, and part of it has been mineralized. In the northern part of the mapped area, near the Dromedary Hump mine, the stratified lake beds lie nearly horizontal or dip gently northeastward at angles of about 18°. Farther to the southwest, just beyond the large barren quartz vein, the same beds have been monoclinally uptilted northeastward at steeper angles; here, as may be seen both on the surface and in the mines, ~~then~~ the underlying beds of coarse agglomerate dip 50° to nearly 90°. Similarly the unconformable contact of the tuff with the underlying pre-Tertiary rocks, which is exposed about a mile to the northwest of the Nevada Hills mine and is there accompanied by a long barren quartz vein, dips steeply to the northeast. From this it is inferred that the Lode porphyry, the formation next described, was erupted along the steep monocline in the dacite tuff, that the monocline probably coincides roughly with a subjacent break in the pre-Tertiary complex through which the Lode porphyry was erupted, and that the dacite tuff and Lode porphyry probably extend to a great depth—perhaps 3,000 feet below the surface at the Nevada Hillx mine.

Lode andesite porphyry

Second in age of the volcanic formations is the Lode andesite porphyry, so named by Dr. A. C. Lawson from the fact that it contains, or is associated with, all the important veins of the district. The Lode porphyry is commonly compared with the early andesite at Tonopah.

Excepting in the western and southwestern part of the camp, where it is drab to ash gray with a purple tinge, this formation is mostly dark green or greenish gray. It consists of a massive, medium-grained to nearly felsitic porphyritic rock, which contains pyrite throughout in minute disseminated crystals. The rock weathers to a light-gray color, commonly tinged with yellow by oxidation of the pyrite, and in places it has been leached and kaolinized to a white seemingly structureless mass. Like in the earlier andesite at Tonopah, it is most altered hydrothermally and is most pyritic in the vicinity of the veins, where pyrite was formed through the addition of sulphur carried by the ascending hot solutions to the iron of the ferromagnesian rock minerals. On the whole it is more siliceous than the average andesite; parts of it, however, are higher in soda and lime than the average trachyte and seem to represent an intermediate type.

The Lode porphyry is extensively intruded into the dacite tuff, forming a large irregular stock-like mass with marginal dikes (fig. 28), some of which lie parallel to its southwestern border. It probably occurs also in the form of flows, but none of these have yet been identified. As suggested by Hershey, the entire intrusion probably represents a network of small stocks and huge dikes that probably merges downward with a batholith of granodiorite or some closely related rock.

This porphyry is exposed chiefly in a triangular area, the southwest side of which extends for about a mile along the Big vein of barren quartz; the other sides, nearly 2 miles long, converge northeastward to a point beyond the limits of the map (fig. 28). On the southeast the area is delimited by the Aztec fault, beyond which the porphyry is covered by the later andesite next described.

Microscopically the rock is seen to consist mainly of a pale greenish to brownish microcrystalline groundmass with flow structure, enclosing porphyritic crystals and smaller grains of all the essential minerals,—plagioclase, orthoclase, biotite, and hornblende—which vary in form from elongated to equidimensional. The plagioclase is mostly oligoclase-andesine or albite. Some of the feldspar is perthitic. The biotite and hornblende are in most places wholly altered mainly to chlorite, epidote, and quartz.

Other secondary minerals in the rock are kaolin, sericite, limonite, hematite, and in some instances, calcite. Pyrite in minute crystals is finely distributed throughout the rock. Some thin sections show minute quartz veinlets and traces of mineralization resulting in the introduction of pyrite. Quartz, apatite, and magnetite occur as accessories.

The rock on the whole stands close to latite, and in its mineralogical and chemical composition, it resembles the quartz latite, commonly called the Wonder rhyolite, which is the dominant ore-bearing formation in the Wonder district. Some of it is felsitic, and some closely resembles a tuff, though it is not regarded as a tuffaceous rock. Chemically some of it stands near the trachytes, and locally it contains sufficient quartz to be classed a dacite. In some places it is partly or wholly replaced by quartz, and in general it is more silicified than the other massive volcanic formations of the district. Dr. Berkey applied the name trachy-andesite to most of the half dozen or more specimens of the rock that he examined microscopically, but called a few of them dacite. This classification of the Lode porphyry as an intermediate type has been corroborated by the writer and by Doctors Larsen and Ross, the Survey's specialists in petrography.

Later andesite

A later andesite, commonly correlated with the later or post-mineral andesite in Tonopah, overlies the roughly eroded surface of the dacite tuff and Lode porphyry. This formation consists of coarse-grained purplish lava and tuff. It is distinguished from the Lode porphyry by the general absence of silicification, mineralization, pyrite and leaching, and it contains more hornblende and less feldspar than the Lode porphyry. Its distribution is partly shown in figure 28, but it extends far outside the area mapped. It is at least 800 feet thick.

Grade tuff

The next succeeding formation, which was deposited and poured out on the Later andesite after a considerable erosion period, is the Grade tuff, so named from its conspicuous occurrence along the road grade leading to the Nevada Hills mine (see lower left part of fig. 28). It consists chiefly of ash beds, tuffs, and coarse agglomerates, which latter include boulders of quartz monzonite and large blocks of several kinds of lavas. The formation contains much rhyolitic material, some of which is in thin flows.

Hershey regards the formation, with its very large angular lava fragments, as forming an old detrital slope.

Rhyolite

After the eruption of the Grade tuff, rhyolite was intruded as a large neck and as dikes into the preceding volcanic formations, seemingly from along the Aztec fault. Its largest exposure is in Rhyolite Hill southeast of the Nevada Hills mine, where it forms a mass about 800 feet in diameter and 100 feet high, from which a large dike or arm extends half a mile or more southward. A similar body of rhyolite, also intruded into the Lode porphyry and the Later andesite, occurs 1-1/4 miles northeast of Rhyolite Hill. Half a mile northwest of Rhyolite Hill a north-south dike of the same rock half mile or more in length traverses chiefly the Lode porphyry, cutting in its course two of the most important veins of the district (fig. 28). Half a mile west of this dike, in the lower foothills, is another rhyolite dike which may also be of the same rock, which it resembles in texture, though it mostly weathers purple; this dike, which is 10 to 40 feet wide and several miles long, is well exposed on the Badger claim half a mile south of Fairview. Farther south, exposures of bed rock and alluvium indicate that similar dikes occur at various places along the west slope of the range.

The neck forming Rhyolite Hill tapers downward, its diameter being about 800 feet at the surface and only 250 feet on the 650-foot level of the Nevada Hills mine.

The rhyolite is a light-gray to cream-colored or brownish rock, mostly laminated or closely banded by flow structure. It consists mainly of a felsitic to glassy groundmass, enclosing small phenocrysts of biotite, quartz, and sanidine. Both the feldspar and the quartz phenocrysts contain inclusions of the groundmass. In places along its intrusive contact with the other rocks the rhyolite is mostly obsidian. On the 800-foot level of Nevada Hills shaft the rhyolite is in fault contact with the Lode porphyry.

Pyramid tuff

The next succeeding member of the volcanic group, so far as could be determined, is a thick, hard, silicified tuff and agglomerate, known as the Pyramid tuff from the fact that it forms Pyramid Hill, in the southeastern part of the camp and several knobs to the south. It normally rests upon the Grade tuff, but in places toward the northeast and southwest, where the latter feathers out or disappears, it rests directly on the Later andesite. It seems to be downfaulted against the Grade tuff along the Pyramid fault.

Fairview Peak andesite

Succeeding the Pyramid tuff is a lava formation known as the Fairview Peak andesite, of which two areas are shown in the southeastern part of figure 28. This is a dark gray medium-grained porphyritic rock composed mainly of a glassy base, in part devitrified and silicified, with long prismatic phenocrysts of oligoclase-andesine and shorter crystals and aggregates of mostly uralitized ~~xxxxxx~~ augite and altered hornblende. Some magnetite and hematite is associated with the augite. Calcite forms interstitial masses and veinlets.

Fairview Peak dacite

The next succeeding formation of the volcanic group is the Fairview Peak dacite, of which there are several areas on the eastern border of the area shown in figure 28 and on the mountainside to the east. It is a purplished-gray medium-grained lithoidal rock speckled with reddish hematite blotches and cavities left by dissolved-out pyrite. Its originally groundmass enclosed phenocrysts or aggregates of plagioclase and quartz. It is intruded into the Pyramid tuff, its contact with which dips steeply to the northwest where it crosses the mountains northeast of the area mapped ~~xxxxxx~~. It doubtless extends to considerable depth and delimits on the southeast the part of the area mapped that has possibilities for mining.

Undifferentiated volcanic rocks

Except for the Lode porphyry, the volcanic rocks described extend both northward and southward beyond the area mapped, though some of the formations are absent in places and younger lavas are present in other places. Only near a few of the mines, however, have the formations been distinguished, and they are shown on the larger map (fig. 4) as undifferentiated volcanics. This category includes a great accumulation of younger lavas, tuffs, and agglomerates which succeed those shown in figure 28 on the southeast, extending up the mountain slope and constituting a considerable part of Fairview Peak and the Fairview Range. Chemically these later rocks are mainly intermedite or siliceous andesites, standing close to latite or quartz latite and frequently tending toward dacite.

Faults

Faults are numerous throughout the Fairview Range. During and since their deposition the volcanic rocks have been considerably faulted, and folded as is abundantly shown by slickensiding, striations, fluting, and grooves, and by offsets of formation boundaries and veins. In places where the foothill belt meets the higher axis of the range these rocks have flexed into piedmont synclines with limbs having dips of 30° to 40° (photo 1658). The faults in the district are nearly all normal. The principal ones, 20 or more in number, some of which are shown in figure 28, have in general a northeast strike and dip steeply to the southeast or to the northwest. The east-dipping and the west-dipping faults appear to be contemporaneous. Besides these, many small faults in the country rock were met with in mining operations. The most important faults are those that dip to the southeast. They commonly exhibit a downthrow ~~km~~ on the southeast ranging from a few feet to several hundred feet, and lateral movement toward the north amounting in some instances to more than 100 feet. The most important of the faults are the Aztec fault, the so-called Main fault, and the Tunnel fault. Their general trend and attitude is shown in fugure 28 and 28a.

The Aztec fault, which is the easternmost, is the greatest structural break in the camp. It dips very steeply eastward, and the movement on it has been mostly vertical. Its downthrow on the east or hanging wall side, is about 600 feet; its east side seems to be heaved a little northward, in the same direction as that of the Main fault. In places it is accompanied by a tough gouge or heavy fault breccia. West of the fault nearly all of the later andesite has been removed by ~~xxxxxxxxxxxx~~ erosion, while to the east there still remains nearly 700 feet of andesite. The fault is younger than the Grade tuff and older than the rhyolite.

The Main fault has in general a downthrow on the east of about 300 feet, and the east side is heaved about 130 feet toward the north. It has displaced all the important veins of the camp, and has cut and dragged the ore shoot on the Eagle vein. The throw and heave of the Nevada Hills vein on this are each about 300 feet.

The Tunnell fault, a normal fault with downthrow on the east, is fairly persistent across the country .

The Pyramid fault, which occurs in the northeastern part of the area shown in figure 28, practically follows the eastern contact of the Pyramid tuff where the tuff is downfaulted against the later andesite. Its throw is probably several hundred feet.

The oldest faults of economic importance, which are not of great throw are strike faults trending northwest. This faulting probably antedates in part the intrusion of the Lode porphyry, though most of it~~s~~ accompanied or followed the intrusion. It produced the monoclinal structure in the Dacite tuff, and opened up fissures or produced lines of weakness in the rocks which determined the position of the barren quartz veins and perhaps other veins. It apparently initiated the stage of mineralization during which nearly all the commercial ore deposits were formed.

As many as 16 faults, having a horizontal movement of from 1 to 130 feet, are said to intersect the 550-foot level of the Nevada Hills mine [3/] within a distance of 300 feet.

3/ Greenan, James O., Geology of Fairview, Nevada: Eng. and Min. Jour., Vol. 97, No. 16, pp. 791-793, April 18, 1914.

The earliest postmineral faults have a northwesterly strike. They are not important, though in a few cases they have displaced the veins.

Ore deposits

General features

The deposits of the district which are worked for silver and gold, occur in a series of twenty or more quartz veins contained in the volcanic rocks. Most of the veins crop out prominently, but many of the minor ones weather below the surface and have to be sought by trenching. In the principal part of the district the veins occur largely in the Lode andesite porphyry on or near its contacts with other rocks, principally with the dacite tuff. They tend to conform with or follow in both strike and dip the margin of the Lode porphyry and its contact with the dacite tuff. Though they have certain group and/individual ~~xxxxxxxxx~~ characteristics, they are geologically and mineralogically similar, in general, to the Tertiary silver-gold deposits occurring in the Tertiary volcanic rocks elsewhere in the southwest, and particularly to those at Tonopah, and they are regarded as of Tertiary age. Lawson compares the veins of the Fairview district with the quartz "blouts" of the Ely District [4/], but the

4/ Lawson, A. C., The copper deposits of the Robinson District, Nev.: Calif. Univ. Dept. Geol. Bull. 4, p. 324, 1906.

Fairview veins are much more of the fissure vein type.

Oxidation in the deposits extends to a maximum depth of about 300 feet.

In general, especially to the east of the Main fault, the vein walls converge upwards. About all the veins of any importance are listed below in alphabetical order. All but the Big vein, no. 2, are ore veins.

Veins in the Fairview District, Nevada.

1 A-B or Blind vein

2 Big or "Blout" vein

3 Dromedary Hump vein

4 Fairview or Eagle vein

5 Eagle's Nest vein

6 Five or 503 vein

7 Nevada Hills vein

8 North vein

9 Three or 304 vein

10 Wingfield vein

The deposits and veins show three or more periods of mineralization; a first period in which there was deposited chiefly barren quartz; a second period in which ore-bearing quartz was deposited mostly in shrinkage cracks and fissures, and a third period in which ore was deposited in and near the veins of the second period after they had been re-opened by strike faulting.

Ore minerals

The chief ore minerals are as follows:

Argentite

Bromyrite

Carargyrite

Chalcopyrite

Electrum

Embolite

Galena

Gold

Polybasite

Pyrargyrite

Pyrite

Silver

Sphalerite

Stephanite

Tetrahedrite

Associated minerals are:

Adularia

Aragonite

Bastite

Biotite

Bornite

Calcite

Cærussite

Chalcedony

Chalcocite (Dromedary Hump mine)

Chlorite

Covellite (Dromedary Hump mine)

Dolomite

Epidote

Epsomite

Fluorite

Franklinite (Webber shaft)

Galena

Hematite

Kaolinic aggregates

Lepidolite

Leucoxene

Limonite

Linarite (Webber)

Magnetite

Malachite

Muscovite

Paragonite

Psilomelane

Pyrite

Quartz

Rhodochrosite

Rhodonite

Selenite

Sericite

Specularite

Sphalerite

Stibnite

Turquoise

Zoisite

Nearly all the minerals named in the above list occur in the Nevada Hills mine. Other places at which some of them occur are as follows:

Bornite,	Eagle vein, Webber shaft, 2nd level.
Chalcocite,	Dromedary Hump mine, Consadao shaft, Eagle vein.
Covellite,	Dromedary Nump mine, Consado shaft, (not noted in Nevada Hills mine).
Epsomite,	Webber shaft, Wingfield vein. As a fibrous crust it coats roofs and walls of the workings at depths of 200 to ~~xxxx~~ 400 feet.
Franklinite,	Webber shaft.
Linarite,	Webber shaft.
Turquoise	Glory Hole

Vein structure

Although the veins occur in or near fractures in the rocks, they are largely replacement veins and consist mainly of quartz and altered rock, partly or wholly replaced by quartz, adularia, rhodochrosite, rhodonite, pyrolusite, and other gangue minerals. They are mostly massive or brecciated and show the fine-grained replacement quartz and ore grading laterally into the silicified wall rock, but large parts of them are well banded and crustified, recording deposition in successive layers on the walls of open fissures.

The veins generally decrease in values downward; to this rule, however, there are exceptions, as is that part of the Nevada Hills vein southeast of the Main fault, which pinches upward.

~~Xxxxxx~~ Intramineral strike faulting is more marked along the footwall side of the veins, and the ore values are best on the hanging wall side of the footwall gouge. The veins in general are larger and richer on the east side of the Main fault than on the west side, and they are most strongly mineralized next to the fault. The richest ore occurs toward the walls.

As the vein quartz occurs in large crystals and grains and in small interlocking plates and bunches, much of it is very uneven in texture. Silicification was very extensive and in general the pyrite came in with the quartz. Much of the silicification was completed by formation of chalcedony accompanied by manganese oxide. Some of the limonite grains are pseudomorphic after pyrite. The limonite is essentially a Tertiary product.

In places, as in the Nevada Hills vein southeast of the Tunnel fault, the best ore streaks occur where there is gouge on either or both walls of the vein. This is because the ore body at such places consists mostly of ore of the second period, which by a process of enrichment was concentrated from primary ore nearby. The deposits are oxidized to the depth of about 300 feet.

In general the veins, or vein groups, are accompanied by zones or masses of hydrothermally altered, highly silicified and pyritic Lode andesite porphyry. Such rock is generally most abundant along the wider parts of the veins. It occurs almost everywhere, appears to be of pyroclastic origin, and, microscopically if not megascopically, is found to contain mineralized volcanic ash, tuff, or breccia replaced metasomatically by quartz. This replacement was not necessarily all accomplished on the spot where it now appears; minute particles of tuff and ash may have been transported by the siliceous vein-forming solutions and deposited with the coarser vein material where they are now found. In all the veins and in the Lode porphyry, especially the silicified wall rock, silicification decreases with depth.

The veins in general strike about N. 50° W., as shown in figure 28. In many places their position is indicated by more or less prominent croppings of vein material or by ridges of silicified Lode porphyry wall rock with which they are all genetically connected (figures 33 and 34). Collectively they represent three or more periods of mineralization, and they fall into two main classes, (a) barren veins, (b) ore veins, the two classes converging downward on their dips. The barren veins dip to the northeast and the ore veins to the southwest.

Barren or first-period veins

General features

Mineralization in the district began with the formation of the barren quartz or so-called "blout" veins. Although it is convenient to classify these veins, since they contain no commercial ore, as barren, they are not wholly destitute of mineralization. In general they contain a little pyrite, mostly in silicified rock fragments, the quartz in which grades outward into later barren quartz, and locally they contain also a little chalcopyrite, galena, sphalerite and other sulphides and give assays of about $10 a ton (at old valuations) in silver and gold. In places they show indications of being modified by later vein-forming action, and most of the occurrences of metallic minerals in the barren veins are at or near contacts with ore veins. Some of these occurrences, however, are remote from ore veins and apparently independent of them, and they may be contemporaneous with the primary mineralization in the ore veins or earlier. Any importance they may have does not lie in their metal content but rather in the physical influence which they exerted on neighboring ore veins. In general a group of veins, such as the Nevada Hills veins, grows richer toward a large barren vein such as the Eagle vein; the ~~xxxxxx~~ individual veins, on the other hand, on nearing the barren veins grow leaner, become barren, and pinch out.

Some of the barren veins afe shown on the map (fig. 28). The largest and most important of them is the one extending along the southwestern border of the Lode porphyry. It is the largest vein in the district and had been referred to as the Mother vein of the camp. It is also called the Barren vein, the blout vein, or the Big vein. The most convenient term for it here seems to be "Big vein"--which avoids the genetic implications of "Mother vein" and blout vein--and that term will consistently be used in this report. The vein has a known horizontal extent of more than 4,000 feet, from near Upper Fairview on the north southeastward to the Aztec fault, where it is abruptly cut off by the fault and the younger rhyolite dike. It crops out boldly alohg most of its course. It varies from a few feet to 80 feet in width. The depth to which it extends is at least 1,000 feet as shown by the deepest mine workings, and it is believed to extend much deeper. It dips steeply to the northeast, cutting the monoclinal beds of the dacite tuff at acute angles. It lies in a shear zone,--a zone of rock fracture, sheeting, and brecciation--mostly in the Lode porphyry but partly in the adjacent dacite tuff or along the contact between the two formations. Its position on these structural breaks favors its continuity to great depth, and it may well extend into the underlying pre-Tertiary rocks.

The vein consists for the most part of a single tabular sheet, but in places it forks or encloses a horse; a horse of Lode porphyry 500 feet long is exposed near the Glory Hole and on the Boulder claim (fig. 28).

Big vein

The Big vein consists chiefly of massive dense horn-like quartz which is replacing the Lode porphyry wallrock and grades into it laterally. The replacement quartz is generally fine-grained, but less so on the average than that in the ore veins. It grows coarser toward the middle of the vein, where it contains vugs with well-developed quartz crystals. The quartz varies from white to gray in color. The gray color is due to disseminated fine-grained pyrite, which in many places can be seen with the naked eye. In places brecciated barren quartz is recemented with silica containing pyrite, chalcopyrite, argentite, and other ore sulphides at what was undoubtedly a secondary phase of mineralization. When weathered the quartz of this vein is generally yellowish, being stained with limonite seemingly derived from its pyritic content.

Large parts of the vein consist of a mottled mixture of dark-gray and light-gray quartz, as is well shown in the Nevada Hills mine from the 4th to the 8th levels. The darker quartz is the more abundant and seems to represent the lesser degree of replacement. It lies next to the Lode porphyry country rock and like it serves as host to the lighter-colored quartz, which is the chief cementing agent. In places both these kinds of quartz are traversed by veinlets or stringers of a still lighter, whitish, quartz.

In general the Big vein is accompanied by a pronounced strike-fault gouge, especially on its south or footwall side, showing that considerable post-vein movement along the strike has taken place. Such a gouge may be seen, for instance, in the Nevada Hills mine from the 4th to the 8th level. Here the gouge sheet, which is from 1 to 3 ffet wide, consists chiefly of tough drab clay or "gumbo", containing finely crushed rock debris, sericite, and pyrite, and is more or less stained in greenish, bluish, and brownish hues by copper compounds and iron oxides. Another distinctive feature of the vein on these levels is ~~xxx~~ its well-defined, slickensided, grooved, and polished footwall, which dips 80° S. At several points, notable on the 6th level, the vein is mineralized or pyritic, and in places coarse calcite is well developed throughout the associated footwall gouge. Here the gouge on the southside of the vein is succeeded by 110 feet of Lode porphyry, which is succeeded in turn by dacite tuff, though both rocks are ~~xxx~~ so highly altered and leached that their contact cannot be definitely located.

In the drift extending west from the crosscut at the Nevada Hills shaft, in the gouge and allied material--regarded at first as absolutely barren ground--on the footwall side of the vein shows some mineralization, presumably of the secondary period, that has resulted in the formation of disseminated pyrite, chalcopyrite, malachite, and azurite. About 70 feet west of the crosscut, also, in the south wall drift, there is about 50 feet of vein ~~mgx~~ material, possibly to be regarded as mineralized "barren" quartz, wholly to the foot wall side of the well-defined foot wall of the Big vein. The "barren" quartz in the crosscut from the shaft and at several other places has yielded low-grade ore. Some ore was taken from the Big vein in the 715 drift, 70 feet south of the Nevada Hills vein and just east of or in the main fault. Here, however, the ground is very heavy, the wall rock being much decomposed and mixed with gouge, ~~Xmmmx~~ "gumbo", calcite, and rounded pebbles of quartz. Such conditions are generally regarded as characteristic of secondary mineral deposits.

At the mouth of the 808 crosscut there seems to have been replacement of wall rock by white barren quartz. Here the vein, which dips southward, contains a ~~sprkkingx~~ sprinkling of coarse pyrite, galena, sphalerite and chalcopyrite, and a little gold and silver. It apparently is between two branches of the Big vein. The drift from the 808 cross-cut is on the northeast border of the left branch of the Big vein, where, alongside a strike-fault gouge, ~~thx xkxxgxkxixt~~ the "barren" quartz has been broken and stained, and sufficiently mineralized by secondary sulphides to make a fairly good streak of ore. It is probable that the Wingfield or 304 vein or both veins combined reach the Big vein at this point, but the ore is due to faulting and secondary concentration of mineral. The 800 level seems to be about the lower limit of the secondary ore between the main and Aztec faults, and only primary ore is likely to be found below that level.

Where the ore veins converge and end or bottom on the Big vein the matter is shattered and partially penetrated by the ore veins, as shown in figure 35, which seems to show that the Big vein is older than the ore vein. Shattering of the Big vein was caused by the forces which produced the shrinkage cracks or fissures occupied by the ore vein and not by the vein being thrust against it. Although the shattered condition of the Big vein greatly facilitated the deposition of mineral at this place, the ore vein generally shows a decided weakening as it approaches the Big vein, and its ore usually pinches out 10 to 30 feet before it reaches the barren Big vein. This impoverishment of the ore vein may be due to the water's having been damned back by the Big vein.

The second important barren vein lies about 1,000 feet northeast of the Big vein and 300 feet beyond the Wingfield vein, to both of which it is approximately parallel. It extends along a contact between the Lode porphyry on the south and an inlier of dacite tuff on the north. It stands about vertical but dips southwestward in places. Toward the southeast it merges with the Eagle vein.

Considerable float quartz, much of it in large boulders, may be seen in the cross washes and gulches that score the lower west slope of the range in the 8 miles of their extent between Fairview and Slate Mountain, and this fact suggests that barren quartz veins similar to the one at the Nevada Hills mine are probably common throughout the range.

Ore veins

Second period

Soon after the first period of mineralization, in which the barren quartz veins were formed, there began the second period of mineralization, which resulted in the formation of the primary ore veins, 10 or more in number. These veins are in the Lode andesite porphyry, along narrow parallel fissures that appear to have been produced in the porphyry as it contracted on cooling. By some students these veins are regarded as branches of the Big vein, and in their southwesterly dip they do, indeed, converge with the Big vein, at which as a rule they end. But where the ore veins bottom on the Big vein the latter is generally shattered, and penetrated by weak stringers, seams, or bunches of the ore vein quartz, which is evidence that the ore veins are younger than the Big vein.

The ore veins are massive and consist mainly of fine-grained ore-bearing quartz, which not only fill fractures but partially replace the brecciated wall rock of Lode porphyry and enclose fragments of the same rock. They are similar to the veins at Tonopah. Nearly all of them lie west of the Main fault, the Eagle vein being the only one of which any part crops out east of the fault. Among the least modified of these primary ore veins are those known as the Glory Hole group, at the western end of the Nevada Hills vein. Nearly all the ore mined at this place was primary ore belonging to this second period of mineralization.

Third-period veins

The primary ore veins were reopened by a system of strike faults, an event which inaugurated the third period of mineralization. In this period, the reopened fractures, fissures, and cavities in the veins and old fissures were more or less completely filled with banded mineral-bearing quartz, calcite, rhodochrosite, and other gangue minerals. The filling also contained enriched fragments of the primary ore vein and of the Lode porphyry. Except in the vicinity of the Glory Hole nearly all the rich ore mined in the district was formed at this time.

The banded structure of the deposits of this period, seen at many places in the mines, shows that the deposits grew inward from the walls of the reopened fissures, and that the quartz and ~~xxx~~ calcite becomes gradually coarser-grained toward the middle of the veins. The mineralization of this period consists in part of a concentration of the ore minerals, but it differs from typical secondary enrichment in having been completed long ago—long before the close of the Tertiary period—and in that it involved no oxidation. There is no evidence that any new ore mineral was brought into the veins during this period of mineralization. The rich ore bodies mined were merely concentrated and enriched by circulating solutions from primary ore bodies ~~xxxxxxxx~~ near at hand. The largest and richest ore bodies formed in this period are at very small distances from ore bodies formed in the preceding period.

Although the commercial ore of this period was all formed along the strike faults, some mineralization occurred also on both east-dipping and west dipping cross faults.

Fourth-period veins

Still later than the third period of mineralization, which produced the rich ore of the district, barren white quartz and coarse-grained calcite were deposited, in irregular openings and seams, in the ore veins. This final vein-forming activity may be regarded as a fourth period of mineralization, but it does not appear to have added anything to the commercial value of the deposits.

Mineralization in the older rocks

No mineral deposits of commercial value have been found in the older or pre-Tertiary rocks in the district, which, however, show patches or bodies of mineralization as follows:

At a few places whefe the limestone is partially crushed, there are shallow prospects showing a mixture of dark altered manganous limestone and wad, which contain moderate values in silver and gold. One of these places is south of Fairview. This mineralization was probably derived by leaching from formerly overlying volcanic rocks and probably is nowhere sufficient to be of economic value. Practically the same is true of copper-stained prospects opened in the shale.

Mineralization on a commercial scale in or associated with the limestone seems most likely to be found near intrusive contacts with quartz monzonite or other granular rocks, but no such contacts have yet been found in the district.

In the weathered and crushed diorite 1-1/4 miles notheast of Fairview, especially in prospect pits ~~mmpx~~ opened to a depth of 10 feet on the Defiance No. 1 claim, the rock is said to ~~run~~ $3 to $130 in silver and gold. The rock has not been tested in depth, however, and as it is not traversed by any vein or other visible feature of mineralization, the values it carries may well have been leached or otherwise derived from overlying disintegrated formations that have since been removed by erosion.

As the Lode andesite porphyry is the chief source of the ore deposits of the district and limestone is well known to be an excellent repository for ore deposits, it would be of special interest to examine the contact zone of the Lode porphyry andesite where erupted through or intruded into the limestone. Such contacts probably exist in depth, but no limestone was reached in the deepest mine workings, nor have any inclusions of limestone been found in the Lode porphyry..

Distribution and character of ore

The ore bodies are opposite, usually north of, thick portions of a barren vein, or near places where the wall rock is strongly silicified— facts that suggest more or less dependence of ore deposition upon the quantity of ore-depositing solution and a decrease in its rate of circulation.

The wider the vein the better the grade of ore. This is probably due to the greater primary ore deposition in the wider parts of the vein; there the secondary enrichment processes had more mineral to work on and consequently formed a richer product.

The commercial ore bodies were all formed at practically the same elevation. This was probably due to the influence of ground-water level at the time of their deposition.

East of the main fault the walls of the Nevada Hills vein converge upward. West of the fault, also, most of the veins seem to pinch upwards.

The ore, a considerable part of which is well banded, consists chiefly of the following ore minerals:

Argentite
Stephanite
Cerargyrite
Bromyryte
Silver iodide
Some rare silver mineral and
Gold

The gangue consists of quartz, calcite, barite (?), rhodochrosite, rhodonite, and altered and replaced andesite. Coarsely crystalline calcite forms some bodies nearly a foot in diameter, especially in the Eagle vein, and it seems probable that in places much of the quartz has replaced calcite and country rock. Masses nearly a foot in diameter of dogtooth spar with crystals up to 1-1/2 inches long have been completely replaced by pseudomorphs of quartz, and some small masses 6 or 8 inches in diameter, containing rich silver ore, consist of platy and finely bladed quartz pesudomorphic after calcite. This pseudomorphic structure is not abundant, however; the quartz is mostly fine grained; but some very perfect prismatic crystals of quartz, 3 inches long and 3/4 of an inch in diameter, are imbedded in the calcite and dogtooth spar.

Some greenish quartz ~~pseudomorphs~~ forms platy or bladed pseudomorphs, as in the Oatman district, Arizona, and some has a peculiar divergent radially flamboyant or pseudospherolitic structure that seems to be of primary origin (fig. 36).

In places the quartz and ore are vuggy, and the vugs, generally of small size, are commonly lined with quartz crystals, some of which are bladed and pseudomorphic after calcite. The quartz and ore often contain inclusions of andesite, dacite tuff, and more rarely of quartz monzonite.

Most of the richer ore consists largely of black or dark metallic bands, streaks, and blotch-like bodies composed mainly of silver sulphides. It is very similar to the Comstock ore at Virginia City. Some ore from the stope on the 7th level of the Nevada Hills mine, consisting of a mixture of dark silver sulphides, galena, and chalcopyrite with a very little rhodochrosite, assayed as follows:

Gold	17.4 oz.
Silver	511.6 oz.

As calcite in or associated with the veins is especially abundant near altered but unsilicified Lode porphyry, and as fresh calcite scales are common in the crevices of altered rock, considerable calcite is believed to have been derived from the wall rocks through processes of decomposition. This view seems to account for much of the large amount of calcite in the Eagle vein east of the Main fault, where the walls are unsilicified, and in the 7th level ore body of the Nevada Hills vein, where the foot wall is greatly decomposed. It is probable, however, that much of the calcite in the veins was derived from the Mesozoic limestone which underlies the volcanic rocks and through which the solutions that deposited the veins may have ascended.

Nevada Hills vein

General features

The Nevada Hills vein has been the most productive in the district. It outcrops about 200 feet northeast of the Big vein, to which it is approximately parallel in strike. It has a length of about 2,200 feet, extending from the Nevada Hills shaft and the main fault 1,200 feet northwestward to the Glory Hole, with the croppings remarkably persistent nearly all the way (fig. 37). Southeast of the shaft and the Main fault it extends nearly 1,000 feet to the rhyolite dike, but in this section there are but few croppings. The Main fault has displaced the vein about 300 feet horizontally and 300 feet vertically.

The vein is from 1 to 8 feet wide. Most of it dips about 70° SW., but in places it stands about vertical. Throughout the part of the vein extending west of the main fault the pay ore was almost continuous. The ore values favor the northeast or footwall side of the vein, though in some places they are mostly on the hanging-wall side; they are best where the dips are low, and poor or absent where the dips become vertical or nearly so. Considerable gouge-ore similar to that found in the Wonder mine was worked in the Nevada Hills vein, especially from the 3rd level down to the 7th level.

West of the Main fault, between the surface and 200-foot level, the Nevada Hills vein yielded a fair tonnage of ore, and on the east side of the fault at 500 feet depth, it produced a considerable amount of low-grade ore. But no ore was found on the 800-foot level.

The ore in general is recognized by its bluish or bluish-purple color. Much of it contains horn silver. Some from the inner or footwall side f a 5-foot quartz andesite replacement body at the northwest end of the lory hole contained over 4,000 ounces in silver and several ounces in gold o the ton.

Toward the northwest the vein divides into two or more branches and forms the nucleus of the Glory Hole group of veins. Still farther northwestward the branches ramify into stringers, which become small, tight, and lean, and finally cease to carry workable ore. The vein and all its branches lie in or are associated with the Lode porphyry, much of which is brecciated and part of which forms boldly cropping reefs or ledges. (fig. 37).

The vein converges in dip with the Big vein, on which, in depth, it finally ends; its ore pinches out 15 to 30 feet before it reaches the Big vein (fig. 35).

At the northwest end of the Nevada Hills No. 3 level, the Nevada Hills ore vein comes down to the hanging-wall side of the Big vein and extends partway into it. The ore here yields values of from $1.50 to $8.25 to the ton. There is no gouge at the junction, and the deposit seems to belong to the primary ore vein period. The sulphides are fine grained and are disseminated through a very fine-grained gray replacement quartz, which in places grades into a coraser-grained white quartz containing empty vugs. In other places the change is much sharper.

Local observations

The Glory Hole/ is an open cut on the Nevada Hills vein, 200 feet long, 12 feet wide, and 70 feet deep, with walls consisting mostly of dense gray or pyritic Lode porphyry. Toward the west end of the cut, the south wall grades into barren quartz, which extends on westward. Much of the ore mined in the early days came from this opening. Much of it was primary with the sulphides very fine grained and contained in whitish quartz resembling that of the barren veins. Most of the ore, however, was secondary and was concentrated in crevices and seams of the highly silicified Lode porphyry. It included a narrow, rich, nonpersistent streak which in places was accompanied by a little gouge.

Much rich ore was taken out of the glory hole in its early days, and in 1912, after the hole was thought to be all worked out, $15,000 in rich secondary ore was taken from a nearly parallel crevice in the north wall. In 1920 also $1,200 worth of rich ore was recovered by a lessee from a pocket in this wall. Some rich ore still shows near the surface.

During 1916 the part of the Nevada Hills vein between the surface and the first or 100-foot level produced $403,000 worth of ore—almost the entire tonnage of the camp for that year. On level No. 1 of the workings near the Nevada Hills shaft the main feature is the widening of the vein, which is normally 8 feet wide, about 30 feet west of the shaft, to an ore body 50 feet wide, containing 10 feet of high-grade ore. Here the hanging wall flattens to a dip of only 10° while the dip of the foot wall remains at about 60°. The large ore body continued downward for 70 feet, nearly to Level 2. Near the crosscut from the shaft the so-called vein seems to be merely a narrow ~~zmmzzz~~ zone or seam of crushed barren vein quartz accompanied by fault gouge, and is mineralized only ~~xxxx~~ in cracks. It extends through the Big vein and ends at its footwall side, but here the Big vein itself consists mainly of altered and leached rock rather than quartz.

On Level No. 2 a distinctive feature, extending from the shaft and the Main fault 450 feet to the northwestward, is the drag of the vein by a tight horizontal fault, causing it to overlap upon itself 60 feet or more. The main fault zone here is at least 50 feet wide and its wall rock is much brecciated.

On Level No. 3, sixty feet south of Nevada Hills shaft by way of the crosscut, the vein for a length of 300 feet is from 3 to 5 feet wide and is fairly good. The Main fault zone, here 90 feet west of the shaft, is more than 60 feet wide. The western part of the vein, which contains good ore, was recovered by sinking, on the strength of rounded quartz pebbles and fragments of sulphide ore found in the fault gouge. About 180 feet west of the crosscut the vein becomes lost in the barren white quartz and gouge breccia and continues so for the distance of nearly 600 feet. Here it consists mainly of barren quartz, with the quartz mostly on the footwall side.

Several small cross-fault fissures a few feet wide are largely filled with gouge containing many round quartz pebbles. At the extreme west end, where the vein reaches the hanging wall side of the Big vein, it is primary and has no secondary gangue. To the east of the main fault it contained stringers of secondary quartz, accompanied by gouge, and the ground was much shattered.

Level No. 4, extending 350 feet west of the Main fault and 200 feet west of the crosscut 70 feet south from the shaft, is mostly along the Big vein.

On Level No. 5, the part of the Nevada Hills vein east of the main fault yielded considerable low-grade ore from minor spurs and branches, mostly in the country rock of the adjacent hanging wall. Similar conditions prevailed also to the west of the Main fault at various depths, especially from the surface to the 200-foot level. On the 5th and 7th levels the western side of the Main fault dragged the dark-gray brecciated ore of the Nevada Hills vein for a distance of several hundred feet. (See under Big vein page (2) - 40).

The part of the Nevada Hills vein southeast of the Main fault on level No. 5 fault seems to pinch out upwards. The ore shoot gives out along a line that pitches southeast; a part of it extended to the No. 5 level near the fault.

On the 650 level, at the mouth of the 808 crosscut there is a southward dipping vein of white quartz, sprinkled with pyrite, galena, sphalerite, and chalcopyrite and containing a little gold and silver. This vein apparently represents the barren vein stage and lies between two branches of the Big barren quartz vein. The vein dies out toward the southeast through the disappearance of a secondarily stained narrow fault breccia. The drift from the 808 crosscut is on the northeast border of the left branch of the Big vein. There, adjoining a strike fault gouge, the barren quartz has been broken and stained, and mineralizzed by secondary sulphides, making a fairly good streak of ore. Probably the Wingfield or 304 vein, or both combined, ended at this point on the Big vein, but the ore here is due to faulting and secondary concentration. This level seems to be about the lower limit for ore deposited in the second period between the Main and Aztec faults, and little but primary ore was found or expected below this level.

On Level No. 7, the Nevada Hills vein was strong for about 300 feet eastward from the Main fault, to North crosscut 724, some ore near the main fault running $600 to the ton. Most of the ore and quartz was on the north or footwall side. The ore is all sulphide. A large stope 30 to 90 feet west of the crosscut extends from above this level to below No. 8 level, and contained good ore all the way. Southeast of the 724 crosscut the vein was a mass of gray and white quartz resembling the barren vein quartz. It was much broken by faulting, with a gray mineral stain of secondary origin in fractures near the gouges. From the crosscut eastward for 300 feet the vein, crossed by several oblique cross-fault slips or so-called "vein robbers", gradually thins and finally pinches out.

On this level the coarse lake-bed tuff extends to the Big vein near the Nevada Hills shaft. Drift 715 of the shaft workings exposes a part of the Big vein, and some ore sulphides are here imbedded in white quartz. These sulphides may be secondary, although they are 60 feet distant from the Nevada Hills vein. On this level, and in the stopes above, the rich ore that was being taken out when the mine was visited is chiefly of the second period. Here occur silicified rock fragments, including some of granite, grading into fine-grained replacement quartz with disseminated fine-grained primary ore sulphides, which in turn grades into barren white quartz seams. These are followed by coarse-grained black sulphides, associated with quartz, medium-grained carbonates, and a pink manganese mineral. This latter ore is crustified and banded and is clearly associated with the strike faulting that occurred along the primary quartz veins. This rich streak follows the old vein to its junction with the Big vein, where it rapidly narrows and soon pinches out.

On the 8th level the Nevada Hills vein lies 400 feet southwest of the Webber shaft, 280 feet southwest of the Wingfield vein, and 150 feet southwest of the 304 vein. Both east and west of the Webber crosscut and the main fault the vein seems to be mostly barren quartz. At the end of the crosscut, it is more than 100 feet wide. About 60 feet west of the Main fault there are many inclusions of granite, but they decrease in number toward the fault. The footwall of the Big vein on this level is irregular even where sharply defined, and crosscuts extending 20 to 60 feet beyond it show fragments of the dark-gray, mineralized, very fine-grained quartz cut by numerous veinlets of practically barren coarser-grained whitish quartz containing open vugs. The latest ore-vein quartz, where oxidized, cannot be distinguished from the ordinary yellowish barren quartz which also is extensively exposed on this level. The possible downward continuation and eastward extension of the vein were looked for on the 800-foot level, but with negative results.

In the part of the district just northeast of the glory hole, it is often difficult to tell whether a given vein shall be classed with the barren veins or the ore veins.

At the mouths of tunnels 3 and 4 the Big vein lies within 16 feet of the Nevada Hills vein, with the ~~intervening~~ intervening space occupied by dense gray pyritic Lode porphyry, which is traversed by many stringers and veinlets of quartz.

The Main fault shows well in the eastern part of tunnel 4, with a smooth grooved easterly dipping footwall on the left or southwest, succeeded by partially banded fault breccia and ~~gxxx~~ ground-up rock material in the roof and opposite side of the tunnel.

On the Webber No. 2 level the Aztec fault is well exposed near the Aztec shaft. The northwest limit of the fault zone is marked by a thick dark-gray tuff gouge dipping 75° NW. On the southeast side of the fault is a heavy fault breccia, composed mostly of rounded fragments of later andesite, traversed by gouges. Near the Aztec shaft the fault seems to be nearly vertical from the surface down to the No. 2 level.

New vein and South vein

The so-called "New vein" showed for an extent of 40 feet just west of the Main fault and 50 feet to the north of the Nevada Hills vein in the 726 drift on the 7th level. About 50 feet to the south of the Nevada Hills vein there was a small associate vein, known as the "South vein".

North vein

Toward the glory hole, almost 500 feet northwest of the Nevada Hills shaft, the Nevada Hills vein gives off a spur to the northeast known as the North vein. It or its fissure has considerable extent, for it crosses Town Gulch and the road and passes into the mountain beyond; but the vein was productive only for the first few hundred feet from its junction with the Nevada Hills vein, which seems to be the source of its ore. Beyond the 400-foot point it feathers out or loses its values. Its workable portion, mostly on the no. 1 level, was from 2 to 3 feet wide. It stood nearly vertical, and carried good ore, some of it rich.

Eagle vein

The Eagle vein, formerly owned by the Eagle Mining Co., was opened in 1906-07. It soon produced considerable ore and was early regarded as next in importance to the Nevada Hills vein. The early-day shipments averaged over $150 to the ton. Much development was done on the vein by the Nevada Hills Company in 1913 to 1916.

Outcrops

The vein lies nearly 1,200 feet northeast of the Nevada Hills vein, d strikes more nearly west. It lies mostly in the Lode porphyry and between e Tunnel fault and the Main fault, but there are also important segments f it between the Main fault and the Aztec fault. It is the only vein of e Nevada Hills group that crops out east of the Main fault.

Its outcrops extend through a distance of about 900 feet, 500 feet est of the Main fault and 400 feet east of it, and its total length is ore than 1,000 feet. It varies in width from 2 to more than 40 feet. t dips from 40° to 80° SW and extends to a depth of more than 800 feet. he croppings of the vein are strong and extend through Flag Butte on the east (fig. 27). On the west they cross Fairview Townsite and Gulch and extend into the south end of Dromedary Ridge.

The vein commonly is accompanied by from one inch to several inches of dark-greenish clay gouge, especially on the foot-wall side. It not only has been faulted by the Main fault, by which the portion to the east was moved 300 feet to the north, but east of the Main fault it is also cut by a series of minor faults probably due to shrinkage of the enclosing rock mass.

Composition

The Eagle vein differs from the other leading veins in containing a much greater proportion of calcite, rhodochrosite, rhodonite, pyrolusite and wad, mostly minerals of the second period of mineralization. In fact it is the best illustration of a vein formed in the secondary ore period. On the Webber No. 2 level and in the stopes above, the primary vein is represented by fragments of fine-grained gray quartz with minute grains of disseminated ore sulphides, while the second ore period is represented by banded layers and seams of quartz and fine-grained carbonates—chiefly calcite with some pink rhodochrosite—together with ore sulphides of coarser grain than those in the primary ore, disseminated through the carbonates and tending to concentrate in layers interbanded with other ore minerals.

A fourth period of mineralization is represented in the vein by barren white quartz and coarse-grained calcite, which were deposited in seams and irregular openings and which in places constitute the final filling of the fissure. Both walls are marked by pronounced fault gouge.

Underground exposures

The Eagle vein is ~~xxxxxx~~ opened by five levels—the three Eagle levels, which ~~xxx~~ are old, and the Webber 2nd and 3rd levels, which are new. From the ~~xxxx~~ surface down the levels are as follows:

Eagle shaft	Depth (feet)	Webber shaft
75-foot level	75	
200-foot "	200	
350-foot "	350	
365(?) "	365	450
565(?) "	565	650

The levels nearly all show fault drag of the vein and ore. The old workings are about 4,000 in aggregate in extent.

From the surface down to the 75-foot level the ore was about all oxidized and very manganous and consisted mostly of cerargyrite. It had a quartz-argillaceous gangue, and was associated or mixed with such an abundance of black manganese oxides that some of the larger bodies were known as manganese "blow outs". From the 75-foot level down the ore was about all sulphide. On this level the lode or mineralized zone was said to have been 60 feet wide and to have contained fair values nearly all the way across.

On the 200-foot level and in the stopes above it the vein was in places 40 feet wide and averaged about 20 feet in width, with fair values all the way across and 4 feet of shipping ore on the foot-wall side; at several points it contained ore running from $100 to $600 to the ton. Much of the vein to the west of the Main fault was mined in the early days to a depth of about 200 feet and yielded most of the production of that time. The first ~~200x~~ 200 feet of the vein to the west of the Main fault was further developed by the Nevada Hills Mining Company in 1913 and 1914 to the depth of 335 feet, and about 2,000 tons of mill ore was recovered, mostly near the surface, there being no commercial ore found at this time below the 50-foot level. Fifty feet west of the Main fault the vein was 20 feet wide.

At the segment of the Eagle vein, about 400 feet in length, between the Main fault and the Aztec fault the country is much broken and includes heavy fault gouge containing rounded quartz pebbles. This part of the vein was worked mostly through a crosscut from the Webber shaft on the 2nd or 450-foot level, which cut the vein 15 feet below the lowest workings of the Eagle mine and drained the entire mine, which had long been flooded.

On the 200-foot level the vein, which in places was 10 to 20 feet wide, consisted mostly of calcite and carried only small values. Lower down, parts of the vein became more siliceous and contained dark bands and seams of rich manganese-silver ore, and eastward it widened out and contained a good ore body about 10 feet in width extending for a distance of 75 feet. It was best at the bottom of the intermediate level, but it ended there or just below, and on the 300-foot level it pinched out in drift 324, 40 feet from the face, ~~whichx~~ which is in the Aztec fault. Near the face, however, the wall rock is mineralized and constitutes fair-grade ore.

On the 2nd or 450-foot Webber level (at the depth of 365 feet) the Company reported the ore body to have been 200 feet long and to have assayed $17 for a width of 28 feet. Here for the first 120 feet west of the Main fault the deposit consists of a foot-wall vein and a hanging-wall vein, separated by a 10-foot horse of country rock containing streaks of calcite. The outer walls of the two veins are well defined, but the inner walls are not. The veins consist of quartz, calcite, rhodonite, and silicified rock fragments, together with the dark sulphide ore minerals stephanite, polybasite, and argentite, all crudely banded. Most of the material carried only small values but some of it constituted $60 ore. From the east end of the horse, 120 feet east of the crosscut, to a point 300 feet east of the crosscut the vein averaged about 7 feet wide. Just beyond the east end of the horse it contained more massive quartz-calcite ore breccia, firm and well cemented, with inclusions of early or primary dark sulphide ore three-fourths of an inch in diameter. Near the 300-foot point the vein contained from 1 to 3 feet of "barren vein" quartz ore, with the foot wall dipping 80° and the hanging wall 65°.

From the point 300 feet east of the crosscut to the Aztec fault, 00 feet distant, the vein is barren except in a couple of spots and is in altered dacite tuff or Later andesite. On this level the country in the vicinity of the vein is much broken and decomposed, with seams and stringers of calcite and quartz running in all directions, as shown in the 50 crosscut on the hanging-wall side and in a 20-foot crosscut extending along the foot-wall side 180 feet from the Main fault. To the foot-wall side of the vein the Main fault has a very heavy gouge containing quartz pebbles, etc., and the vein itself is cut diagonally by ten or more cross faults accompanied with gouge.

~~Lxgx~~ Later developments on and from a crosscut on the Webber 650-foot level, including diamond-drill tests in depth, showed that the vein weakened and the values ended about 90 feet belowthe 450-foot level. On the 650-foot level the vein was found to consist of a series of narrow stringers having no commercial value, and at depths of 800 and 900 feet the vein, though wider and better developed than on the 650-foot level, contained only a little mineral, of no commercial value.

Wingfield vein

The Wingfield vein lies in the Lode andesite porphyry, about 400 feet south of the Eagle vein, to which it is approximately parallel in strike, and about 700 feet, measured along the Main fault northeast of the Nevada Hills vein. It extends 1,400 feet northwest-west from the fault and terminates at a point about 200 feet northeast of the end of the Nevada Hills vein, with which it converges in strike. East of the Main fault it does not outcrop but has an underground extent of about 150 feet, as shown on the 8-3 level in the Nevada Hills mine. It is about 5 feet wide, dips about 40° S. and converges in dip with the Big Barren quartz vein, on which it bottoms at a depth of about 770 feet, the geological and mineralogical conditions at the junction being very similar to those existing where the Nevada Hills vein passed out of ore, pinched, and bottomed. The vein contains much barren quartz and calcite most of which apparently belongs to the fourth period of mineralization. It is accompanied by little or no gouge. At the Tunnel fault it is downfaulted to the east with a northward heave of about 50 feet. For 500 feet west of the fault it is well defined by croppings and has a southerly dip of about 42°. The vein locally contains bunches of ore, but they are too sporadic and small to be of commercial value, for which reason the vein is sometimes referred to as barren.

Much epsomite occurs in fibrous coatings on the walls and roofs of the workings from the intermediate to the 450-foot level.

On level 2, 220 feet north of the Webber shaft, the vein dips 45° S. and carries or is represented by stringers of secondary (?) quartz, calcite, and siliceous rock material. In the west drift it is crushed and pyritic, and apparently only 2-1/2 feet of its width on the hanging-wall side carried ore. On the intermediate level, however, above the second or 450-foot level, some ore was mined from a stope showing several hundred feet of work done. Bunches and stringers of coarse calcite occurring in fractures and slips in the Lode porphyry country rock to the north of the vein seem to be of the third period of mineralization.

On the third or 650-foot Webber level the Wingfield vein lies 120 feet southwest of the ~~xhaft~~ shaft. It is 5 feet wide and flattens in dip to 20°. It carried low-grade sulphide ore in a quartz-calcite gangue extending interruptedly for a distance of 180 feet, but it was of only small commercial value. Some of the ore, however, ran high in precious metals, the ratio being 1 oz. of gold to 25 oz. of silver.

At a depth of about 730 feet, 40 feet above the Big Barren quartz vein, the Wingfield vein is joined of intersected by the ~~22x~~ 304-foot vein. At or just below the junction the ~~xxx~~ combined width of the two veins is about 2-1/2 feet. It carried only very low values down to ~~xpxx~~ a point just above the junction and has a strong gouge on the foot-wall side.

Eagles Nest vein

The so-called Eagles nest vein, which is about 100 feet south of the Wingfield vein, consists chiefly ~~xfxx~~ of a 40-foot wide fault-shear zone in silicified Lode porphyry, which here is highly oxidized and gives no promise of being of commercial value. It is opened to a depth of more than 200 feet by two shafts, with a little work done on each of the 60, 100, 150, and 200-foot levels. Below a depth of 150 feet the ground is pyritic being of the sulphide zone type. Some vein material and a little dark oxidized ore were found on the 60-foot level.

304 vein

The 304 vein is blind. It is best developed on the 8-3 level of the Nevada Hills mine, ~~xxxxx~~ about 105 feet south of the Wingfield vein. Here it strikes approximately east and west, extends 210 feet east of the Main fault, is 3 feet wide, and like the Wingfield vein contains much quartz and calcite of the fourth period of mineralization. It is crossed by several small faults, some of which have a dimplacement of about 10 feet. The vein appears also as a stringer on the 7th level in drift ~~xxx~~ 724.

It was hoped that as the vein descended to the Big Barren quartz vein it would become minable, but it contained only a few bunches of ore too small and widely scattered to be of commercial value. As already noted, the 304 vein joins the Wingfield vein at a depth of 730 feet, 40 feet above the Big Barren quartz vein, and it probably contributed most of the meager ore that occurred there. About 3 feet above its junction with the Wingfield vein there was a small ore shoot about 3 feet wide, containing both primary and secondary ore sulphides, which, however, ran only $4 to the ton.

A- B vein

The A - B vein is a small blind vein that occurs east of the Main fault on the 5th ~~xxx~~ or 900-foot level, 400 feet northeast of the Webber shaft, in drifts 503 and 504. This occurrence is noteworthy as being the deepest ore, or mineralization approaching ore, found in the mine or in the district. The vein has a length of about 150 feet and a height of 60 feet, about half lying on either side of the crosscut, and is nearly a foot wide. It consists chiefly of hard quartz containing dark streaks of good sulphide ore mineral.

503 vein

The 503 vein was discovered by a crosscut on the 900-foot level. It is parallel to the Eagle vein and about 200 feet south of it. For a length of more than 200 feet it was explored by raise and winze, and was found to be very discontinuous and irregular in width and tenor; it yielded a small quantity of ore, however, mostly mill ore, with shoots about a foot wide running up to $18 a ton. Its discovery was encouraging inasmuch as it afforded evidence that conditions suitable for ore deposition existed at this depth.

Dromedary Hump vein

In the northern part of the camp, toward the north border of the main Lode porphyry area, there is a minor zone of mineralization, approximately parallel to that of the Nevada Hills mine, which lies about 4,000 feet south. The topography is hilly, as expressed in figures 33 and 34.

West of U. S. location monument no. 182 the mineralization in this zone is regarded as extending down the slope ~~xxx~~ on the Cyclone and other claim groups, but it is best developed on the Dromedary Hump and Golden Boulder properties, southeast of the monument, from which it extends ~~xxxxx~~ about a half mile to the east-southeast. It lies almost wholly in the Lode andesite porphyry. It has a width of about 600 feet, and contains several parallel veins or parts of veins, mostly dipping steeply southward~~s~~, (see fig. 33), the most important of which is the Dromedary Hump vein. The following description of that vein will serve to illustrate the character of the entire group.

The Dromedary Hump vein lies about 4,000 feet to the north of the Nevada Hills vein, to which it is approximately parallel. It trends about N. 60° W. across the upper part of Dromedary gulch and has a known length of 2,400 feet. It lies mostly in the Lode porphyry andesite, but its western 1,000 feet lies along or near the contact of the andesite with an island of the dacite tuff on the north, and it is this part of the vein that has been the most productive. Closely associated with it here are two smaller parallel veins, one on the hanging-wall side and the other on the foot-wall side, known respectively as the front vein and the back vein.

On the east the vein is displaced by the Main fault nd the Aztec fault. It was discovered in 1904 and the Dromedary Hump group of 3 claims was located on itswestern part in January 1906, by Joe Davis and Jack Blair, who soon sold the group for $25,000 to the Dromedary Hump Mining Co. of Kansas City. The Company increased its holdings by the acquisition of adjacent ground, including the Golden Boulder Mining Co.'s Boulder No. 6 claim, adjoining it on the west, which it absorbed in 1917, and it was then reorganized as the Dromedary Hump Consolidated Mines Co. Both the Dromedary Hump and Golden Boulder properties were equipped with electric power in 1913.

From 1906 to 1918 the vein in its western part was worked almost continuously on a small scale by the Fairview Golden Boulder Mining Co. and the Dromedary Hump Mining Co. or its successor, and was opened to a depth of more than 500 feet by several thousadd feet of work on four levels. Its production, however, has been small. The main opening is through the Golden Boulder shaft, and most of the work is on the 370- and 420-foot levels.

From the outset the vein was regarded as the third best vein in the district. Its croppings and surface ore were the richest in the district, carrying values up to several thousand dollars a ton in some places. For the most part, however, the ore is hard and is difficult to treat. Several methods of treatment were tried without success. The Golden Boulder Co. built a 150-ton mill and cyanide plant, but the Filler ball ~~pulverizers~~ pulverizers employed in it were wholly inadequate for crushing the hard ore, and, on account of the copper and manganese content of the ore and the hardness of the quartz, cyanidation proved to be wholly inadequate. A flotation plant was therefore installed, together with a heavy rock crusher and Hardy 10-inch ball pulverizers capable of treating 500 tons of ore a day. In 1916 it was reported that the mill was running satisfactorily, that the mine had a 3-year supply of ore in sight, and that development in the deeper part of the mine, especially on the 400-foot level was encouraging. ~~xxx~~ In 1920 it was said that the Dromedary Hump mine was being worked by lessees.

The Dromedary Hump vein or lode, which in places is about 50 feet wide, consists chiefly of massive quartz and silicified rock. It is in part brecciated and in places crudely banded and vuggy. The included angular ~~xxxxxxxxxx~~ remnants of altered rock seem to relate it to the quartz of the Nevada Hills mine, and it probably is of similar origin. The quartz, especially as seen in the ore, is stained reddish and rusty brown by iron oxides, and is well oxidized down to below the 500-foot level, although the country rock is more or less pyritic as high as the 200-foot level.

The deposits are very irregularly distributed in the vein or lode and the adjacent wall rock. They occur in discontinuous streaks and pockets, some of them rich—some being said to run about $5000 to the ton—but most of them small. They could hardly pay the cost of mining, which even in most of the horizontal work is about $40 per foot. Ore to be ~~xxxxxxxxxx~~ profitably mined and shipped should run not less than $40 a ton.

The deposits are distinctively silver deposits, the metal content in the run of mine ore being about 115 oz. of silver to 1 oz. of gold, but some of the ore was said to run about half ~~xxxx~~ gold and half silver in value (at the prices then prevailing).

The ore minerals, which are fairly well distributed in the quartz ore and some adjoining soft altered rock are:

Argentite
Cerargyrite
Embolite
Ruby silver
Gold

Associated with these in places is a little tetrahedrite, galena, pyrite, chalcopyrite, specularite, and malachite stain, and some rhodochrosite or rhodonite and black manganese oxide.

From the development done in the Dromedary Hump and Golden Boulder mines the vein seems to contain considerable ore, but the ore seems to be too pockety to be profitably mined, and it does not seem to include deposits of the second period of ore formation, which have yielded most of the commercial ore in the Nevada Hills mine. Altogether the showings in the considerable portion of the vein which has been opened up or prospected offers little hope that larger ore bodies will be found in depth. The ore is of such character, moreover, that it cannot be readily sorted for milling and shipping, and there would be much need for a suitable method of treating it economically at the mine.

Origin of the deposits

The deposits are believed to have been formed by hot mineral-bearing magmatic solutions that circulated through the rocks in the period immediately following the eruption of the Lode andesite porphyry and perhaps to a less extent at periods following later volcanic eruptions.

As already stated, there were four periods of mineralization, which formed, in order,

(1) Barren quartz veins.

(2) Primary ore veins.

(3) Secondary or enriched ore veins.

(4) Barren calcite-quartz fillings in the reopened veins.

Barren quartz veins

Mineralization in the first period began with the formation of sentially barren quartz veins, the oldest veins in the district, by cending thermal solutions, which circulated while the Lode porphyry ndesite was being erupted, or very soon after. The most important eature in this period is the formation of the Big vein of barren quartz, long the monocline of dacite tuff and the contact of the dacite tuff with he Lode porphyry, which was intruded into it. As the deposits are large and onsist almost wholly of quartz, the depositing solutions seem to have been ery siliceous and to have had great inherent power of replacing the country ock. They probably acquired some of their silica from the dacite tuff through hich they ascended. Conversely, they were also very poor in metallic minerals, he metallic minerals being mostly later than these ~~xxxxxx~~ oldest veins. Ore minerals may, however, have been deposited contemporaneously with the veins to a slight extent, for the barren veins were formed by solutions arising from the same general magma as those that formed the ore veins, and some occurrences of oreminerals in the barren class of veins seem to have no connection with the ore veins.

Ore veins of second period of mineralization

Shortly after the deposition of the barren veins there came a second period of mineralization, in which the primary ore veins were formed. The primary ore veins, like the barren veins, were deposited by hypogene solutions, to judge from the similar effectiveness of these later solutions in dissolving and replacing the country rock, but these solutions contained larger quantities of metals, which were deposited in the form of sulphides.

ions are believed to have derived from practically the same those that formed the barren Big vein. If this were the case, seem that the solutions could have entered the ore vein fissures ectly by ascending through the Contact fissure, now occupied by vein. Hershey, Greenan[5], and others believe that they took

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Greenan, James C., Geology of Fairview, Nev.: Eng. and Min. Jour., , No. 16, pp. 791-793, April 18, 1914.

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ourse. Certain facts, however, are hard to reconcile with this view. is only a feeble connection, and in some instances no connection at between the ore veins and the Big vein or its fissure; ore is generally in the Big vein; and ore minerals become scarcer, or fail altogether, e ore veins as they near the Big vein. In support of the view held by on the other hand, Greenan suggests that the dacite tuff formation, in the Big vein largely lies, may have been unfavorable for ore deposition ared to the Lode porphyry andesite, in which the ore veins mostly lie; oints out also that circulation in the ore fissures, which may have been nd, was probably much more retarded than in the supposedly open barren n fissure, thus favoring precipitation of the metallic constituents. But ough the difference in conditions here suggested may have been influential, ey do not seem nearly adequate to account for the ore deposits. The pinching the ore veins, and their decrease in metallic content, as they near the arren veins ~~xxxxxx~~ seem to preclude the possibility of the solutions having ~~xx~~ entered the ore fissures along ~~xxx~~ their contact with the barren veins.

Another conception is that the solutions might have ~~xxxxxxxx~~ entered the issures at their ends, which they might have reached by ascending suitably situated fault fissures, and then circulated horizontally or longitudinally through the fissures; but no faults can be pointed to as having afforded such passage-ways.

Another view is that the veins may have been formed by descending solutions. Lawson believes that the veins were formed in this manner, by descending meteoric waters which acquired their mineral content, by a leaching process, from the Lode porphyry as they percolated through it. Such a process, however, seems wholly inadequate to have accomplished the results, considering the large volume of the mineral deposits produced and the relative leanness and limited thickness of the superincumbent porphyry from which the metals must, on this theory, have been derived. It is extremely improbable, moreover, that relatively cool descending solutions could have had about the same power to replace country rock as the solutions that deposited the barren veins, whereas replacement appears to have been about equally extensive along the two sets of veins.

Still another hypothesis to account for the formation of the veins holds that they were formed by descending solutions of magmatic origin. In this view the solutions must have entered the fissures at some higher level than that at which the apices of the veins and the surface now stand. This view requires that the Lode porphyry must have had a considerably greater vertical thickness than it now has, or that its subareal surface stood at a higher elevation than at present, which is reasonable. The magmatic solutions are supposed to have ascended through fissures to its intersection with the ore fissure, and to have formed the vein and ore as they descended the ore fissure from those intersections. In this manner the solutions were maintained at a high temperature, and accordingly at a high mineral-bearing efficiency and solvent power, by the slowly cooling but still comparatively hot rock mass. This hypothesis has not been supported by pointing out any fissures through which the ore solutions may be supposed to have ascended.

Latef vein formation

The second and third stages of ore deposition--the third and fourth periods of mineralization--which took place chiefly in the reopened ore veins ad their fissures are less difficult to account for on the last ~~phxxx~~ hypothesis proposed for the primary ore veins, assuming that they followed the primary ore veins after a reasonably short time interval.

The second ore stage has been described as corresponding closely to secondary enrichment, in that it locally concentrated the relatively lean primary ore into commercial ore bodies. This was accomplished by descending solutions, which from the results they produced must have been hot, and seemingly less siliceous than the solutions of the primary ores.

The fourth period of mineralization was unproductive ~~fxxx~~ so far as ore was concerned. It deposited for the most part only barren quartz and calcite in the then recently reopened fractures and fissures and perhaps in some pre-existing cavities.

Age of the deposits

From the genetic connection of the deposits with the Lode andesite porphyry, which has been referred to the Middle Tertiary or Miocene, it follows that the deposits are Miocene. They belong to the large class of similar deposits in Nevada referred by Lindgren to the Middle of Late Tertiary, and also to the group, mainly of silver deposits, in the volcanic rocks that has been referred to the Miocene by Ferguson.

Mine water

The water in the Nevada Hills mine at present is not very siliceous. An analysis of it, made by Mr. Herman Harnes for the Nevada HillsCo. in 1914, showed it to contain considerable quantities of calcium carbonate and magnesium sulphate but less than 2 grains of silica per gallon.

Other deposits

Besides the deposits already described, there are many properties, consisting mostly of claim groups, on which several hundred feet or more of work was done, from some of which small shipments of ore were made, and some of which were sold for several thousand to $10,000 dollars or more. They are mostly outlying and include the following, only a few of which can here ~~bxxx~~ be described.

Bonanza group
Cedar group
Clipper group
Coxey or Goldfield group
Cyclone group
Fairview Central group
Golden Crown mine
Grand Central mine
Hailstone group
Hot Onion group
Ida mine group
Jelinek mine

Kimberly group

Livingstone group

Lookout group

Mizpah mine

Nevada Crown mine

Nevada Fairview or Snyder mine

Nevada Hills Florence mine

New Yorker group

Ohio group

Philadelphia group

Pyramid mine

Red Rock mines group

Seymour Fraction

Mizpah mine

Location

The Mizpah mine, formerly called the Austrian mine, is 4 miles south of Fairview and 3½ miles south of the Nevada Hills mine (fig. 3). It is near the middle of the west slope of the Fairview Range, in the upper part of Mizpah Canyon, at an elevation of about 5,700 feet. The canyon forms an avenue of easy approach, though the surrounding topography is rough and mountainous.

History

Aug 13 107' Mineral was discovered on the site of the Mizpah ground in 1906 by Otto Steinheimer and his brother, of Colorado, who soon conveyed to each of two other partners a quarter interest in the property. One quarter went to Sam Watkins for surficially developing the property and finding an ore shoot, which, it is said, was a foot wide and of considerable extent, averaged $240 to the ton, and yielded specimens that assayed as much as $10,000 a ton.

A 70-foot shaft sunk in the vein at the summit of the mill, 200 feet above the bottom of the canyon, is said to have been in ore all the way down and to have shown the vein to be about 20 feet wide.

Soon after the finding of ore the property was sold for $50,000 to D. J. Kennedy, who organized the Mizpah Mining Co., of Reno, and endeavored to sell stock. In the next few years, extending to June, 1911, he did nearly all the additional development work. The mine contains about 1,600 feet of work (fig. 39) including a shaft and upraise of 200 feet. Later the property passed to Henry Bartell. In 1914 the mine was examinedd by the Nevada Hills Mining Co. with the view of taking it over, but it is said that the company did not find it sufficiently attractive. The ore is said to run only about $6 to the ton, which is obviously too low grade to be shipped.

As the surface of the ground containing much of the vein rises steeply 200 feet above the floor of the canyon, the property is favorably situated for development by a crosscut adit tunnel which cuts the vein about 200 feet in from the portal. The important claims are the Mizpah and Atlanta. On the southeaxt the vein has a considerable extent on the Rubie group.

The production of the mine has been small--not much more than $1,000 worth of ore.

Country rock

here The region is underlain by volcanic rocks which have not been divided nto formations. The country rock at the mine is mostly light-colored hyolite or latitic breccia, which is locally silicified. A specimen of he rock from the face of the crosscut tunnel, 200feet below the surface, ppears to be brecciated rhyolite, It is medium grained and light gray, ith reddish and greenish tinges, and is highly altered. It contains onsiderable secondary calcite, some in large areas, also quartz-calcite tringers and veinlets and small cubes of hematite, pseudomorphic after yrite.

The mineralization in the vein occurs in bunches ranging from less than an inch up to several feet in extent or diameter. Within these bunches the ore minerals tend to occur in irregular streaks or bands, depending on the character of the openings in which they were deposited. The mineralization occurred after the rock was brecciated and often follows the quartz cement matrix, with which it partly envelops many fragments of the rhyolitic breccia. The ore minerals are mostly dark silver sulphide (argentite and stephanite?) which ~~[illegible]~~ begin near the surface and are associated with cerargyrite, and a little native silver and gold. From the surface to a depth of 40 feet the gangue is mostly soft whitish kaolin, locally called talc, which contains disseminated grains and specks of the dark sulphide ore minerals.

In the lower part of the workings on the tunnel--or 4th, level and in the so-called "manganese" winze sunk below it, the ore contains considerable pyrolusite and wad. A manganese zone 5 to 20 feet wide contains $12 ore in places.

The mine seems to contain a fair quantity of medium-grade ore ranging from $5 to $10 to the ton, which is obviously too lean to be profitably mined and shipped under present conditions.

The vein

The vein strikes about east and west and dips 60° S. It varies from to 20 feet in width and averages about 6 feet. It locally has sheets of ouge on either wall, which, especially on the hanging wall side, show by lickensides and grooves that conđiderable post-vein movement has takem lace. Several small normal faults of steep westerly dip are exposed in he mine, one of which has offset the vein about 10 feet as shown in the ast drift on the 4th level (fig. 38). The croppings of the vein are not ontinuous but locally stand several feet above the surface. They consist hiefly of whitish quartz and silicified rhyolitic breccia. The vein is pened to the depth of about 265 feet, on five ~~xxxxxxx~~ levels, as shown in igure 38. It consists mainly of hard white quartz, mostly formed by replacement, and silicified brecciated rhyolite, and parts of it resembles a replaced recciated dike. It is locally vuggy. A considerable portion of the vein nd ore shows the peculiar structure of the quartz and adularia replacement gangue pseudomorphic after calcite.

Grand Central prospect

The Grand Central prospect is situated a third of a mile northwest of the Mizpah mine, approximately in alignment with the Tom Boy and other prospects a few hundred yards to the northwest. It was discovered in January 1915 by J. A. Nave, by whom and Henry Bartell it is owned.

The geological and mineralogical conditions are similar to those at the Mizpah mine, in that the country rock seems to be a rhyolitic flow breccia containing disseminated minute cubes and grains of pyrite. The principal surface showing is a ledge of silicified rhyolitic breccia and quartz 100 feet long by 40 feet wide, standing 5 feet above the surface. The most important part of the showing is a strip 4 feet wide, which is in part crudely banded with fine-grained vuggy comb quartz, and contains in places streaks and ~~xixx~~ disseminations of dark silver-sulphide ore minerals, such as argentite and stephanite. It is said to be mostly ore running about $45 to the ton, and from it, at the time of the writer's visit in 1916, the owners had just quarried and shipped 2-1/2 tons of mostly silicified ore that ran 48 oz. in silver and $11 in gold to the ton.

From what is revealed by meagre development work, which comprises a 50-foot shaft on the northside and a 40-foot crosscut tunnel driven on the lower side of the outcrop, the deposit does not seem to have continuity in either horizontal extent or depth.

Big Ledge or Jelinek mine

Location

The Big Ledge or Jelinek mine is about 4½ miles south of Fairview and a half mile south of Mizpah mine, on the south side of Mizpah Canyon.

History

Mineral on the property was first discovered early in 1906 by John Horgan and R. L. D'Arcy. The discovery was made on the eastern end of the property, where the veins are most deeply eroded by Mizpah Canyon. In May of that year the property, consisting of the five original claims, was purchased from the ~~dixxxxxxxxx~~ discoverers by W. H. Davis, who in April 1909 shipped from it 3 tons of ore running 94 oz. in silver and $23 (old values) in gold to the ton. By 1913 more than 20 tons of ore is said to been shipped. Later in 1916, W. M. Jelinek of Goldfield became the owner he property, and in September 1918 he shipped 6 tons of ore that ran 47 oz. ilver and $31 in gold to the ton.

At the writer's visit in 1920 the property was comprised in a belt about 4 miles long by 1/2 mile wide and consisted of 10 or more claims, the most rtant of which are shown in figure 39, with the camp located in the western of the property. On the north and on the south the group is joined by other m groups, some showing veins or considerable mineralization; some of these ms are owned by Mr. Harris, a pioneer prospector in the district. The Jelinek perty then contained about 1,000 feet of work, mostly in tunnels and drifts he eastern end, overlooking Mizpah Canyon. Machinery was then being put place for doing 5,000 feet of development work. Fuel oil and gasoline were e the source of power. In 1928, it was said that about 2,500 feet of develop- t work had been accomplished.

Country rock

The topography is hilly and more or less rough, with a relief of about feet, but the property is not difficult of access. The country rock sists of siliceous light-colored volcanics, mostly rhyolite or quartz latite. pecimen of the rock from the western part of the property, near the cross n at the northeast corner of Big Ledge No. 4 claim (figure 39) proved when mined microscopically to be a soda rhyolite. It is a light-brown medium- ined vesicular flow breccia containing angular fragments of lighter and ker rocks. It is about 80 percent cryptocrystalline groundmass, in which a few microphenocrysts of orthoclase, albite-oligoclase, and quartz, small es and other forms of hematite pseudomorphic after pyrite, and small foils of otite altered to bottle-green chlorite, all in flow arrangement. There is also resent considerable heisingerite, a hydrated ferric silicate in golden yellow rains, small crystals and aggregates, associated in places with the hematite. e silicified rock together with quartz forms a boldly cropping cross reef of in several hundred feet in extent.

Nine hundred feet southeast of the above locality, near the middle of Big edge claim No. 2, a dull-gray silicified rhyolite tuff, forms the hanging wall f the vein and strong bouldery croppings. The rock is hard, firm, crudely anded, and moderately porphyritic, with a few small phenocrysts of feldspar and uartz. Under the microscope itis seen to have a greenish glassy base and to e very similar in composition to the specimen just described. A little epidote s present, and some of the albite and chlorite is bent or flexed by dynamic ressure.

In the workings a few hundred feet to the east of this last locality e hanging wall of the vein consists of a buff-colored medium- to fine-grained pparently ~~xxxxxxxxxx xxxxxxxxxx~~ waterlaid rhyolite tuff which may belong to e lake bed tuffs near Fairview.

On the eastern part of the property, for instance at the workings over- oking Mizpah Canyon, the rock is similar to that near the middle of Big ~~xxxxx~~ dge No. 2 claim, described above, except that it has a more brownish or purplish e. East of Mizpah Canyon the same rock extends in full force up the mountain lope and forms steep cliffs facing the canyon.

The rhyolite is cut by a prominent sheeting, which, e.g., on the Big Ledge laims 2 and 4 where it is well exposed, strikes N. 75° E. and dips 80° south, d by a less prominent sheeting which strikes about N. 20° E. with nearly rtical dip. On the east, near the middle of the Big Ledge claim, a heeting which corresponds in strike to the one first described dips 80°

the north instead of to the south; the 20° difference in dip may, however, resent a local disturbance. The rock is also cut in places by dikes of esite porphyry, as on the eastern part of Big Ledge No. 1 claim and in the e workings on Big Ledge No. 2 claim (figs. 39 and 40).

Ore deposits

General features

The mineral deposits are silver-gold deposits contained in or associated h two or more veins found in the rhyolitic rock. They are characteristic the silver-gold deposits occurring in the Tertiary volcanic rocks of the thwest. The veins dip for the most part steeply to the south. They vary m 2 to about 20 feet in width and their position on the surface is for the t part well marked by bold croppings of the veins themselves and of silicified ll rock, locally standing 10 feet or more above the adjacent surface. The licification of the wall rock is mostly on the south or hanging-wall side. places where the vein croppings pinch or vanish the course of the veins d fissures continues to be well marked by a prominent reef of the silicified ll rock.

The veins in large part at least occupy fault fissures, but the posits also include replaced adjacent wall rock. They are composed inly of vein quartz, calcite, and fragments of silicified and replaced olite breccia. Associated with the quartz is considerable adularia, and places this quartz-adularia phase of the gangue has replaced calcite, after ich it is pseudomorphic, as shown by its meshy and fan-shaped structure, e up of radiating blades and rhombohedral forms. The ore is mostly ft and easily broken, but much of the quartz is relatively firm and has a eenish hue, being of a type that in the Oatman and other districts in the uthwest commonly constitutes good ore.

The ore minerals are mainly dark silver sulphides, mostly argentite and ephantite, occurring conspicuously as small bodies and specks disseminated the whitish quartz-adularia-calcite gangue. Cerargyrite and gold are ually associated with these sulphides. The ore is said to average about 0 to the ton, of which about $7 is in silver and $3 in gold.

The depositx represent two or more periods of mineralization. The ore ems to have been formed by hot ascending solutions of magmatic origin at circulated after the eruption or intrusion of one or more members of the lcanic rocks. The ore minerals and silica were carried by solution that posited the ore minerals while partially replacing calcite and rhyolite breccia th quartz. Though the veins contain fine-grained secondary calcite, most of e calcite present is believed to be primary or to belong to the pre-ore period mineralization.

Big Ledge vein

The most important of the veins are the Big Ledge and the Big Ledge No. 3. e Big Ledge vein, the pioneer vein of the camp, lies in the east-central rt of the property and has a length of nearly 3,000 feet. It extends from ar Mizpah Canyon west-southwestward almost entirely through the length the Big Ledge and Big Ledge No. 1 claims, and near the end of the latter joins the Big Ledge No. 3 vein at an angle of about 40°. As neither in intersects the other and they both have about the same composition y are believed to be of the same age. The Big Ledge vein strikes about

70° E. and dips about 80° S. or stands vertical. It is well marked by ppings almost throughout its course. It is opened mainly on its east Mizpah Canyon slope, at about 200 feet above the canyon, to the depth about 100 feet by a tunnel and shaft. There are fairly good showings these workings, from which considerable rich ore is said to have been duced. The tunnel, which is 200 feet long and extends beyond the shaft, in the vein all the way. The vein looks fairly good. It is from 20 feet wide and is more or less crushed. It contains considerable orable looking greenish quartz and about 12 percent of calcite.

A lower and shorter tunnel, driven from near the bottom of the canyon the trend of the vein, did not find the vein, from which fact, together h surface indications, it is inferred that the vein is faulted off about feet above the canyon floor. A prospect opened toward the western of the Big Ledge claim shows that the vein there also carried good-looking rtz.

Big Ledge No. 3 vein

The Big Ledge No. 3 vein lies in the southern border of the property, an extent of more than 4,000 feet and is slightly curved or concave toward south. Its middle part, which is its best part, lies in Big Ledge claims 2 and No. 3. It strikes N. 70° E. and for the most part dips 70° and 80° S. e of its eastern part, however, on No. 3 claim, dips 80° to the north (figs. 39 40).

In 1920 the vein was opened at several points with good results, especially t west of its junction with the Big Ledge vein where the croppings are sually strong and the ore seems to be unusually good at depth. Here the n, 6 feet or more in width, is composed of good-looking quartz and is mpanied on its hanging-wall side by 15 feet or silicified rhyolite tuff ing strong bouldery croppings. The tuff, as shown in the lower tunnel, nderlain by andesite, which in depth forms the hanging wall.

Outlook

Judging from the character and composition of the veins and their ilarity to productive veins of their class, the Big Ledge vein and the dle part of the Big Ledge No. 3 vein probably extend to depths of at least eral hundred feet and contain a fair quantity of commercial ore.

Nevada Fairview or Snyder mine

The Nevada Fairview or Snyder mine is 6 miles south of Fairview, at elevation of 5,450 feet. It is in Snyder Gulch just below the point at ch it forms a steep-walled box canyon (fig. 32).

The deposit was discovered in 1906 by L. H. Bartholomew at the place re No. 2 tunnel was later driven in the north side of the canyon. It was n optioned by Grant Snyder, who with his brother William incorporated property, comprising a gwoup of 14 claims, as that of the Nevada irview Mining Co., a subsidiary of the National Development Co., with adquarters at 25 Broad Street, New York City. The company soon employed a rce of 20 men who worked the property for 10 months without interruption. sides the ore produced at this period the property is said to have made fair-sized shipment in 1910. The property contains about 1,200 feet underground work, which is mostly in two adit drifts or so-called nnels and a shaft at the site of discovery.

The country rock is a tuffaceous quartz latite. At the mine it is faulted, ...ed, shattered and silicified.

The vein strikes about N. 20° E. and dips for the most part steeply ...e east. It is associated with what seems to be a fault and a prominent ... of silicified rock (fig. 32). It consists largely of quartz, which has ...ced brecciated rock and calcite. Sulphides are said to begin at about ...00-foot level and that the ore is said to be better there than near the ...ace, probably because of leaching by descending percolating waters.

In the south adit drift or Tunnel No. 1, which is 325 feet long and ...ins a depth of about 250 feet at the face, much of the vein is said to ...y ore shoots ranging up to 2-1/2 feet in width, with the ore running $10 to $100 to the ton. At the time of visit, however, in 1913 the ...el roof showed only altered reddish gray gouge-like material containing ...t irregular stringers of crystalline calcite. It showed no regular vein ...any good indications of ore. In the last 80 feet of the tunnel the ...nd is bouldery and blocky. The dip of the vein wherever seen is ...p westerly, and for short distances only there is a fairly well-defined footwall.

Tunnel No. 2, starting on the discovery site, runs northward 125 feet. It ...driven on a steeply eastward dipping fault plane, at the eastern edge ...a worn down vein 20 feet wide. The vein is deeply eroded, but on either ... of it the silicified wall rock stands up boldly to a height of 10 to 30 ...t. For the first 70 feet the tunnel follows the vein, which is 2 to 6 ...t wide, consists mostly of quartz, and for most of the distance named ...tains an ore body 2 feet or more in width. At the portal of the tunnel is a ...ft 100 feet deep, the first 60 feet of which is mostly in the same vein and ... body as the tunnel. At this depth the vein dips eastward away from the shaft,

it was later recovered by a crosscut on the 100-foot level and explored there
20 feet of drifting and an upraise. The shaft was timbered and equipped with
o-horse winze. In nearly all of the tunnel and shaft the ore is said to
run $40 to the ton, with some very rich streaks. The only place found,
ver, in this examination of the tunnel from which ore could have been
ved is a chamber on the east or hanging wall side, and the roof of the
al shows only altered gray and brownish rock and gouge-like material.
ore produced must therefore have come mainly from the shaft.

About half a mile northward up the slope from the workings in the
n, just described, and 400 feet higher, the vein crops out boldly for a
ance of several hundred feet. It is opened here by a 300-foot adit drift
n as Tunnel No. 4, from which a winze was sunk 130 feet from the portal.
e workings are said to be nearly all in a white quartz vein 10 to 15 feet
, containing an ore shoot that is several feet wide in places and that
yed more than $20 (at gold and silver prices then current) to the ton,
streaks of very rich ore on the foot-wall side.

The tunnel dump, which is large and seems to be representative of the
material, consists mainly of replacement quartz pseudomorphic after
ite. The better portion of it constitutes ore. The whole forms a
rkable mixture whose materials range from coarsely crystalline calcite
domorphs down to dense quartz. It affords the best example of this type of
acement seen by the writer in this part of Nevada. Much of this gangue
ore, especially the finer and more silicified part, is stained and
d with black manganese oxide, with which the silver and gold minerals
said to be closely associated. The worn condition of the ore bin and
road indicates that ore was shipped from this place.

Nevada Crown mine

The Nevada Crown mine, known also as the Gold Crown and as the Port and Sampson, is nearly 8 miles south of Fairview, on the north side of Crown Canyon or Downeyville Pass, at an elevation of 5,400 feet, and is easy of access (figs. 3 and 31). It was discovered and located in August 1906 by W. H. Port, J. W. and M. L. Sampson, and W. H. Walker, and was worked intermittently until 1909 by a force of 12 men. The property comprises a group of 12 claims. It is said to be owned by Wm. T. Morgan and Wyman Moore, members of the Schlitz Milwaukee Brewing Co. It is developed mainly by a 600-foot tunnel running N. 35° E. and a 250-foot shaft formerly equipped with a gasoline hoist. Unfortunately, the mine was locked and not enterable at the time of visit, so that no underground examination could be made.

The country rock is a medium-grained greenish-gray andesite, similar to that at the Nevada Fairview mine but not pyritic. It is highly chloritized and silicified, however, and presents several diverse phases. It is much crushed and is cut by sheeting with a steep southerly dip and by east-west dikes of a younger andesite, which weathers reddish (fig. 31). About half a mile northwest of the mine, at an elevation of about 5,150 feet, the andesite area is crossed by an east-west belt of pearl-gray, dense andesite, which seems to be a dike. A short distance farther northwest the country rock andesite contains beds of andesite tuff dipping gently southward.

At the shaft, 2,000 feet northeast of the tunnel, there crops out an iron-gray fine-grained laminated quartz schist belonging to the pre-Tertiary complex. This rock dips gently ~~xxxxx~~ northward into the mountain, underneath the andesite.

ne mine is probably on the same general north-south zone of mineralization Nevada Fairview mine. Many encouraging prospects are said to have been on the property, most of them running high in silver and gold and some n containing much free gold. The most important of the showings was a t quartz vein with a rich ore shoot on the hanging-wall side.

he long tunnel dump, consisting mostly of altered andesite, contains itic aplite, regarded as pre-Tertiary, and some fine-grained greasy-ed vuggy replacement quartz, which probably occurs in the form of ic stringers rather than as a vein. Some of this same class of al, however, seen at the house contains silver sulphide ore minerals obably also gold.

heexposures of the quartz schist on the ground and the nearness of ne to Slate Mountain on the south are regarded as evidence that vering of volcanic rocks thins rapidly southward and is too thin property to contain ore in depth, and, as veins in the volcanic rocks never, in this district, been found to extend into the underlying rocks, seems to be no hope of finding ore in depth on the property. It may be however, that the monzonitic aplite of which fragments occur in the dump is probably intruded into the calcareous quartz schist exposed at aft and possibly into limestone also, though no limestone has yet been ed nearby. These geologic conditions would seem favorable for ore deposition pre-Tertiary rocks, but it has not yet been proved that they actually ed in ore deposition.

he Revenge group, about a mile north of the Nevada Crown mine, is y Harry Light to present a good showing.

CARSON SINK AREA, NEVADA

By

F. C. Schrader

Wonder District (1)

Wonder District

Location

The Wonder district is about 10 miles northeast of the center of the area and about the same distance southeast of the center of Churchill County at the south end of Dixie Valley and in the lower west slope of the Augusta Range at an elevation of about 5,700 feet. It is about 40 miles direct and 57 miles by road, via Sand Springs, a little south of east from Fallon, the nearest supply point, on the Hazen-Fallon branch of the Southern Pacific Railroad, and it is about 12 miles north of the Lincoln Highway at Westgate, fig. 3.

Wonder

History

Wonder has been the most active and steadily productive district in the Carson Sink area. The first discovery of mineral in the district was made in 1906 by Tom L. Stroud, a lone prospector who came hither from Fairview 18 miles distant with only a blanket and what little food and water he could pack on his back. He was attracted by the light color of some of the exposed rocks that are conspicuous from a long distance, fig. 5. On March 18 he made the first location which he called the "Lost" claim and is now embraced in the "Stray Horse" group. A few weeks later on April 7 he located the Dickey V or famous Jack Pot group of claims, and subsequently in company with R. L. D'Arcy he made still other locations. Others who soon visited the district were Frank Schulty, R. S. Smith, Charles Lamb, and William Mays.

Samples of the ledges discovered assayed at Fairview are reported to have run as high as $1200 to the ton in gold and silver. 1/ News of the

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1/ Parker, T. C., The new Eldorado of the West, The Salt Lake Mining Review, Vol. 9, No. 3, p. 20, May 15, 1907.

trike soon became public, and the Wonder stampede began. The rush from Fair-iew started May 28. Many who could not procure even a burro came on foot. oon ground was staked in all directions, and the Wonder townsite 9 blocks ong by 4 blocks wide was located and surveyed. With only surface discoveries ut little idea of the nature and value of the ore was gained until in June. Nevertheless, many original locators, more it is said than in any other istrict in Nevada, sold their claim interests for handsome fortunes.

In September, claims which had been located by Mays and associates on a ich strike on Wonder Mountain were optioned by J. B. Daniel, mining engineer, who interested with him certain Philadelphia capitalists, amongwhom were several directors of the Tonopah Mining Co. These parties formed the Nevada Wonder Mining Co. which became the nucleus, life and longevity of the district. The Company took the property over at a consideration of $300,000 and 400,000 shares of the stock having a capital of 1,500,000 shares of $1 each. The issue of the first block of treasury stock at 50 cents per share and its rapid rise to $3.50 on the Philadelphia market aroused public interest in Wonder, and many of the properties were soon capitalized for a million dollars or more.

The town of Wonder, fig. 6, was built and the principal boom occurred in 1907 and ended with the financial panic of July to August of that year. Among the many buildings which soon sprang up were a half dozen stores, a large hotel, two banks, and a $14,000 club house. The promise of the district was so great that many of the most successful mining men of the west soon acquired interest in it, and by April 1907, it is estimated that more than $2,000,000 had been expdnded in the district. In May the district had a

ation of 1,200 people, of whom 300 men were at work in the mines and
ects. Supplies were freighted in from Hazen and Fallon for 2 1/2 cents
cents a pound respectively. Lumber in Wonder sold for $72 a thousand.
, which was hauled from Horse Creek, the nearest source of supply 7 miles
e north, cost $6 a barrell, fig. 4A. barrel

Other thriving townsites were Hercules, 2 miles north, and Victor, 4 miles
west of Wonder, fig. 7.

Toward the close of August the population had decreased to 800. Sub-
ently ground was taken up on the more promising prospects and developed
more rational manner. Many of the more promising properties were soon
n over by mining companies or mining men of experience and means, with
result that by 1908 the Nevada Wonder, Jack Pot, Spider and Wasp, Vulture,
Wonder, and Capitol Wonder companies were working in good ore. Of these,
Nevada Wonder had 5,000 sacks of ore ready for shipment, the Jack Pot 1,000,
Spider and Wasp 1,600, and the Vulture had shipped 16 tons. Fully 30 other
erties were working on ore bodies or prospects assaying from $2 to $50
the ton.

By 1913 the district, especially the town of Wonder and the larger mines,
e supplied by the Wonder Water Co. with water brought by pipe line from
ch Creek, 6 1/2 miles to the northeast, at 75 cents per barrel or $1.50
1,000 gallons, in large quantity for mill use etc.

Also in 1911 the Nevada Wonder Mining Co. constructed a private 10-mile
er pipe line from Horse Creek Ranch, 6 1/2 miles to the north, which amply
plied its needs for mining, milling, and domestic use. Also under a

tract with the Pacific Power Co. the district was being furnished with ctric power and light for mining, milling, and domestic purposes, the ctricity being brought 130 miles from Jordan near Bodie, Mono County, Calif.

Crude oil cost 16 cents, distillate 26 cents, and gasoline 42 cents a lon. The principal producer of ore was the Nevada Wonder Mine, which rated steadily with a force of 54 men.

From 1911 to 1919 the history of the district is essentially that of the vada Wonder mine. This mine holds a remarkable record for 8 years or more steady production during that period, in which it was almost the sole pport of the district.

Topography

The topography of the district is hilly to mountainous and in part gged. It is essentially the type produced by trenchant erosion in an arid egion of deformed Tertiary volcanic rocks that were deposited mostly in flows. t is well expressed in compact form in fig. 3, and more in detail in fig. 7, nd in figs. 5 and 8, photos. It trends nearly north and south and is drained orthward into Dixie Valley principally by Hercules Canyon which forms a natural thoroughfare through the eastern part of the district on either side of which the surface is more or less rugged. The surface in general declines northwest into Dixie Valley while on east it rises into the Augusta Range, which, 8 miles to the northeast, culminates in Mount Grant at an elevation of 9,000 feet. The relief is about 2,750 feet with the surface ranging in elevation from 4,250 feet on the northwest to 7,000 feet at Twin Peaks on the southeast. Beginning on the north, important land marks on the east are Queen Peak, Wonder Mountain, and Twin Peaks, and on the west Dickey, Porphyry, Camelback, Driscoll, and Crown Peaks.

In the southwestern part of fig. 7 on the slope descending from the Camel Back Peak--Crown Peak ridge westward toward Dixie Valley the topography is systemless and intricate. It is composed of rhyolitic to andesitic lavas difficult to distinguish and map.

The accompanying topographic map, fig. 7, was made in anticipation of its use for detailed geologic mapping with the attempt throughout this part of the work to distinguish areas of different phases of formational units in the volcanic rocks of which the district is composed. As will be explained in the following description of these rocks, however, the rocks are practically all rhyolites and the local ~~xxxxxxxx~~ variations of color and texture which it was at first attempted to trace and map are probably of no value or important significance.

The topography shown by the map serves a very useful purpose for the interpretation of some of the major faults of the district. The map serves as a base upon which to locate the more important mines and show their situation and accessibility, also for the location of the rock specimens which were collected including those which have been examined microscopically, and upon which determinations are here given 2/.

2/ The map was made with a 15-inch traverse planetable, 6-inch open sight alidade and aneroid barometer. The U. S. Mineral Land monuments on Queen Peak (No. 191) and on Driscoll Peak (No. 196) were taken as ends of a base line, the length of which has been determined by several mineral land surveys. The field work of the present map was plotted on a scale of 2 inches equals 1 mile, and the relief sketched in contours of 50-feet vertical interval.

Geology

Excepting a few patches of alluvium deposits or wash the district is erlain essentially by a complex aggregate of volcanic rocks. The dis- bution of the rocks is indicated on the accompanying map, fig. 7.

Sedimentary rocks

Pliocene lake beds

Humboldt formation.--Just beyond the north limits of the district map, . 7, the alluvkum deposits rest on eroded sedimentary lake beds of faceous sandstone described under the Humboldt formation p. (G)-15.

Quaternary alluvium deposits

The alluvium deposits of the district consist of Quaternary gravels, lus, and silts accumulated in low places and at the foot of slopes. On e west and northwest they merge with and form a part of the Dixie Valley ll. Within the district and the limits of the map they rest essentially the eroded Tertiary volcanic rocks.

Igneous rocks

Tertiary volcanic rocks

General statement.--The Wonder district is underlain almost entirely a rhyolitic complex of Tertiary/~~xxxxxxx~~ volcanic rocks, which is the southwestward ontinuation of the formation which the Fortieth Parallel Survey mapped as hyolite to the south limits of ~~its~~ map,3/ which coincides with the north

3/ Fortieth Parallel Survey, Map 5, east half.

dge of the Wonder District map, fig. 7, on Par. 39° 30'.

The rhyolites are the volcanic equivalents of the granite, having been produced by the consolidation of the granite magma under volcanic conditions. They are highly acidic containing in most cases free silica in the form of quartz.

In the district the rocks have a known thickness of more than 2,000 feet and probably a very much greater thickness. They, in general, are similar to the Tertiary volcanic rocks found elsewhere in Nevada, but they are so inherently structureless, deformed and altered that, in most instances, their relationship and manner of deposition can not be definitely determined. Besides being much faulted, as is shown by scarps and other topographic features and by slickensiding, brecciation and gouge associated with nearly all of the veins, they are also extensively altered, mineralized and discolored hydrothermally and otherwise. For instance, in the western part of the district, about 4 miles west of Wonder Mountain, occur four north-south belts of altered kaolinized rock, chiefly Wonder rhyolite. They follow lines of lower gaps in the topography and have been extensively prospected. They probably represent a fault zone part of which is shown in fig. 7, map.

Also approximately the middle part of the district is crossed by several east-west lines of light-colored spots or areas constituting zones near which at first were thought to be light-colored rhyolite but which examination showed to be areas or zones of hydrothermal alteration. They seem to ~~mxkx~~ mark lines or belts of fracture or disturbance along which interruptedly hydrothermal alteration took place. Similar appearing zones were seen to be present in the Stillwater Range directly across the Dixie Valley but were not examined.

Of the several fault systems, the most important trends with variations n a northwesterly direction with its fissures containing nearly all of the eins in the district the most of which are indicated in fig. 11. These aults mostly dip to the northeast. Other faults are shown on the map, ig. 11.

The valley of Hercules Canyon for the most part seems to follow a ault, as does also the South Fork of Stray Horse gulch and the foot of the teep mountain slope at the eastern edge of the town of Wonder, with both f which features the scarp forming the ~~wxxk~~ west face of Twin Peaks to the outh is in alignment, suggesting that these three features are probably ll on the same fault.

On the uppermost slope of the Camel Back Peak-Driscoll Peak ridge a early north-south demarcation line of the topography extending a mile or ore along the foot of the steeper mountain slope and passing just above he Ruby shaft seems to represent a fault with upthrow on the east. Just est of the line streams of moderate grade and low divide steepen abruptly nd are entrenched in narrow gorges which are difficultly passable for a orse. Just northwest of Driscoll Peak the line is one of contact between darker rhyolite on the east and a lighter one on the west, and many rospects have been dug along it north of Driscoll Peak and along the est flank of ~~Camxxx~~ Camel Back Peak.

There seems to be more or less faulting all along the west front f the Augusta Range. One fault system trends a little west of north. ust east of the Nevada Wonder vein it includes the so-called Wonder fault which 30- to 50-foot wide in places contains tabular sheets of sliced or crushed rock kaolinized gouge and rhyolitic breccia up to 5 feet or more in width.

The rocks and veins are also cut by a post-mineral cross jointing which trends N. 70° W. and dips steeply to the north as shown in the Nevada Wonder mine.

Faulting or crustal disturbance has continued intermittently up to the present time, some having taken place in the mining life of the district, as follows: One night in December 1906, prospectors and mining engineers in the district, particularly at Hercules, and sheep herders in the surrounding region were startled by pronounced earthquake disturbance which produced among other fractures a north-southerly rift or fissure 3 miles or more in extent, (which for convenience of reference may be referred to as the Gold King-Ruby fault). The fissure lies just west of the middle of the district and as indicated on the map, fig. 7, and fig. 11, is known to extend from a point beyond the Gold King ground which it crosses on the north, southward across the Quartzite and Ruby ground to a point 1/4 mile southwest of Driscoll Peak. As seen by the writer in 1911 at several points the course of the fissure is marked by an open cleft or crack 3 to 5 feet wide, particularly in alluvium, which in places was still open to depths of about 5 feet at which points it had become infilled with earth and slide rock debris (on the hill sides) and alluvium (in low places).

In places the rift is compound, as shown in the lower loop of the Quartzite road, where it consists of a detached longitudinal fault block 3 to 4 feet wide contained between two open fractures.

The fault in the Gold King tunnel is thought to be a part of the fissure, from its alignment and that of a line of overlying excavations made by burrowing animals and other features extending to the south.

n interesting feature of the fault is the curvature of its course. The amelback Peak mountain mass lies in direct alignment with the northern art of the fault, which, however, as it approaches the mass curves gently estward thence southward along the west base of the mountain mass following pparently the line of least resistance. here

As there seems to be no report of this disturbance having been felt t Fallon or other surrounding settlements, it is inferred to have been comparatively local to the Wonder district and vicinity and with its epicentrum probably within the district. It was probably caused by a minor slipping and adjustment along an earlier fault.

At the time of the Pleasant Valley earthquake of October 2, 1915, which extended over all Nevada and westward to the Pacific Coast, campers sleeping on the ground at Wonder and at Westgate 10 miles to the south report that they experienced the feeling of having the ground "jerked" from under them by degrees, but so far as learned no rifts were opened in the Wonder district. In Pleasant Valley and vicinity, however, near the center of disturbance the quake was so severe that it toppled over chimneys and railway water tanks, opened up fissures 12 feet wide and produced fault scarps having a vertical displacement of 15 feet. It is described by Professor Jones 4/ of the University of Nevada.

4/ Jones, J. Claude, The Pleasant Valley, Nevada, earthquake of October 2, 1915: Seismological Society of America, Bull. 5, pp. 190-205.

The most of the rocks, though they include tuffs, breccias, etc., are believed to have been deposited as flows, but only in the few following localities were indications to this effect found.

n the northeast part of the district, as seen from the west in bright oon light, the uppermost slope of Queen Peak presents the appearance ng composed of alternately hard and soft flows dipping gently east- The more prominent or outstanding part of the flows form low ridges ongated ~~parallels~~ parallel knobs known as the black rock knobs of Jack Pot extending up to Queen Peak.

Also in the southwestern part of the map on the western slope of the Peak--Driscoll Peak Mountains the harder layers of successive lava outcrop as ledges like sedimentary beds, with a distinct tilt to the and northeast. The lower slope is made up of a pale-blue-weathering lite. About two-thirds of the way up the slope is a massive outcropping e of volcanic breccia showing the same tilt. Overlying this rock is nk porphyritic rhyolite. Two nearly vertical dikes of white rhyolite all of these beds, with approximately east-west trend.

Likewise in the southern part of the Driscoll range,-the part extend- beyond the limits of the map, fig. 7. The rocks, as their ~~xxxxx~~ exposed es of thin beds viewed from Chalk Mountain indicate, are seen to dip tly northeastward toward the Fallon-Wonder road. The upper portion the flows, several hundred feet in thickness, are dark brown while the erlying ones, constituting the major part of the section, are light own. Also, 3 miles to the east in the main part of the Augusta range e rocks have the same dip as noted later on p. 70 at the Wolverton ospect.

Thirdly: In the southeast part of the district from a westerly view h bright afternoon light, west Twin Peak presents an escarpment cliff ttered by nearly vertical jointing, the upper 500 feet of which appears be of a distinctly lighter yellow weathered color than the lower, which ows a darker reddish brown. The line of division is nearly horizontal the west face of the cliff, and may represent flows of which the untain is made up. Near the base of the steep slope prospects are pened in the bluish-white beds supposed to be the fresher rhyolite, ssibly consisting of dikes or even an underlying flow, which appears to younger than the Twin Peak rock.

From the foregoing observations and mine data the following provisional ge succession of the rocks arranged in their natural columnar order has een made out. They were deposited chiefly as ~~fxkx~~ flows and were subsequently sliced into several ~~or more~~ longitudinal zones or segments by north-south faults, and tilted toward the east.

Basalt ?

Andesite

Rhyolite (Extension rhyolite)

Rhyolite (Dickey Peak)

Dacite (Alpine dacite)

Rhyolite (Wonder rhyolite)

Wonder rhyolite.—The oldest rock in the district and by far the most abundant (of the Tertiary volcanic rocks) is the Wonder rhyolite, [illegible] is essentially nder mine. It extends nearly all the way acorss the middle of the map, g. 7, from east to west and from Crown Peak on the south to beyond the mits of the map on the north. In the east base of Wonder Mountain, and st of Wonder, its continuity is interrupted by a dacite dike half a le wide, beyond which, however, it extends eastward nearly to the top f the Augusta Range where intrusive andesite forms the crest. It has a aximum known thickness of more than 2,000 feet, to which depth it has een penetrated in the Nevada Wonder mine without any indication that the eepest workings may be nearing its lower limits. This thickness is not urprising in the light of the fact that to the north in the Augusta range, n the rhyolite formation of which the Wonder rhyolite is a southward continuation, the 40th Parallel Survey 5/ reports a thickness of 7,000 feet.

5/ 40th Parallel Survey, vol. I, p. 632.

It is the principal ore-bearing, and therefore the most important, formation in the district. It shows veins throught its extent, and the veins that carry values show the same general mineralogical characteristics, namely they contain gold and silver, but a little less gold than the Nevada Wonder vein whose production has been remarkable and constitutes almost the entire production of the district.

Microscopically the Wonder rhyolite is brownish drab or dull ash-gray, massive, medium grained or porphyritic with small whitish feldspars, vitreous quartzes, and dark biotite disseminated through the finer groundmass.

It commonly presents a tuffaceous or brecciated appearance due to angular fragments of black calcareous slate or shale, basalt, or granite, and lighter plutonic rocks it contains. These included fragments are mostly sharply angular, and they are as plentiful near the surface as in the bottom of the Nevada Wonder mine, more than 2,000 feet in depth. Throughout this depth the rock shows little or no change in formation or character. It has no definite structure or attitude that can be made out. The nearest granitic rock exposed is that at Chalk Mountain, 9 miles to the south.

Davie 6/ determined the Wonder rhyolite to contain, on the average,

6/ Davie, Robert G., Company engineer, Manuscript on geological data on the Nevada Wonder mine, July 10, 1916.

about 5% by volume of foreign volcanic, metamorphic, and plutonic rocks, slate being by far the most abundant inclusion. The included fragments in general may range up to an inch in diameter, and the black slate inclusions range up to 2 inches in diameter. They were doubtless derived from ~~xxx~~ some underlying slate formation through which the rhyolite was erupted. The nearest known outcrop of any such rock is 4 miles south of Wonder in the axis of the Augusta Range, and the rock is of Jurassic age. As it is known to have a wide occurrence in the Carson Sink region, it is probably deeply buried by the volcanics in the Wonder district and vicinity.

The rock here called Wonder rhyolite is a basic type of rhyolite and has been determined petrographically by Prof. E. S. Larsen, Jr., formerly the Survey's specialist in petrography, to be quartz latite, which stands near rhyolite but differs from rhyolite chiefly in containing more plagioclase, less silica, and with augite, hornblende, and biotite varying in lative amounts. However, as rhyolite is a good field name and with which s rock the mining public is familiar, and as the Wonder rhyolite is a rt of a complex of typical rhyolitic flows, and has been quite generally own by this name almost since the discovery of the Wonder district, the rm Wonder rhyolite is here retained, with the accompanying explanation the latite character of the rock as determined mineralogically by Larsen.

The rock was probably deposited as flows,but it is too devoid of tructure to afford any conclusive evidence on this point. The only indica-ions of flows are those of a topographic nature which were detected in a ew localities only under very favorable light, as described on page (1)-12. n the extensive workings of the Nevada Wonder mine which penetrated the ock to a depth of more than 2,000 feet no suggestion of flows could be etected.

The microscope shows the Wonder rhyolite to consist normally of a icrocrystalline to cryptocrystalline devitrified groundmass in which est phenocrysts and fragments of phenocrysts of quartz, orthoclase, lagioclase (andesine-oligoclase) and biotite, and accessory magnetite, patite and zircon. With decrease in quartz and increase of orthoclase, s occurs in places, the rock approaches trachyte.

The rock, however, is nearly everywhere considerably altered, the most common or secondary minerals being sericite, calcite and kaolin derived from the feldspars, limonite and ~~xxx~~ chlorite from the biotite, quartz, and epidote.

In a thin section from a specimen of the rock collected from the Nevada Wonder mine, main shaft, at a depth of 1,000 feet Davie 7/ by

7/ Op. cit.

Rosinwal's method determined the volume of minerals and groundmass to be as follows:

	Percent
Quartz	4.6
Orthoclase	10.9
Plagioclase	5.0
Biotite	2.0
Groundmass	77.5
	100.0

In some sections the volume of plagioclase is relatively higher.

The following chemical analyses have been kindly supplied by the Nevada Wonder Mining Co.

Chemical analyses of the Wonder rhyolite

By

Booth, Garrett, and Blair, Philadelphia, Pa.

	M-14	M-91	M-92
SiO_2	70.10	71.79	70.70
Al_2O_3	14.98	15.11	14.47
Fe_2O_3	1.68	1.06	1.14
FeO	0.33	1.71	1.51
MgO	0.70	0.67	0.45
CaO	1.46	0.43	1.65
Na_2O	2.64	1.66	2.80
K_2O	4.78	3.44	4.38
SO_3		0.65	

"M-14 is the same rock as described above, i.e. from the main shaft at 1,000 feet below the collar; "M-91" is taken from XC 13-29, which is about 40 feet from the vein in the hanging-wall just south of the sunshaft, and consequently considerably altered; "M-92" is taken from XC 13-1 near station 13-18, that is, in the cross-cut from the main shaft and distant about 200 feet from the vein in the hanging-wall."

The norm of the rock computed by Larsen from analysis M-14, and which is very near the actual mineral composition, is as follows:

Norm of Wonder rhyolite.

Quartz	32.10	
Orthoclase	28.36	
Albite	22.53	: ab 76 an 24 or oligoclase
Anorthite	7.23	:
Corundum	2.75	: not in mode. Probably partly due to TiO_2 included in Al_2O_3 of analyses P_2O_5, etc.
Magnetite	2.55	
Hypersthene	1.70	
	97.22	

The Wonder rhyolite is intruded by 4 or 5 lavas which, beginning with the oldest are as follows:

Alpine dacite	: Pre-vein or pre-mineralization
Extension rhyolite	:
Hidden Treasure rhyolite ?	:
Andesite	:
Basalt	

These intrusives are described in order in the following pages. All of them except the basalt are pre-vein or earlier than the mineralization of the district and some seem to be associated with its origin. The most important, both quantitatively and mineralogically, are the Alpine dacite and the Extension rhyolite.

Examples of the intrusives shown on the map, fig. 7, are the Alpine dacite, just east of Wonder Mountain and Wonder, the Extension rhyolite at Queen Peak and andesite and basalt dikes south of Wonder Mountain.

Alpine dacite.--The rock next younger than the Wonder rhyolite is a dacite, a rock standing very near to quartz latite or quartz-bearing andesite, which by the Nevada Wonder Mining Co. has been called Alpine dacite. It is in fresh specimen an iron-gray medium-grained porphyritic rock. It is darker and cleaner than the Wonder rhyolite, but like it contains fragments of black slate and other rocks, is more or less calcareous, and in places, corresponds ~~xxx~~ to a flow breccia. It contains phenocrysts of quartz, orthoclase (sanadine), oligoclase, (andesine), biotite, hornblende, hypersthene, and the accessories magnetite and apatite in a slightly greenish to brownish microcrystalline to glassy partly devitrified groundmass. The biotite and hornblende crystals mostly long are frequently bent or bowed to angles of 30 degrees or more.

In general, however, the rock has been considerably altered, the feldspar and hornblende being changed mostly to sericite which occurs in segregated bunches and in veinlets traversing both groundmass and phenocrysts, and the biotite to chlorite. There is also considerable calcite replacing feldspar. The rock is intrusive into the Wonder rhyolite, but it probably occurs also as a flow or flows. It contains no veins or ore deposits and is not genetically connected with the mineralization.

The following analyses of the dacite were kindly furnished by the evada Wonder Mining Co.

Partial chemical analyses of the Alpine dacite in the Nevada Wonder mine, Wonder district, Nevada.

By

Booth, Garrett, and Blair.

	M-76	S-75
SiO_2	62.050	61.03
Al_2O_3	17.905	18.00
Fe_2O_3	1.085	3.32
FeO	2.734	1.71
CaO	3.160	3.30
MgO	0.911	1.00
Na_2O	2.390	3.39
K_2O	4.380	4.33

"M-76 is from the 700 station of the Extension shaft and is somewhat ltered; S-75 is from the surface about 300 west of the vein and is fresh."

The best known exposure of the Alpine dacite is just east of Wonder Mountain and the Nevada Wonder mine, where it occurs in a belt about 1/2 mile wide in the Wonder rhyolite and underlies the Nevada Wonder camp whence with increasing width of the belt it extends southward about 2 miles to the edge of the map, beyond ~~xhxhx~~ which it continues on southeastward up into the mountains.

It occurs in the Nevada Wonder mine extending approximately from the 300-foot to below the 800-foot level. It is present in the lower part of the middle excavation and at the fault zone at the portal of the Last Chance tunnel. On the surface it is exposed as far north as the Hidden Treasure shaft and as far south as the Extension shaft. West of Hercules Canyon it occupies an area about 3/4 of a mile in diameter, including Porphyry peak and Camelback peak which culminate in this rock. ~~Nxkhxx~~ Northeast of Hercules it forms the middle part of the west ridge of Queen Peak.

Dickey Peak rhyolite.--What seems to be the next younger rock in the District than the Alpine dacite is rhyolite. It is mostly gray or dark gray but ranges to reddish brown and includes various phases, as flows, tuffs, and breccias. It is mostly medium- to fine-grained and is profusely porphyritic with many small phenocrysts of glassy quartz and whitish orthoclase in a felsitic to glassy base often with flow structure. A little magnesite and biotite are generally present and, in places, secondary sericite and leucoxene. In places, the quartz phenocrysts are pale-reddish or wine-colored.

The rock occurs chiefly in the northwest part of the district where in the Dickey Peak field it occupies an afea of nearly 3 square miles which contains the Spider and Wasp, Dickey, Wonder and many other so-called mines. It is thought to be older than the Extension rhyolite next described because it is cut by whitish dikes referred to that rock. Its areas shown on the map probably include exposures of that rock.

Extension rhyolite.--The next younger rock in the district is a rhyolite which has been called the Extension rhyolite by the Nevada Wonder Mining Co. It is a whitish siliceous porphyritic rock apparently more siliceous than the Wonder rhyolite. It consists mainly of many small phenocrysts of quartz and sanadine in a felsitic groundmass. In places it is porous or pumiceous,and it contains fragmentary inclusions of granitic, volcanic and sedimentary rocks. It outcrops southeast of Wonder Mountain near the office building of the Nevada Wonder mine; the Extension shaft is sunk in what seems to be an intrusive volcanic neck of it, and it occurs in the hanging wall in the workings near the shaft. It is thought to be genetically connected with the mineralization of the district. It occurs chiefly as a flow,but it is also intrusive. It intrudes both the Wonder rhyolite and the Alpine dacite, and in the western part of the district it is conspicuous as a dike rock. It occurs also with a more siliceous phase in the Hidden Treasure mine, where the Company at one time regarded it as a different rock and called it the Hidden Treasure rhyolite. It is also present at Queen Peak and vicinity and in the western part of the district is occupies a couple of areas each a half mile or more in extent south of the Dickey Peak area.

In the Nevada Wonder mine, on the 450-foot level at about 100 feet rth of the sub-shaft and near the vein, the Wonder rhyolite is cut by 2-foot dike of dense drab felsitic rock which may be a phase of this yolite.

Andesite.--The rock next younger than the Extension rhyolite is desite. It is medium-grained porphyritic bluish ash-gray when fresh d weathers reddish or ~~pkxx~~ pale lavender. It is a quartz-bearing biotite rnblende andesite standing near dacite. The conspicuous phenocrysts e black biotite, generally in elongated foils less than 1/10 of an inch length, and andesine.

Microscopically the rock is seen to consist mainly of a pale greenish icrocrystalline felsophyric and vitrophyric flow structure groundmass of eldspar and ferro-magnesian minerals in which rest scatteringly small henocrysts of andesine, biotite and sparingly sanadine, hornblende and uartz. There is also present a little magnetite. The hornblende occurs n short prismatic forms. Much of the quartz is spherulitic. Some of the feldspar is altered to sericite, and some is replaced by secondary quartz, and some of the biotite is changed to chlorite. In places, particularly in some dikes as at Victor and to the northwest of there, the rock is fine grained, nearly aphanitic with the biotite and hornblende phenocrysts restricted to slender needle-like almost microscopic forms.

The principal exposures of the rock are in the northwest part of the district where it underlies the townsite of Victor whence forming a belt 1/3 of a mile wide it extends southeastward for more than a mile on either de of the Victor Gulch and road. Northwest of Victor a dike of it trudes the country rock rhyolite. A 6-foot dike of it cuts the Wonder yolite on the southwest slope of Wonder Mountain. The rock is present t the June Wonder mine, 1 mile northwest of Wonder. Also on the Little iant ground and vicinity a mile south of Victor it, as a dike, cuts oth the Wonder rhyolite and the White or Extension rhyolite, which latter t seems also to underlie as an intrusive sheet or sill. The andesite is ot known to be genetically connected with mineralization.

Basalt.--The youngest of the volcanic rocks is basalt, a massive lackish dense rock resembling trap. It is composed mainly of a mass f basic plagioclase principally forming a micro-crystalline trachytic artially devitrified groundmass containing considerable interstitial ugite, olivine, and magnetite. The olivine is mostly altered to greenish alcium carbonate, serpentine and iron oxide. There is also present considerable secondary feldspar, principally orthoclase; and chlorite and green hornblende or uralite derived from the augite.

The rock occurs mainly in the northwest corner of the district about 3/4 of a mile northwest of Victor where it outcrops in two areas each a half mile or more in diameter and similarly in two much smaller areas in the southwest corner of the district. It forms relatively conspicuous hills, and its weathered croppings culminate in knob-like forms.

In the outcrops afore cited its relations to any other rock in the district are not exposed excepting with the alluvium deposits through which it protrudes, nor was it seen to be in any way associated with the mineralization of the district. In these western occurrences the rock may represent remnants of a flow or flows. In the south base of Wonder Mountain, however, it occurs as a dike cutting the Wonder rhyolite and also in the Nevada Wonder mine, from the surface down to the 1300-foot level, it occurs as a 3- to 10-foot dike branching in part and cuts directly the vein as well as the wall rocks, showing it to be intrusive and post-mineralization in age.

Summary of geologic history

The geologic history of the principal events recorded in the district may be regarded as beginning with the eruption of the Wonder rhyolite and its deposition in a series of heavy flows more than 2,000 feet in thickness on an eroded surface of Jurassic ? sedimentary rocks consisting principally of dark slate, shale, and limestone. This event was followed by the eruption and intrusion of the Alpine dacite, which, in turn, after a period of erosion during which probably much of the dacite was removed, was followed by eruption of the Dickey Peak rhyolite. This in turn was succeeded by the eruption and intrusion of the Extension rhyolite. The next event was eruption and intrusion of the Victor andesite and its deposition unconformably on the older rocks which, in turn, was followed by that of the basalt. Thus the general trend in composition of the eruptive products of volcanism from first to last has been toward more and more basic.

During eruption of the volcanic rocks, their finer ejecta, for a time suspended in the atmosphere, were deposited as Tertiary lake beds in the vicinity on the northwest.

Faulting and fracturing due in part to contraction of the lavas in oling attended or followed the principal eruptions, as did also minerali- ation, the latter especially following the eruption of the Wonder rhyolite nd the Extension rhyolite.

Though faulting has continued intermittently down to the present time, ilting of the volcanic rocks toward the east probably took place for the ost part following the maximum eruptions and was aided by local sinking r settling down of the superincumbent mountain mass on the east into the uge hollow reservoir or cavern from which the lavas had been erupted. elatively recent faulting or uplift is evidenced by abundant gouge and lickensiding associated with the veins and tilting of the Lake beds at igh angles. The northwestward dip of the Lake beds in opposite direction rom that of the volcanic rocks suggests, on the one hand, the possibility f a northeast-southwest anticline trending approximately through the orthwest margin of the district which also may have shared in tilting the olcanics on its east limb toward the east; and, on the other hand, hat tilt of the Lake beds may represent the drag of a fault marking a eneral uplift of the range along its western front, as in the case of he Sonoma Range at the time of the Pleasant Valley earthquake.[8/]

8/ Op. cit.

The Gold King fault passing just west of Geiger Gap, fig. 7, is traceable for more than 3 miles and was apparently caused by the midwinter earthquake of 1906-07.

Mineral deposits

General characteristics

The mineral deposits of the Wonder district consist mainly of 50 or more siliceous silver-gold ore-bearing tabular veins and lodes contained in fissures and shear zones in the crushed Tertiary volcanic rocks mostly in the Wonder rhyolite. They are largely replacement deposits after an earlier mineralization. The general distribution of the veins is shown in fig. 11. Some of them, with slight interruptions, have an extent of 2 or 3 miles. The most of them outcrop at the surface and some are locally marked by prominent croppings, as shown in figs. 12 and 13. The prominence of some of the croppings associated with the veins, however, is due more to silicification of the inclosing wall rock than the vein itself.

The veins range from less than a foot up to 40 feet or more in width, and they are usually separated from the wall rock by a tabular sheet of gouge from less than an inch to several feet in width. Locally the gouge is well banded and mineralized and constitutes good ore some of which, ~~xxx~~ in the Nevada Wonder mine, ran up to $60 to the ton.

Some of the veins probably extend to considerable depth, judging from the Nevada Wonder vein which has been worked to the depth of more than 2,000 feet, the Jack Pot vein to 1,000 feet, and others to depths of more than several hundred feet.

However, as practically all the veins have been truncated by long periods of erosion, and some of them occupy shallow fissures or shrinkage cracks formed by contraction of the heated lavas in cooling, many of them probably have only moderate depth and represent only the roots of their former selves that once extended far above the present surface. This, however, is not so great a drawback as would at first appear in the light of the fact that although considerable deep mining has been done, nearly all the production of the district has come from depths of less than 700 feet.

Unfortunately, the Nevada Wonder vein is the only one of the deposits that has produced sufficient ore to be profitably mined.

The deposits are genetically connected with the volcanic rocks and are accordingly referred to the Tertiary age. They, in general, are similar to deposits of this class and age found elsewhere in Nevada and neighboring states in the Tertiary volcanics, as in the Jarbridge district, Nevada, and the Oatman district, Arizona.

The vein filling in general is soft and is crushed by faulting and pressure, with the result that it is easily mined and milled.

The principal gangue mineral is quartz, with which there is frequently associated considerable adularia or vein orthoclase, white potash feldspar, and more or less brecciated and crushed wall-rock material. Occasionally there is also present minor quantities of reddish fluorite, and in the oxidized zone there is also present the ~~xxxx~~ usual feldspar and rock alteration products, including much soft clay-like material, kaolin, sericite, limonite, and in places, a little psilomelane or manganese. In places the veins are ~~fxxxx~~ fairly well banded. Locally the quartz adularia gangue is pseudomorphic after an earlier spar mineral, calcite or barite, and presents especially in the weathered state the pitted or re-entrant angle laminated and bladed structures so characteristic in many of the western Tertiary gold veins. This pseudomorphic feature, however, is not so common as in many other districts.

Some of these minerals and ore structures are well shown in figs. 14, 15, 16, 17, and 18 (specs. 21, 112A, 50, 40, and 88, respectively).

The deposits are deeply oxidized. In the Nevada Wonder mine oxidation extends quite uniformly to the depth of 1300 feet, which level seems to mark a somewhat persistent ancient groundwater table at that depth.

The oxidized deposits ordinarily white are, in part, stained yellowish brown with limonite. The deposits constitute a clean silver-gold ore very favorable for mining and milling. The valuable metals of the deposits, silver and gold, occur chiefly in the quartz-adularia gangue of the veins including their contained rock material and as replacements in the wall rock and gouge. The values occur mostly in the hanging-wall side of the vein. The silver occurs chiefly as argentite, cerargyrite, and as halogen salts. 9/

9/ Burgess, J. A., Halogen salts of silver at Wonder, Nevada: Econ. Geol., Vol. 12, No. 7, pp. 589-593, Oct.-Nov., 1917.

The gold occurs both free or native and in combination with the argentite. From the standpoint of value the two metals occur in about equal amount with the gold being slightly in the lead, and from the standpoint of volume in the ratio of about 1:5 to 8.

The following minerals have been found in the district, mostly in the Nevada Wonder mine as described under that heading.

Minerals

Adularia

Apatite

Argentite

Azurite

Bromides (very common in Nevada Wonder mine)

Bromyrite

Cacoxenite

Calcite

Cerargyrite

Chalcedony ?

Chalcopyrite (especially in June Wonder mine)

Chlorides

Embolite

Fluorite (In ore part of vein)

Galena

Gold

Gypsum (As incrustations in water courses in Nevada Wonder mine)

Hematite

Hyalite

Iodides

Iodo-bromite ?

Iodyrite

Jarosite

Jasper

Kaolinite

Limonite

manganese oxides

Manganese oxides

Malachite malachite

Manganite manganite

Molybdenite Molybdenite

Polybasite ? Polybasite

Psilomelane Psilomelane

Pyrargyrite

Pyrite

Pyrolusite

Quartz

Siderite

Silver

Sphalerite (Nevada Wonder mine)

Stephanite

Wavellite (In Nevada Wonder mine)

Wulfenite (Nevada Wonder mine)

Zircon

Fluorite is plentiful in the ~~xxxxxx~~ quartz veins on the Cyclone group of claims in the northern part of the district.

Source of the mineral deposits

The source of the mineral deposits is complicated. It is referred to the volcanic rocks, and to heated mineral-bearing solutions that emanated from the rock magmas and circulated through the fissures, shear zones and fractures in the rocks following their eruptions. The deposits are therefore regarded as of Tertiary age, late Miocene, or Pliocene.

There were at least two periods of hypogene mineralization, one probably following the eruption of the Wonder rhyolite and the other that of the Extension rhyolite. Judging from the great quantity of the Wonder rhyolite and its eruption apparently all at one time or nearly so it seems reasonable to infer that its magma supplied large quantities of hot mineral-bearing solutions and conditions favorable for their circulation in the aftermath of eruption through the fractures, shear zones, and fissures in the slowly cooling or but recently cooled rock mass, as in the old rhyolite at Jarbidge[10] and other camps, and that considerable

10/ U.S.G.S. Bull. 741, p. 34.

mineralization took place which later was changed or replaced by solutions that followed the eruption of later rocks and ushered in a new period of mineralization. Thus the structure of the present siliceous gangue pseudomorphic after calcite or other spar points to an earlier period of mineralization than that which produced the present ores, a mineralization in which the principal gangue minerals were probably calcite and quartz.

The solutions of the second or later mineralization, following chiefly the eruption of the Extension rhyolite, were much more siliceous than those of the first period and inherently more suitable for the transportation and deposition of metallic constituents both by precipitation and replacement. Burgess, 11/ who also believes that there were several periods of mineralization, thinks that the earliest vein filling was a barren quartz and that the second filling which succeeded and partially replaced it was a light-gray chalcedonic quartz which may have brought with it a small quantity of silver.

11/ Burgess, J. A., Unpublished manuscript and oral communication.

The principal primary constituents of this later mineralization are:

Gangue minerals

- Quartz
- Adularia

Ore minerals

- Argentite
- Gold

Associated metallic minerals

- Pyrite
- Chalcopyrite
- Galena
- Sphalerite

-dary minerals

Ore minerals

Cerargyrite

Iodobromite

Iodyrite

Embolite

Bromyrite

Gold

Silver

Argentite

Polybasite ?

Stephanite ?

Pyrargyrite

Associated metallic minerals

Siderite

Hematite

Limonite

Cacoxene

Jarosite

Malachite

Azurite

Manganese oxides

Molybdenite

Wulfenite

Gangue or associated nonmetallic minerals

Calcite

Quartz

Adularia

Hyalite

Gypsum

Kaolinite

As the minerals have been studied chiefly in the Nevada Wonder ine, some are described more fully under that head.

), ed

From the character of the deposits which are herein described and have been worked in the Nevada Wonder mine, it is concluded that the ores now mined in the district in the oxidized zone, though primarily of hypogene origin, owe their present economic value to secondary supergene or downward enrichment.

Before oxidation the present productive zone extending from the surface down to the 1,300-foot level in all probability contained only lean sulphide ore similar to that found in the deep part of the mine which is much too low grade to be profitably mined. However, during long periods of oxidation and weathering as the overlying rocks and veins rising hundreds of feet above the present surface were truncated by disintegration and erosion their sulphide mineral contents also became oxidized and broken down, and through the agency of gravity and descending percolating atmospheric waters were leached, filtered and carried downward to successively lower and lower levels where they were redeposited and formed the deposits now mined.

In this process of enrichment the oxidation or breaking down of argentite, the principal primary ore mineral, yielded the important secondary minerals cerargyrite, free gold, silver, electrum, and pyrargyrite, and the silver constituents for the silver halloid salts. The alkaline salts of chlorine, bromine and iodine contained in the percolating waters and regarded as of extraneous origin are believed by Burgess 12/ to have been supplied by the agency of wind from neighboring salt marshes or playas where such salts have been found.

12/ Burgess, J. A., Op. cit.

Gouge-clay

Tests made of several specimens of the whitish gouge or selvage which is more or less prevalent in tabular or sheet form between the veins and wall rock, and which is frequently erroneously called kaolin and talc by the miners, show it to consist largely of a white micaceous hydrous silicate of aluminum, corresponding in large part to what has been described as beidellite, 13/ "leverrierite", and in part to montmarillonite. It is

13/ Larsen, E. S. and Wherry, Edgar T., Beidellite, a new mineral: Jour. Wash. Academy of Sciences, Vol. 15, No. 21, pp. 465-466, Dec. 19, 1925.

closely related to kaolin in the ratio and combination of its constituents, but it contains more silica, less aluminum and less water than kaolin and retains only 7 per cent of its water at 110°, whereas kaolin retains nearly all of its 14 per cent of water up to 400°.

Pending more definite investigation being made by the chemists of the relations of these minerals, and because the material varies in composition in different fissures and from place to place in the same fissure the material in this paper is called gouge-clay. In places it apparently contains also considerable haloysite, and locally it is pink or reddish and resembles alunite.

Mines and prospects

Under this heading belong more than 200 so-called mines and prospects, of which only a few as types can here by described. Their distribution is indicated on the claim map, fig. 10, on the vein map, fig. 11, and the location of the more important ones is shown on the geologic map, fig. 7.

Though a score or more of the properties present good showings and have been opened to depths of several hundred feet, or have had this equivalent of development work done on them and several have produced some ore, the Nevada Wonder mine is the only one that could be profitably worked.

Nevada Wonder mine

Location and topography.—The Nevada Wonder mine is in the eastern part of the district, 1/2 mile north of the Wonder townsite and about the same distance west of the foot of the steep mountain slope on the east, fig. 19. It is mainly in the upper east slope of Wonder Mountain, a prominent round hill standing about 400 feet above the surrounding surface. It is ~~xxxx~~ easy of access from the east, while in the remaining directions the topography is rough, especially on the west where the surface rapidly declines 800 feet into Hercules Canyon.

History and production.—The deposits were discovered in the pioneer days of the district in 1906 by William Mays and/associates ~~xxxxxxxxxx~~, and in September of that year the ground consisting originally of 7 and a fraction claims, fig. 20, was acquired by J. B. Daniels and others who jointly formed the Nevada Wonder Mining Co. with headquarters in Philadelphia, which became the nucleus, life, and longevity of the district.

Development was begun immediately on acquisition of the property but was arrested by the financial stringency in 1907 and not resumed until April 1911. The mill was completed by July 1 of that year since whence, excepting slight interruptions due to inclement winter weather, both mine and mill were operated continuously until the property became worked out and was closed down for good December 1, 1919. About $2,000,000 worth of ore was blocked out before the mill was built.

The total production of the mine during this period was approximately

Production of the Nevada Wonder mine

Year	Tons of dry ore	Value	Percent of value recovered
		$	
1911	3,444	64,183	92.60
1912	25,186	412,458	94.50
1913	39,118	572,359	93.20
1914	48,570	753,993	93.20
1915	58,124	812,118	94.11
1916	72,241 1/	1,112,835	92.67
1917	55,800	923,606	89.10
1918	49,710	742,306	91.82
1919	40,570	629,131	93.99
Total	392,763	6,022,989	
Average		15.60	92.80

1/ Oct. 1, 1915, to Dec. 31, 1916.

The average tenor of the ore was $15.60 to the ton, and the percent of value recovered 92.8. Some of the ore was very rich. During most of the first half of the period of operation the mill run of the ore assayed about 18 oz. silver and 0.25 oz. gold to the ton.

During the six years May 1913 to May 1919, the company paid $1,549,005.45 dividends. 14/

14/ Thirteenth Ann. Rept. Nevada Wonder Mining Co.

The first dividend paid May 20, 1913, being 10% on the outstanding capital stock of $1,500,000.

In 1914 the company completed acquisition of properties formerly belonging to the Wonder Extension Mining Co., the Hidden Treasure Mining Corporation, and the Reorganized North Star Mining Co. of Wonder, in all about 15 claims, the first-named adjoining the Nevada Wonder property and lying on the southerly extension of its vein system, and the last two lying similarly on the northerly extension of its vein system, fig. 20.

By further purchase the property in 1915 was enlarged to 401 acres of ground of which 328 acres were patented. Still later considerable additional ground was acquired.

Development.--During its period of operation the mine was developed to the depth of more than 2,000 feet and horizontally to the extent of 3,400 feet as shown in the level map, fig. 21 and the longitudinal stope plan, fig. 22. It was also developed laterally for a distance of 1,555 feet. The development work totals more than 66,000 feet or nearly 12.3 miles. The amount of development work done is large compared to the production of the mine. This, however, is due in part to thorough search made for ore in depth, and more especially to the sound policy pursued by the management of maintaining sufficient blocked out ore in reserve to enable both mine and mill to be operated at a profit to the date on which the property was closed down for good.

The development done in search of ore preceding the final closing of the mine includes besides what is shown on the lower part of fig. 22, drifts on the ends of the ore bearing zone and short cross cuts run in many places; also 400 feet of raising and two long prospect cross cuts on the 700-foot level. One of these cross cuts extended westward under Wonder Mountain into the footwall country for the distance of 1,000 feet, and the other passing through the Extension shaft was run 555 feet in the hanging wall. The two crosscuts together therefore cut the formation for 1,555 feet at right angles to the strike of the veins.

The largest yearly development was 11,416 feet in 1917 and the next largest nearly 11,000 feet in 1914. The development was nearly all done through the Nevada Wonder or main shaft which stands at an elevation of about 6,100 feet, fig. 22-A. Extension shaft stands at an altitude of about 5,850 ft.

Equipment.--The principal equipment of the company at the mine during its period of operation, all of which was up-to-date, was the mill, machine shops, warehouses, offices, officials' dwellings, electric power and light transformers, distributing lines and other equipment, water supply and water rights including a 10-mile 4-inch pipe line from Horse Creek and a 125 horse-power double drum electric hoist, and ice plant, storage tanks for oil and water, a 3-size compartment mine shaft down to the 1,342-foot level, double deck hoisting cages, air compressor having a capacity of 1,200 cubic feet per minute, ore ~~xxxx~~ bins, and an Ingersoll-Rand No. 5 drill sharpener, refining and melting furnaces, most of which are shown in (the photographs) figs. 19 and 5. The power used in both mine and mill was electric, the electricity being supplied by the Pacific Power Co. as noted on page (1)-5, at the rate of $7.50 per horse power per month which was ery cheap compared with the cost of $20 per h.p. per month when derived from gasoline distillate for hoisting and other purposes.

During cold weather the mill was heated by oil-burning furnaces. No difficulty was experienced in cold weather with the water pipe line ntil the temperature fell below 10° F., when it had to be watched to prevent freezing and insure the maintenance of adequate service. 15/

15/ Burgess, J. A., The Nevada Wonder pipeline; Mining and Scientific Press, March 25, 1916, pp. 435-438.

During the greater part of its period of operation the Company mployed a force of 150 men, most of whom worked underground. The wage for miners and machine men was $4.50 a day, hoist men and timber men $5 a day, and muckers and surface labor $4. The miners regarded the camp as the best-moneyed camp in the State. The employees were all Americans, or of the white races. There was always a good payroll and liberal circulation of money, and the labor was on the cash-bonus basis, whereby any mployee who had been continuously working for the Company for a year received, in addition to his regular pay, such proportion of the total bonus as his yearly wage was of the whole bonus wage, the total bonus being 5% of the Company's dividends.

<u>Ore deposits</u>.--The ore deposits were contained chiefly in the veins of a vein system which has been called the Nevada Wonder vein system by the Company. The system, consisting locally of 1 to 4 parallel veins, has a lineal extent of more than 1-1/4 miles through the property. On the north it extends down Hercules Valley to the lower end of Hercules townsi
ere it probably crosses the canyon and ascends the hill on the we
it on the Missouri ground where heavy vein croppings occur. On t

the veins are separate, but on the southern part of the property unite and form a single vein. The veins are usually much crushed or en by minor faulting.

The vein system lies almost entirely in the Wonder rhyolite, which, escribed on page (1)-13 is the dominant and most widely distributed rock tion in the district. It strikes N. 25° W. approximately and dips 75° d the east, the hade being quite uniformly 35 feet per level or each eet in vertical descent. It lies about 40 feet to the west or foot-wall of a pronounced mineralized fault or shear zone, the Wonder fault with it is more or less closely associated, in consequence of which the idual veins or branches are in general closely spaced, as indicated g. 20. The fault is usually marked by a tabular sheet of gouge-clay aolinized rhyolitic breccia from 4 to 5 feet in thickness.

The veins are known as the Nevada Wonder, Badger, Extension, Hidden ure, and North Star veins, the Extension vein being merely the erly underground continuation of the principal deposits to the south e original Nevada Wonder property and the HiddenTreasure and North veins respectively to the north of the same.

The veins vary from less than a foot to 40 feet in width. They st principally of quartz with more or less adularia, broken, crushed, ltered wall-rock material and clay-like products resulting from the ization and other alteration of feldspar. The most of the vein al is dimly and imperfectly but fairly persistently banded or streaked which, in places, is seen to be due to thinly sliced rhyolite having been partially replaced and silicified by quartz solutions that filtered through and finally filled the interjoint and cleavage planes with quartz. Locally the quartz-adularia gangue is pseudomorphic after an earlier spar mineral found to be calcite, figs. 14-16.

The deposits are deeply oxidized. In the Nevada Wonder mine oxidation extends uniformly to the depth of 1,300 feet and seems to ~~mmkx~~ mark a somewhat persistent ancient ground-water table at that depth.

The mine for the most part is dry. Its deepest workings did not reach the present ground-water table of the region whose depth is unknown. On the 800-foot level north there was dampness, but no water. On the ~~100~~ 1000-foot level south in the hanging-wall of the Extension ore shoot a small quantity of water was found impounded in a local reservoir, yielding for a while about a bucket of water daily. On the 1300-foot level north only there was slight seepage. The first water that required bailing was found on the 1750-foot level, from which point on down a little bailing was necessary. The water was distinctly alkaline and was not injurious to the iron piping. No excessive heat was found in the mine, the highest temperature reported in the deep workings being 86°.

A few of the veins were mined to depths exceeding 2,000 feet, but the principal ore production came from depths of less than 1,300 feet which is approximately the lower limit of oxidation, see stope map, fig. 1, though considerable good ore was found in the sulphide zone. In the sulphide zone the veins became leaner with depth, carried less quartz and more barren or nearly barren pyrite. The principal producers were the Nevada Wonder, the Badger, and the White veins.

Nevada Wonder vein.--The Nevada Wonder, or main vein, is the most easterly or hanging-wall member of the vein systems. It is accordingly the nearest to the Wonder fault, from which it is about 40 feet distant, which fact probably accounts for its containing larger and richer ore deposits than any of the other veins.

It has an extent of 5,000 feet or more, but the principal productive part had an extent of only about 1,800 feet, the extent being about 900 feet each to the north and to the south of the Nevada Wonder or main shaft through which most of the vein was worked, fig. 22. Accordingly, it is to this part of the vein that the following description is mostly directed. With this latter extent the croppings of the vein which led to the discovery of the mine, interruptedly approximately coincided. They occurred chiefly at three points, namely on the top of the hill, under the engine house, and at an intermediate point. They were from 14 to 60 feet wide in places over the top of the hill, but were not bold or prominent compared with some of the other big veins or ledges in the district. They consist of a more or less continuous reef of brownish iron-stained quartz and silicified rhyolite in part brecciated and contained good ore interruptedly through the distance of 1,500 feet.

The vein dips steeply 75° to 80° to the east and lies in the Wonder rhyolite except that toward the south in the vicinity of the Extension ore shoot the hanging-wall was Alpine dacite which in depth extends from the vicinity of the 400-foot level to below the 800-foot level. On the surface the dacite is exposed as far north as the Hidden Treasure shaft and as far south as the Extension shaft. The vein is commonly spearated from the wall rock by a sheet of gouge from less than an inch to several feet in width.

Locally the hangingwall for considerable distances is fairly uniform, smooth and well defined, and shows well-marked joint planes and slickenslides, but generally these conditions soon give way to mineralized ore-bearing material or merge into crushed rock material in the country rock wall.

The fore part of the tunnel in the upper northeast slope of the hill exposes a width of 90 feet of kaolinized wall rock, rhyolite, and fault gouge containing considerable slickensiding. The rock alteration is due probably very largely to hydrothermal action.

On the Extension part of the vein where dacite forms the hanging wall, in proximity to the vein the dacite was much decomposed and formed a very heavy gouge, so that in mining it was necessary to keep the stopes filled with waste up to the working positions.

Break or rupture in the rocks along the location of the ~~veins~~ vein is also indicated by the southeast slope of Wonder Hill or its spur a short distance east of the fissure, the rock being relatively little oxidized at the surface, showing that it cannot have been eroded and exposed for a long period.

The principal or northern part of the vein, the part worked through the main shaft, may be referred to as the Wonder or main ore shoot. The southern part, the part worked through the Extension shaft, is well known as the Extension ore shoot. It does not outcrop at the surface but was first found on the 500-foot level in 1914. It extended from the 250-foot level to below the 1400-foot level and horizontally about 700 feet, and through most of this extent it was about 14 feet in width, nearly all of which was good grade milling ore. The ore is of the same general character as that of the main ore shoot.

Besides the Nevada Wonder vein the mine contains three other small veins or spurs known as the Badger vein, White vein No. 1 and White vein No. 2, the two latter being named from their containing a much larger quantity of white quartz than the other veins, the better values being in or associated with the whiter part of the quartz.

The Badger vein for the most part parallels the Nevada Wonder vein from which in the latitude of the main shaft it lies about 40 feet to the west or footwall side, fig. 20. At about 500 feet to the south of the shaft it joins the main vein in depth. Its junction with the main vein, however, is indefinite, there being much quartz and siliceous material at this point in both the vein and the wall rock.

The White vein No. 1 and White vein No. 2 are blind spurs of the Extension ore shoot which they join from the east or hanging wall side north of the latitude of the Extension shaft mostly between the 1000- and 1400-foot levels. They were first found on the 1300-foot level. Their known extent horizontally is shown on fig. 22.

The White vein No. 1 joins the main vein or Extension ore shoot on the south on the ~~100~~ 1000-foot level and vicinity by roll on top and also by dip in depth, the dip being slightly steeper than that of the main vein. Nothing further is known of its upper edge. It probably wedges out perhaps along a fault.

On the 1300-foot level it joins the main vein with a more or less pronounced interfingering, and at the junction occurred a marked increase in the amount of ore in the main vein, but there was not much increase on the 1450-foot level or the lower levels. Though the vein is regarded as all primary sulphide below the 1250-foot level there are two oxidized streaks traversing it diagonally.

The following notes on the various levels will help to convey an idea of the distribution and character of the ore. In general, the ore was mostly in the hanging wall side of the veins, and the best ore was found between the 500- and 700-foot levels, which probably indicates an ancient water table at this horizon.

Beginning with the main ore shoot, that was worked through the main shaft, the grade of the ore was fairly well maintained in the oxidized zone from the surface down nearly to the 1300-foot level where the oxidized ore was succeeded by primary sulphide ore, some of which was mined to below the 2000-foot level.

From the surface down to the depth of 600 feet the workable or milling portion of the vein ranged from 4 to 10 feet in width and averaged about feet, and much of the ore ran about $27 to the ton.16/

16/ Mining and Engineering World, No. 9, Vol. XL, Feb. 28, 1914, 432.

The ore in the Badger vein did not carry quite as good values as that of the Wonder vein. It occurred mostly to the south of the main shaft. On the 70-foot level and just below it in the reentrant angle formed by the junction of the Badger with the main vein, a large body of ore r more feet wide and high by 80 or more feet long was found. Much of ore body was in or favored the Badger vein, but it and the Badger ~~Badger~~ vein ably were formed by solutions that in course of ascension crossed onally over from the Wonder vein fissure. The Badger vein, however, ends also more than 100 feet to the north of the shaft where, though of importance, on the 200-foot level, it contained ore part of the way.

On the 500-foot level the main ore shoot was productive for the distance 700 feet north of the shaft, and at one place it was 15 feet wide. On same level to the south, however, the vein was not solid but was composed various stringers.

On the 600-foot level south the vein was 6 feet or more wide, was ciated, banded and well spotted with mineral and gouge on the hanging l. On the north it continued good for about 600 feet, beyond which nt or limit of the old workings and the Hidden Treasure shaft through istance of about 900 feet but little commercial ore was found.

On the 700-foot level the vein was 12 feet wide and contained good , but this width included in places 2-1/2 feet of gouge-clay which to north merged into the hanging wall. Some of the gouge carried ore t ran as high as $60 to the ton, notably in stope 7-5.

In the 1000-foot drift south on the 7th level, driven in part for a k passage to the Extension ore shoot and mostly in the hanging wall side the vein, stope-ore was found at two places, and the post-vein basalt ke was intersected. Opposite the shaft and to the south occurs fresh oking rhyolite which is thought to be intrusive.

Samples of the 4-foot ore shoot on the 800-foot level south assayed out $56 to the ton.

On the 900-foot level the portion of the vein stoped was about 6 feet wide. The best ore seen by the writer in the drift to the north was 2 feet of brownish-grayish siliceous ore in the foot-wall side of the vein. It was too crushed and friable to yield a good hand specimen.

On the 1000-foot level the development was mainly to the south of the main shaft. The ore continued on down here from the 700 level. A considerable portion of the ore shoot averaged nearly $100 to the ton, and much of the ore ran about $12 to the ton. The workings when seen by the writer in 1916 showed several feet of relatively high-grade ore.

The oxidized ore on the 1200-foot level and down nearly to the 1300-foot level continued good and of about the same grade as on the upper levels.

At a short distance above the 1300-foot level the oxidized ore gave way to primary sulphide ore, of which a 4-foot wide shoot extending to 45 feet below this level averaged about $35 to the ton in the winze stope 14-2. A polished section of a rich specimen of this ore (632) was found to contain pyrite, chalcopyrite, sphalerite, galena, argentite, and much wire silver. Argentite is closely associated with galena, usually forming intergrowths with it. There is no evidence that it is supergene. Northward, ore was found on this (1300) level at three points at about 400, 600, and 1000 feet from the winze, as indicated respectively by stopes and raises. The ore included some banded quartz. The occurrence at the 1000-foot point was oxidized ore and ran high in gold. The oxidation here is due to decrease in depth by reason of the northward decline of the overlying surface. Here on the 1300-foot level and on the 1450- and 1600-foot levels seepage water followed the ore-bearing quartz, especially in the sulphide zone.

Between the 1300- and 1600-foot levels but little ore was found. It was mostly sulphide and mostly contained galena and chalcopyrite.

Other than very sporadic assays, but little ore was found on the 1600-foot level. Between the latitudes of the main and Extension ore shoots, the vein consisted largely or varying deposits of brecciated quartz and rock locally crudely banded with the quartz the more abundant in the foot-wall side. It contained several streaks of oxidized ore, one of which was mined for the distance of about 200 feet, but it yielded only from $2 to $5 to the ton.

From the sub-shaft and winze considerable development was done ~~xxx~~ on the 1900- and 2000-foot levels. But none of this work gave encouragement as to the possibilities of finding commercial ore deposits at this depth.

The Extension ore shoot as noted extends from the 250-foot level to the 1400-foot level and was productive throughout its extent. Its ore was of the same general character as that of the main ore shoot. On the 500-foot level south, in vicinity of raise 19, bot the vein and hanging wall rock are coarsely ~~xgk~~ agglomeratic with material resembling weathered boulders mostly stained dark brown with iron and manganese oxides. On the north, through much of the 1200 feet distance between the Extension and main ore shoots, not only is the value character of the ore incapable of discrimination by observation, but the vein itself in large part shows no line of demarcation but grades imperceptibly into the country rock, especially on the footwall side.

Between the 500-foot and 700-foot levels the ore shoot was brownish mottled. It had a horizontal extent of nearly 700 feet. Portions of it worked were 35 feet wide, especially in stopes 7-3 and 7-5. It was worked by the bench and fill method, the ore being stoped down on platforms laid the waste. In places, as in a few other parts of the mine, assays were necessary to discriminate between pay ore and waste.

In stope 7-5 the vein was split by a rhyolite horse 10 feet wide by [illegible] feet long. Toward the north, 1 to 5 feet of the hanging wall side of the vein consisted mostly of brown or ochre-colored mineralized gouge-clay or "yellow talc," which carried values ranging from $2 to $30 to the ton.

In stope S. 8-5 on the 800-foot level south from Extension shaft was found some of the richest gold ore in the mine, a considerable body of which ran more than $80 to the ton, and a 3-foot wide shoot of $20 ore had an extent of 35 feet.

On the 1000-foot level the ore shoot carried ore of good milling grade.

On the 1150-foot level north in stope 13-5 which was 25 to 30 feet in width the ore was siliceous and consisted mostly of iron-stained blocky quartz and rock. The White vein No. 1 is shown here coming in to join the main vein toward the south. It is more yellowish here than on the lower levels.

On the 1300-foot level the ore shoot in stope 13-3 was 12 feet wide and mostly good ore. The White vein is situated 30 feet to the east or hanging wall side. Lower down on the floor of this level and vicinity the White vein is about 9 feet wide, consists mainly of light-colored siliceous altered and replaced rhyolite and quartz with 1 foot wide of $10 ore and tapers out to the north.

The 1401 winze, sunk from the 1400 level to the 1450 level, was all ore.

On the 1450-foot level just north of the long crosscut the wall rock Alpine dacite. The face of the drift on this level 1300 feet south of sub-shaft was mostly low-grade primary ore banded with stringers of artz and dark rock, the quartz containing many angular inclusions of the ck. To the south of the productive ground shown on the stope map is a rge quartz lens extending from a little below the 1000-foot level nearly the 1900-foot level with its north edge plunging steeply to the north.

On the 1600-foot level good oxidized ore, with some primary sulphide e, was found both to the north and to the south of the sub-shaft. The ite vein No. 1 occurs on this level in cross-cut 16-5, but it is not trong.

As to the deposits in the deeper part of the mine, the primary sulphide e which came in on the 1300-foot level was found to be continuous on down yond the deepest workings below the 2000-foot level, but in depth it became o low grade to be profitably mined. The condition here experienced is keeping with that of similar deposits in other districts, where the epest developments in the mines have shown that the degree of mineralization general gradually decreases with increase in depth; the veins carrying more artz and pyrite and less of the ore minerals than on higher levels.

In the Hidden Treasure and North Star ground, opened by shaft and tunnel spectively at about 1900 and 3500 feet to the north of the Nevada Wonder ft, the geological and mineralogical conditions are, in general, similar those just described in the Nevada Wonder mine in the oxidized zone. rock formations, the Wonder rhyolite and the Alpine dacite, are both present in about the same manner, and the deposits are thought to be on the northward continuation of the Nevada Wonder vein, but they have not been productive.

On the Hidden Treasure ground the deposits consisted of a 60-foot wide lode of crushed altered oxidized and, in part, silicified Wonder rhyolite with quartz stringers and veins from 2 inches up to 2 feet in width, that form lenses, bunches, or pockets, and are sometimes abruptly cut off by slips and faults. Nearly all the quartz has moderate values. The dip of the lode is ~~XXX~~ 85° to the east.

In the deepest workings which are on the 300-foot level,17/ or 300 feet

17/ The 300-foot level of the Hidden Treasure shaft accords with the 00-foot level of the main shaft.

below the surface, fig. 22, the quartz veins or stringers are strong and look well, but they average only about $1 to the ton in values. On the North Star ground where the relief is higher the principal opening is a 0-foot adit tunnel, but the results were not encouraging.

Mineralogy.—As nearly all the minerals listed for the district, on page 11-31, were found in the Nevada Wonder mine the following notes on the ore ~~xxxxxxxx~~ important occurrences are here included.

Bromides were very common in the ore.

Stephanite was an important ore mineral in some parts of the mine and caused difficulty in cyanidation of the ore.

Chalcedonic quartz occurs sparingly in the veins. Some was found on the 1600-foot level.

A little ruby silver (pyrargyrite) was found on the 1500-foot level.

The ore contains much free gold, which is liberated during the milling process. It is of a very light or pale brass color and is worth $15 to $16 to the ounce. It probably stands close to electrum, some of which alloy was found in the mine. Occasional small flakes of free gold are visible in the ore.

Native silver was found at various places and depths in the mine. It occurred in the forms of wire, tapering fangs, flakes, and other irregular small bodies, and was frequently associated with argentite from which it seems to have been derived by oxidation and in part replaced.

Some iodyrite occurred on the 1500-foot level.

The oxidized ore is in general almost entirely free from base metals. About the only evidence of their presence is in places a yellowish brown limonite or red hematite stain of iron derived from altered pyrite, and similarly a little greenish-copper carbonate or malachite stain derived from altered chalcopyrite.

Black manganese oxide, psilomelane, is locally present as dendritic forms and black stain in the ore and in joint planes in the wall rock.

Jaspery quartz is common. Hyalite, partly in globular forms and associated with adularia is present in places.

The glistening surfaces common in the ore are laminae or cleavage faces of sanadine feldspar.

Fluorite was frequently present in the ore-bearing part of the veins especially in the ~~xxxx~~ rich ore with adularia, but it can scarcely be regarded as an important gangue mineral.

Wavellite, white hydrous aluminum phosphate, in spherical forms composed of radiating fibers beautifully encrusts joint planes of the wall rock, notably on the 500-foot level north.

Embolite occurs as an alteration product in cracks and porous quartz.

Gypsum occurred as incrustations in former water courses in the oxidized part of the vein, especially on the 500-foot level.

Wulfenite, lead molybdate, occurred in the oxidized part of the vein in the Extension ore shoot from the 800-foot to the 1300-foot levels.

In the sulphide zone, beginning at about the 1300-foot level, the principal ore mineral is argentite and with it are associated most of the gold ~~xxixxx~~ values. In this zone the base metals besides pyrite and chalcopyrite include also a small quantity of galena and sphalerite. No zinc was found, however, above the 1300-foot level.

The silver haloids were found in the following descending order principally in the Extension ore shoot.

Embolite or bromochloride.

Iodobromite or iodo-bromo-chloride.

Iodyrite or iodide[18]

18/ Burgess, J. A., op. cit.

The minerals associated with them besides the quartz and feldspar of the vein and their usual decomposition products were pyrolusite, manganese oxide in small amount, and wulfenite.

Embolite was found down to the 950-foot level and iodobromite from that depth to the 1300-foot level.

Iodyrite was found in limited quantity only on the 1000-foot level, with some partially oxidized rich ore, and with the decomposition products as associated flaky jarosite, and well-known hydrous iron sulphate.

The embolite occurred as grayish green waxy translucent coatings of deformed crystals on the ore, the iodobromite as light to dark olive-green crystal coatings. Both minerals were associated with wulfenite and had a pronounced bromine or drugstore-like odor which first disclosed their presence in some of the stopes.

The iodyrite was found chiefly as loose sulphur-yellow crystals in ~~xxxxx~~ pockets and cracks in the ore. Its bromine-odor was not quite so strong as that of the embolite and iodobromite.

<u>Mining methods</u>.--From the surface down to the 400-foot level where the walls were firm the shrinkage system of mining was employed to good advantage. In the lower levels, however, where the walls were inclined to cave away in large masses, a waste filling system was employed in which waste material for filling was mined from the walls of the stopes by inclined raises, and the cribbing of chutes and manways required a minimum amount of timber. The method is described by Smither.[19]

19/ Smither, Thomas M., Stoping methods of the Nevada Wonder Mine, Mining and Scientific Press, May 15, 1915, pp. 757-759.

Milling.--The method of ore treatment was by the Slimes process throughout. The mill was built as a 100-ton mill and cyanide plant on a 30° slope, fig. 19. The principal parts of the equipment named in order of use are as follows:

Blake crusher

Challenge feeders

Ten 1400-pound stamps

Trent Chilean mill

Dorr duplex classifier

Tube mill

Callow tanks

Deister tables

Dorr thickener

Pachuca-Type agitators

Dorr thickener

Callow tank with stirrer

Oliver filters

Zinc boxes

Faber Dufaur melting furnaces

Through improvements, however, by successive addition of essential parts, the plant was made so efficient that it easily treated 200 tons of ore a day and established a record of 240 tons a day, the average being 4,000 tons monthly. This, however, is in part due to the softness, incoherent character and other favorable qualities of much of the ore as absence of base inerals, etc., which enabled it to be easily crushed, rendered it ble to cyanide treatment, and yielded a high extraction.

The added equipment included chiefly Dorr thickeners, Callow tanks, classifiers, Oliver filters, Larger air compressor, Centrifugal pumps, ton filters (in 1916), and 4 Senn concentrators (in 1917) to remove ess soluble silver sulphides found in depth in the mine where the ecame harder to treat and yielded a lower extraction.

Details of the mill equipment and ore treatment together with flow s appear in the following papers given in chronological order.[20/]

20/ Van Saun, P. E., New mill at Nevada Wonder mine: Eng. and Min. , Vol. XCI, No. 10, pp. 520-522, March 11, 1911.

Negraw, Herbert A., Cyaniding at the Nevada Wonder Mill: Eng. and Jour., Vol. XCV, No. 14, pp. 693-695, April 5, 1913.

Carpenter, E. E., Cyaniding practice of Churchill Milling Co., r, Nev.: Trans. Am. Inst. Min. Eng., Vol. LII, pp. 123-137.

The mill is credited with having turned out more bullion per ton of han any other mill in Nevada. During the first few years of its tion $7 ore could be mined and milled with profit. As the mine ned, however, and the ore became leaner and less docile for treatment was no longer possible, as shown by the following paragraph.

The average cost per ton of ore of producing and marketing the bullion g the entire period of operation was about $8.92, the costs being ibuted as follows:

Mining (including transportation to mill).	$5.00
Milling.	3.68
Marketing the bullion.	.24
Total	8.92

Jack Pot Mine

Location and topography.--The Jack Pot mine is in the northeastern part of the district about a mile and a quarter north-northwest of the Nevada Wonder mine and Wonder Mountain. It is in Jack Pot Gulch, a prominent east side tributary of Hercules Canyon through which it is easy of access, though the surrounding topography is hilly and comparatively rough, figs. 7 and 12. The main opening, the Jack Pot shaft, is at an altitude of 5,250 feet, which is 850 feet lower than the Nevada Wonder shaft. Therefore, the 50-foot level of the Jack Pot mine accords in altitude with the 900-foot level of the Nevada Wonder mine.

History and production.--The Jack Pot mine is prominently identified with the early history of the Wonder district. The property was located in April 1906, by Tom Stroud and associates and was one of the first properties in the district to produce shipping ore of which $40,000 worth was taken from a 50-foot shaft, the first opening made. The property consisting of 12 patented claims and several others was soon acquired by the Jack Pot Mining Co. of San Francisco, for $750,000 it is said, who soon took out considerable ore. In August 1910, this Company was succeeded by the Atlas Wonder Mining Co. who greatly improved the property by retimbering and adding new and heavier machinery for deep sinking, and developed it in a broad workmanlike manner with the view of blocking out sufficient ore to warrant building a milling plant as the long freight haulage to the smelter enabled only high-grade ore to be profitably shipped, the freight and treatment charges on $60 ore being $48.50 per ton. However, as the development was not sufficiently encouraging the Company ceased operations

The production, made mostly in 1906 to 1908, was more than 4,000 ore which averaged about $115 to the ton. It was shipped mostly estern Ore Purchasing Co., at Hazen, some to Bingham, Utah, and Goldfield.

values in the ore are gold and silver in the ratio of about 1 to 5 rease in gold with depth. Following discovery, good grade shipping soon mined at five or six points on the property.

elopment.—The mine is opened to the depth of 960 feet mainly through Pot shaft and comprises more than 6,000 feet of development work, n half of which is drifts. It includes the Grand View and Hercules each 375 feet long. The Jack Pot shaft is a double compartment d was equipped with a 50-horse power gasoline hoist. As the ground 00-foot level was wet,a sump was sunk to drain it.

logy.—The country rock is chiefly the Wonder rhyolite, but the mine erty in part are on or near the contact of this rock with the Alpine nd the Extension rhyolite, fig. 7. On the southeast the dark dacite a series of "black knobs" on the ridge rising to Queen Peak. In it occurs on the 200-foot level west,and on the 300-foot level it cut or crowd out the vein. In the face of the crosscut on the level it is also present and is pressed and in part laminated. also present in the mine in dike form intrusive andesite which parallels the vein, it being locally in the ~~gix~~ fissure, and else- n 2 to 50 feet distant from it.

The deposits are of the same general class as those of the Nevada
ıder mine and other deposits in the district, the ore being in part
laced brecciated quartz and rock. They are contained chiefly in a vein
tem which is thought to continue as the Doctor vein system west of
cules Canyon, fig. 11. They are contained chiefly in 4 veins known as
A, B, C, and Grand View veins, which, in general, strike about N. 80° W.
nearly east and west) and for the most part dip steeply to the north,
25. The veins though composed mostly of crushed material are firmer
those of the Nevada Wonder mine. The ore is oxidized and stained
nish and blackish with iron and manganese, and is in part drusy.

The deposits differ from most of the veins of the district in their
nese content. Much of the crushed or brecciated quartz and rock is
y recemented and partially replaced by seams, veinlets and stringers
ack shiny metallic mineral which chemical tests show to consist chiefly
ilomelane, with a little associated manganite and hematite or ferric
but no ferous iron. This manganous ore is always auriferous and occurs
in the hanging wall side of the veins. A thin section of this ore
he A vein on the 200-foot level shows the gangue to be about 75 percent
uartz and 25 percent adularia.

e veins in general are narrow, and where they are ore-bearing they
contain but little gangue other than that contained in the ore.
-foot level contains some reddish or pink stringers of talc-like
esembling alunite.

e most important of the veins is the A vein on which the main or
shaft is sunk, and it has yielded nearly all the production.

ne vein strikes northwest and stands about vertical or dips about 88°
the south down to the depth of 500 feet, excepting that between the
nd 300-foot levels. It is convex to the northwest, its position being
to the north of the shaft on the 200-foot level. The ore continued
own to the 450-foot level, but in the lower part of the mine development
encouraging though the vein is represented there by seams and
ers of good-looking quartz.

ne B, C, and Grand View veins crop respectively about 400 feet, 500
nd 600 feet to the south of the A vein, fig. 12 and 25, and the
veins dip convergingly about 80° toward the A vein and join it on
-foot level and vicinity, but apparently they make no material
e in the ore at the junction.

om the surface down to the 100-foot level, vein A consisted almost
of an ore shoot from 1/2 foot to 6 feet wide that extended nearly
t on each side of the shaft and ran $30 to $60 to the ton from which
was cobbed to about $115 to the ton and shipped. In places a width
nches of the ore is said to have been "thickly plastered with horn
" Below the 100-foot level and on the 200-foot level the vein
ed mostly $30 to $40 ore.

1911, 7,500 tons of $15 ore is said to have been blocked out between
face and the 300-foot level. On the 300-foot level and just below
foot shoot of $20 ore extended about 100 feet on either side of the
eyond which limits the values decreased to ~~$4~~ $3 to $7 to the ton due
roken character of the vein as it neared the junction with vein B.

Vein B is about 4 feet wide of which width slightly more than half is ore-bearing, and near the surface much of it will average about $20 to the ton. On the 200-foot level, however, where it is opened for 200 feet both to the east and to the west of the shaft it is much broken and crushed and carries scattered values of only $2 to $10 to the ton.

Where crosscut on the 200- and 300-foot levels the C vein is about 18 feet wide, is more or less impregnated with sulphides, and about half of its width carries values of $1 to $7 to the ton, the ore being mostly of the replacement type.

Grand View vein.--The Grand View vein dips 40 degrees toward the south and contains some replacement ore. Where cross cut on the 300-foot level, however, it consists mainly of 1 to 2 feet of crushed or brecciated and seamy rock and sugary quartz contained in a 12-foot wide shattered zone of the dacite wall rock, and does not look promising.

Source of the ore.--The source of the ore, like that of the Nevada Wonder mine, is referred to heated solutions that followed the eruption of certain of the volcanic rocks, probably that of the Extension rhyolite lastly. Of the two most important periods of mineralization the first deposited a dark gray slate colored flinty or jaspery mineralized quartz, with which much of the gold and manganese is associated. Fragments of this dark hard ore as nodules or nuclei are often found inclosed in the lighter ore-bearing quartz of the last mineralization. This feature was early recognized by Mr. E. S. Cunningham, Superintendent of the mine.

ok.--From what has been described concerning the mine, from the the Company, though having done extensive development, did not nted to install electric power when it was cheaply available in ct, and the fact that in mining below the 1000-foot level or ep workings water will have to be contended with, the mine, probably contains considerable ore, is not regarded as workable ent transportation and labor conditions.

Vulture mine

ulture group, consisting of four claims, is in Hercules Canyon he Victor road forks and joins the Jack Pot mine on the northwest. d by the Vulture Mining Co., formerly of Wonder and Goldfield, dited with having made, in March 1907, the first shipment of ore istrict. Its principal production and shipment was 40 tons of anged from \$60 to \$200 and averaged about \$100 to the ton. At f visit the tunnel dump also contained about 100 tons of \$23 ore. ine is in the east side of the canyon, the main tunnel opening eet above the floor, fig. 9.

rincipal vein, the Vulture vein, strikes N. 10° W. and stands ical in Wonder rhyolite, with the croppings in part prominent ddle part of the property. It is opened chiefly by a 600-foot llel adit tunnel, cross cuts and shaft at the face of the tunnel h of about 200 feet. The vein is about 2 feet wide. At the the surface down nearly to the depth of 50 feet it yielded early all that the mine produced. The values occur in the north called hanging wall side of the vein in a 1/2 foot to 2-feet wide ore consisting in places of crushed quartz and silicified rock and else- of a group of parallel quartz stringers. Much of the ore is of the d type and contains many angular fragments of altered rhyolite firmly ed in quartz which is more or less drusy.

ome of the ore contained much yellowish-brown silver chloride including ilver which was so brittle and fragile that it was easily screened elded ~~[illegible]~~ screenings having a high silver value. There is also present ore some argentite, and with it are associated better gold values than he silver chloride.

n the deeper workings, however, the results were not encouraging. mineralized bunches, streaks, and stringers of crushed, silicified te and quartz are present, they, so far as learned, do not carry le values.

he Vulture ground is much broken and faulted. The tunnel shows beds lt breccia and gouge 5 to 6 feet in thickness which seem to be very tent. The faulting shows two main sets of fault or joint planes which dips northerly and the other southerly. The tunnel exposes whitish dike of the Extension rhyolite which probably is genetically ted with the ore. At about 250 feet south of the tunnel the country s traversed by a 10-foot wide dike of andesite described on pages 24 and 25.

Other properties

ng the many other properties or claim groups having showings of e of which have made small productions, are ~~thx~~ the:

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e Wonder

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der and Wasp

ay Horse

d King

wever, operators of many properties who had splendid surface showings, d croppings, good veins 6 or more feet wide, and found good ore e surface, reported that they abandoned their property because the inched out or became barren at shallow depths, depths of 90 to 150 feet. ese reports and their corroboration by examination made of many of the ies, it is inferred by the writer that this pinching out at shallow is in general characteristic of the veins of the district. To this owever, there are doubtless exceptions. Some well experienced mining o ~~x~~ are familiar with the district, have expressed their confidence in sibilities of the Colorado group, and each of several other properties western part of the district, making a mine.

Outlying deposits.--Between the Wonder district and Westgate, 8 miles the south, the country is said to be more or less mineralized, and it tains several prospects which in 1911 to 1913 were receiving attention. The country rock through this part of the range seems to be mainly canic rocks ranging from quartz latite to trachyte and is probably ated to the Wonder rhyolite. It is intruded by large dikes and masses light-colored rhyolite and aplite which locally occupy small areas. The e of the range contains also exposures of Mesozoic limestone and shale cribed on pages (G)-2-11 on which formation the volcanic rocks seem to rest. Among the more important of the prospects are the Cirac, Lansing and verton prospects, on some of which ground is said to have held since 1896.

Cirac prospect.--The Cirac prospect, formerly known as the "New Strike," about 2 miles nearly south of Twin Peaks and the neighboring summit of Fallon-Wonder road, at an elevation of about 5,800 feet in the west nt of the range, fig. 3. It comprises a compact group of 6 or more claims n as the Yellow Jacket group, owned by Cirac Brothers and C. G. Witbeck Fallon. The strike that drew attention to this part of the region was e here in August 1911. The deposits occur mainly in a lode on the tact of a 90-foot wide rhyolitic dike with the country rock quartz ite. The latite forms the hanging wall, and the deposits occur mostly in foot wall rhyolite, the gangue being largely dark jasperoid replacement rtz similar to that in the Jack Pot mine. Much of it is stained reddish h hematite. The lode dips about 60° toward the northeast, and the croppings end through a vertical range of several hundred feet. Sheeting in the te dips 70° to the west. The lode and rocks are cut by a nearly vertical fault. The openings are a short tunnel, cuts and trenches, on the ow Jacket claim, and drill tests at other points. Pannings of the sit from the croppings down are said to nearly all show considerable , and some assays are said to have yielded about 30 oz. in silver and) in gold to the ton. Adjoining ground had been taken xpm up on the heasterly extension of the lode and to the northwest on a shear zone he lower front of the range. Another prospect, known as the Lansing spect, had been opened near by, principally by a shaft about 90 feet , which contained water in the bottom. This water is probably storm r, but as a spring is said to occur a short distance to the east on a e dike, it may be sub-surface water. Here the ore carries considerable te, and the rhyolite which is flow banded is sprinkled with pyrite and ains also a little chalcopyrite.

Wolverton prospect.--The Wolverton prospect is about a mile nearly h of the Lansing prospect and just back of the front of the range. oo is associated with a large rhyolitic dike cutting the country rock hyte. The trachyte is disposed in heavy flows which dip gently heasterly. It is freely intruded by dikes and sheets of rhyolite and kes of aplite, which latter rock, in places, forms very sharp contacts the trachyte.

Placer deposits

So far as learned, no placers have been found, nor has any explora-
or prospecting been done for them in or near the district.

If the veins of the district formerly extended much above the present
ce, carried considerable gold, and have been greatly truncated, as
sed, to their present croppings, one would expect to find concentra-
of placer gold in the bordering lowlands on the northwest where
etritus eroded from the veins has been deposited. However, these
ntrations, if present, probably do not constitute workable placers
st of their gold content is probably in too finely divided a form
successfully recovered.

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DEPARTMENT OF THE INTERIOR

Geological Survey

September 15, 1927.

__Chalk Mountain, Quartz Mountain, Gold Basin, and King Mining Districts, Nevada.__

The Chalk Mountain and Quartz Mountain mining districts are in southwestern ...da southeast of Fallon, the nearest railroad station to which the ore is ...d by autotrucks over the Lincoln Highway and thence shipped to Salt Lake ..., Utah. The districts have recently been brought into prominence by the ...very of valuable ore bodies. This general region was examined by the ...gical Survey several years ago, but in view of the recent discoveries and ...derable production another visit was made in October, 1926. The work was ...by F. C. Schrader, geologist, who received valuable aid and information ...the local mining companies. The deposits occur mostly in Triassic (?) ...stone and are associated with porphyritic intrusive rocks, like the ores ...ntic, Utah, and Leadville, Colorado.

Chalk Mountain District

The Chalk Mountain district is about 40 miles east-southeast of Fallon, in ...hill County, midway between the famous old Fairview and Wonder districts. ... fig. 2.) Chalk Mountain, in which nearly all the ore occurs, is a conspicu... whitish hill in Fairview Valley. It is about 3 miles long, in a north-north... direction, and 2 miles wide, and it rises to an altitude of 5,440 feet, or ... 1,000 feet above the surrounding surface. (See fig. 3.) It is separated ... the west front of the Westgate Range, which contains the eastern part of ...district, by a valley about a mile wide.

Geology

Chalk Mountain consists mainly of whitish dolomitic limestone which has ...arched into an anticlinal fault block along its longitudinal axis and in...d by granodiorite porphyry. The limestone contains the ore deposits. It ...edium to thick bedded and is more or less marmarized. It has been faulted, ...ted, and locally intensely folded. Pronounced faults occur along the east ... of the mountains, and with them is associated the principal zone of miner...ation. Faulting and mineralization have occurred also on the west slope, in ...oss zone, or "iron belt," nearly a mile south of the north end, and across ...south end. Along the contact the granodiorite prophyry has changed the lime... into dolomitic marble and produced a contact-metamorphic zone, in places ...al hundred feet wide, containing a score or more of the usual metamorphic ...rals and also bodies of ferruginous magnetic greenstone or low-grade iron ... with which copper minerals are associated. Epidote, a green calcium-aluminum ...cate, occurs in large bodies on the west slope of the mountain, and large ...s of phlogopite, a light-gray, pearly-lustered magnesium mica, are found at ...southeast base. No fossils indicative of its age have yet been found in the ...stone of Chalk Mountain, but because of Jurassic fossils found in limestone ...e foothills to the south and in the adjacent part of the Westgate Range, and ...se of the more highly metamorphosed character and dynamically shattered con...on of the limestone in Chalk Mountain, it is thought to be probably of Triassic ...nd to belong to the formation that occurs 12 miles to the north, in the Still... Range, and was described by the Fortieth Parallel Survey as the Koipato series.

The granodiorite porphyry, with which the ore deposits are genetically connected, is a medium-grained gray porphyritic rock composed chiefly of soda-lime and alkali feldspars, quartz, biotite, and hornblende.

The limestone and granodiorite porphyry are intruded by dikes of a greenish iron-gray diorite and a whitish aplite, which are presumably complementary to each other and have been differentiated from the granodiorite porphyry magma. In places ore deposits are associated with these dikes.

At the north end of the mountain the limestone and the granodiorite porphyry are mostly covered by rhyolite, a light-colored siliceous volcanic rock. On the northeast slope occur two small areas of a dark-greenish iron-gray andesite, and a small belt of the andesite crosses the south base.

Covering the consolidated rocks on the lower slopes of the mountain is a thin mantle of alluvium or wash, which increases in thickness to at least 150 feet in the surrounding valley.

Ore Deposits

Chalk Mountain

Since the early Comstock days it has been known that ore occurs in Chalk Mountain, but until 1921 there was only sporadic production, occasionally in carload lots, running about 60 per cent of lead and 60 ounces in silver to the ton. Until about 1920 the operators believed that the mountain contained considerable ore but that it was of too low grade to be shipped and that the veins were not persistent. Beginning with the operations of the Chalk Mountain Silver-Lead Mines Co., about 1921, more extensive deposits were found, which stimulated activity and increased production. The property of the company lies about the middle of the lower east slope of the mountain and extends nearly 1½ miles on the zone of mineralization, in which the vein along the main fault fissure dips steeply to the east. The mine is situated toward the south end of the property. (See fig. 2.) By May, 1923, the company had shipped, mostly from development work, 120 tons of $80 ore, comprising about 80 per cent of the ore mined. By 1925 a 5-foot ore body had been developed for 375 feet on the 110-foot level and a new shaft, 600 feet south of the old shaft, showed the ore body to be about 10 feet wide on the 160-foot level, from which the company was shipping daily 12 tons of $100 ore. In July, 1926, a large, rich ore body was opened on the 335-foot level. It alone produced $175,000 worth of ore, some of which ran 70 per cent in lead. In places it was 12 feet wide. The ore was found to continue down to the 500-foot level, where the main vein contained 6 feet of rich ore. By February 1927, the company had shipped 51 cars of ore, which returned $127,400, or an average net value of $60.94 to the ton. About $500,00 worth of $25 mill ore had been blocked out in the mine and about 3,000 tons of $20 ore accumulated on the dump. The ore shipped runs about $90 in gross value to the ton, of which $60 is in lead and $30 in silver. The company can profitably mine and ship ore of $30 grade.

Other operators at Chalk Mountain, mostly on the west side, are the Nevada Chalk Mining Co., the Chalk Mountain West Side Mines Co., the Quartz-Chalk Mountain Mining Co., and the Chalk Mountain Extension Mining Co., each with a group of four to eight claims. The Nevada Chalk Mining Co. has for some time been producing on a small scale.

The deposits are mostly oxidized, and the ore bodies, though a few are tabular, are mostly irregular masses of porous iron-stained material. They occur as veins and replacement deposits along fractures or bedding planes in the lime-ltered limestone, quartz, calcite, dolomite, chalcedony, jarosite, garnet, lote, jasperoid, iron oxide, and brown ferruginous material. Iron is present ufficient quantity to make the ore desirable for smelting.

The ores were deposited as sulphides, principally argentiferous galena, te, molybdenite, and chalcopyrite, by hot solutions that ascended from the odiorite porphyry magma and circulated through the openings in the limestone. were deposited soon after consolidation of the granodiorite, probably at hs of about 1,000 feet below the surface, largely in the places they now py. Since their deposition they have been partly enriched through the pro-es of leaching and concentration by descending surface waters.

Additional commercial deposits probably occur in and near Chalk Mountain, ciated with the zones of mineralization in the limestone. Most of the veins, cially those of steep dip, probably continue in depth to or below water level, enrichment probably extends to that depth, which is from 300 to 500 feet in mines. Below water level, however, the deposits are probably leaner than e, having received less, if any, enrichment from descending surface waters. g to irregularity in the occurrence of the deposits, the best guide in pro-ting and mining is to follow the signs of mineralization in the limestone, may range from a broad iron-stained zone to an almost invisible seam. g to the prevailing easterly dip of the limestone and of the eastern zone ineralization, the east side of the mountain seems to be the more promising, is more favorably situated for enrichment by concentration, along the ing planes and fractures, of minerals leached from higher levels.

Westgate Range

bout 2 miles east of Chalk Mountain, in the west slope of the Westgate Range, here is composed chiefly of Jurassic limestone, is a north-south series of e prospects or claim groups, including the Mogul, Huber-Morrell, Watkins, r, Twin Metals, and Wolff. These prospects extend through a distance of al miles and are mostly at altitudes between 5,000 and 5,500 feet. Some em have made a small production. The deposits, like those at Chalk Mountain, lead and silver and occur in veins and replacement bodies in the limestone, hey are closely associated with intrusive andesite and rhyolite and there-may belong to the Tertiary period of ore deposition.

Quartz Mountain District

he Quartz Mountain district is in Nye County, 60 miles east-southeast of n, 25 miles south-southeast of Chalk Mountain, and just northwest of Marble he old Illinois mine. (See fig. 2.) It is about 8 miles long east and west miles wide. Quartz Mountain and the town and post office of Quartz Mountain ear its center. (See fig. 1.) The population is about 200. A daily auto stage is in operation from Fallon.

e district lies in open rolling country. It is drained southward into Valley. The dominant topographic and structural features and the ore de-s trend northwestward. The southeastern part of the district is occupied western half of the Lodi Hills, which have the form of an isosceles triangle its apex on the northwest in Quartz Mountain. (See fig. 1.) The ground-table probably stands at a depth of about 800 feet.

e district is named from Quartz Mountain, a low ellipitical hill about mile long and 100 feet high, much of whose northern half is strewn with and whitish silicified rock. Ore deposits similar to those it contains eastern part of the district, 2 miles west of Quartz Mountain, where the Broken Hills mine has produced more than $210,000 in similar ore.

Ore was discovered at Quartz Mountain in 1920, and by the end of 1925, under the Annette-Walker lease, the discovery property had produced $90,000 worth of ore. Then the property, henceforth known as the San Rafael mine, and many surrounding claims were taken over by several mining companies, including the San Rafael Co., which has since produced and shipped from the mine about $250,000 worth of silver-lead ore running about $40 to the ton and has opened up sufficient ore to continue its present rate of output for a year.

Mining or deep prospecting is also being done on several other properties, including the Wuartz Mountain Metals, Hasbrouck, Calico, San Felipe, Exchequer, Standard, Argentum, West Divide, Tripod, Desert, and Iron Mountain. Some of them are opened to depthsof 400 feet, and some have made a small production.

Geology

Most of the surface is covered by a mantle of alluvium or wash, 150 feet in maximum thickness, beneath which the consolidated rocks are mostly Tertiary volcanic flows, but the Lodi Hills, in which are nearly all the recently discovered ore deposits, is chiefly Cretaceous or Jurassic granodiorite porphyry or allied intrusive rocks, together with areas and masses of Triassic (?) limestone and greenstone. (See fig. 1.) The assignments to the Mesozoic are based on age determinations of similar rocks in the adjoining Paradise Range, on the southeast, made by H. G. Ferguson and S. H. Cathcart, of the Geological Survey. In the Lodi Hills the limestone is locally underlain by an older series of volcanic greenstones and tuffs of Triassic (?) age.

The most abundant of the granitic rocks i the granodiorite porphyry, which has intruded and metamorphosed the limestone and together with its complementary dikes of diorite, quartz monzonite, and aplite represents the magma from which the ores were derived. It is a dull greenish-gray medium-grained rock and is locally compressed, with most of its minerals considerably altered.

The oldest sedimentary rock is the limestone exposed in the Lodi Hills. These hills consist mainly of a batholith of granodiorite porphyry containing remnants of a huge limestone roof, most of which has been removed by erosion. The limestone is the principal ore repository. It is a medium to thick bedded bluish-gray crystalline rock and contains a little interbedded black shale and volcanic greenstone. It has been metamorphosed, faulted, and folded. The structure is mostly monoclinal, as at Quartz Mountain. Just north of Quartz Mountain the limestone is thought to be down faulted and deeply buried by the Tertiary volcanic rocks. It has not yet been found in the Calico mine, which is 400 feet deep with its bottom in rhyolite and granodiorite porphyry. The faulting seems to have included the northeast side of Quartz Mountain, as neither the limestone nor the Lease vein occurs northeast of the fault.

Encircling Quartz Mountain on the north and west is a series of nearly flatlying, mostly light-colored lavas of Tertiary age, consisting chiefly of rhyolite but including also basic types. The series consists of flows, tuff, and breccia and is about 500 feet thick. (See fig. 1.) These rocks are considerably altered hydrothermally, as well as by oxidation, and contain much sericite.

In places the volcanic rocks are cut by dikes which probably are branches of the younger flows. A large dike of this class is intruded along the contact of the lava flows with the older rocks of Quartz Mountain. It is a brownish-drab dense rock which is regarded as originally andesite but now consists mostly of secondary sericite. Branches of it in the San Rafael mine consist almost wholly

In the western part of the district the lava series, which there has not been differentiated, consists chiefly of the andesite and andesite breccia that contains the Broken Hills ore deposits. It has a known thickness of 350 feet.

Ore Deposits

The general distribution of the ore deposits and mineralization is indicated by the position of the mines, prospects, and claim groups shown on the map (fig. 1.) The ore deposits occur in two groups -- Mesozoic and Tertiary.

Mesozoic deposits

The Mesozoic deposits are genetically associated with the granodiorite porphyry and its complementary dikes. They occur in the limestone in the Lodi Hills area and are mostly the result of replacement. The ores, which yield silver and lead, are characteristically gray and yellowish lead carbonate ores containing lumps of galena. The ore minerals are chiefly cerusite, argentiferous galena, gangue mineral consists chiefly of iron-stained comminuted quartz with chert or flint, jasperoid, calcite, dolomite, jarosite, and argillaceous material. Proximity to ore or an ore body in the limestone is usually indicated by the presence of iron or manganese oxides, cerusite, specks of galena, and copper stain. The largest deposits are those of the Lease vein, in Quartz Mountain, which have been most exploited in the San Rafael mine.

The Mesozoic ores were formed by ascending hot solutions as replacement deposits in the limestone at moderate depth and temperature. They were deposited as sulphides, principally argentiferous galena, from which oxidized ore minerals were subsequently leached by descending surface waters and concentrated at lower levels, where they formed new deposits and enriched the ore bodies already there.

The succession of events as indicated at Quartz Mountain was about as follows:

1. Upheaval and intrusion of the limestone by the granodiorite porphyry.
2. Deposition of the Lease vein by hot magmatic solutions ascending from the granodiorite porphyry and circulating through the limestone.
3. A long period of subaerial erosion during which Quartz Mountain and the Lease vein were brought to or nearly to the surface, and the ores were more or less oxidized.
4. Effusion of the Tertiary volcanic rocks, which probably covered Quartz Mountain and vicinity.
5. Intrusion of the andesite dike at the northeast side of Quartz Mountain, accompanied by faulting down of the limestone and the Lease vein on the northeast.
6. A second period of erosion during which the volcanic covering was removed from the Mesozoic rocks at Quartz Mountain and the deposits were further oxidized and partly enriched by descending surface waters.

Tertiary deposits

The Tertiary deposits occur chiefly in veins and fault-breccia zones in the Tertiary volcanic rocks. They contain lead, silver, and gold. The ore minerals

that of the San Rafael mine except that it contains more galena and 5 per cent copper.

normal fault fissure that cuts the limestone, granodiorite porphyry, and volanic rocks. It extends longitudinally through Quartz Mountain and the San Rafael roperty, south of which it continues into the Quartz Mountain Metals ground, and 00 feet to the northwest of the mountain it appears in the Calico mine. It dips 5° NE, or stands about vertical, and it cuts off the Lease vein, as shown on the 50-foot level in the San Rafael mine. (See fig. 4 and section in fig. 1.) In ts outcrops at the north end of the mountain and on the 450-foot level in the San afael mine it is 35 feet wide. In the Calico mine it is 80 feet wide and in laces contains mineralized pockets running about $6 in gold and silver to the on. The filling of the vein is siliceous brecciated granodiorite porphyry, anesite, quartz, and calcite containing in places moderate quantities of galena nd sphalerite, with traces of antimony and a little gold and silver.

The Tertiary deposits were formed by ascending hot solutions that circulated hrough the rocks after the eruption of certain of the Tertiary volcanic rocks. hose at or near Quartz Mountain seem to be genetically connected with the large ndesite dike intruded along the contact of the Tertiary lavas with the Mesozoic ocks. Since they were deposited they have been partly oxidized and enriched by escending surface waters.

Mines and prospects

The San Rafael mine, around which the history of the district as described bove largely centers, is in the northwest end of Quartz Mountain. It is prinipally on the Lease vein, but it includes also a part of the Vertical vein and everal other lesser veins or large ore bodies. The Lease vein strikes about N. 0° W., with the trend of the mountain, and dips 25° NE., into the mountain, tord the Vertical vein. (See figs. 1 and 4.) It is a large bedding-plane reacement deposit in the limestone and is the principal ore deposit in the disict. It is opened by a 450-foot 40° inclined shaft sunk near its north end. rom the 70-foot level to the 352-foot level the vein was an almost continuous e body, from 3 to 14 feet in width and about 120 feet long, and much of the e was of high grade. Decrease of the dip just below the 250-foot level gives the vein, between the 250- and 352-foot levels, 180 feet of stoping ground which the ore body is 5 feet in width. Here the ore is more uniform and of tter grade, contains more sulphide than that on the higher levels, and runs gh in silver, much of it yielding $50 to the ton, of which $14 is in gold. me of it is rich galena ore running about $100 to the ton. On the 200-foot vel occurs a 13-foot bedding-plane ore body, which is at a higher geologic rizon than the Lease vein and contains more quartz and galena. It carries 12 et of milling ore and on the footwall side 1 foot of shipping ore and shows od indications of persisting in depth. A 7-foot ore body has been found on e 352-foot level in the southeast drift, beyond the south end of the Lease in. It is in virgin ground, with 400 feet of unexplored backs, and shows 3 et of $60 ore and 4 feet of mostly $20 ore. The ore runs high in gold and lver and shows native silver in wire and other forms. In the footwall below e Lease vein is another vein which produced some shipping ore on and above e 200-foot level. In the northeast side of the mine the Verticalvein, on the 0-foot level south of the crosscut, contains an ore shoot 70 feet long consting principally of galena ore, and below its junction with the Lease vein shows 12 feet of milling ore in the crosscut.

In the Hasbrouck mine, at the south base of Quartz Mountain, the southeast rkings on the 200-foot level are said to traverse a wide mineralized zone which a limestone footwall and an aplite hanging wall and which contains several ore ots or veins, including an east-northeast 3-foot vein of shipping ore similar hat of the San Rafael mine except that it contains more galena and 5 per cent copper.

In the eastern base of Quartz Mountain the lower 70 feet of the Quartz ountain Metals shaft, which is 300 feet deep, is said to be in mineralized limestone that looks promising.

Just north of Quartz Mountain, on the Nye-Mineral and other claims, are prospects on several fault breccia veins in the rhyolite (flow No. 4 in the section accompanying fig. 1) in which a little galena and lead carbonate occur. The San Felipe prospect, three-quarters of a mile northwest of Quartz Mountain, is opened 145 feet deep in rhyolitic rocks. It was supposed to be on the continuation of the Vertical vein, which recently, however, has been found to have a more westerly course. A little mineralized rock was found which assayed about $2 in gold and silver to the ton, but the prospect is not encouraging.

The outlook for the Quartz Mountain district is regarded as favorable. Its best probability is that of finding further ore deposits in the limestone. There is also a fair measure of probability that new deposits may be found in the large area of volcanic rocks extending from Quartz Mountain to Broken Hills. Owing to the irregularity in occurrence and the replacement character of the deposits, the best guide in prospecting is to follow mineralization in the limestone. The most promising places are on or near the contact of the limestone with the intrusive rocks, especially granitic rocks, as granodiorite porphyry and quartz monzonite. The larger the intrusive body the more chance there is of discovering an ore deposit.

Promising platinum deposits are being developed south of Lodi Tank. Highgrade cheelite deposits are being developed in Cottonwood Canyon, east of Lodi. The llinois mine has recently opened up a large body of high-grade silver-lead ore.

lower

Gold Basin District

The Gold Basin district is 45 miles southeast of Fallon, 5 miles south of halk Mountain, and just east of Fairview Peak. (See fig. 2.) It is a northouth area 3 miles long by 2 miles wide, which drains northwestward into Fairview alley. The surface consists mostly of steep ridges and deep valleys eroded in ulted and folded Tertiary volcanic rocks. The predominant rock is a dull-gray uartz latite like that of the Wonder district, where it is commonly called a yolite.

The ore bodies are principally gold-bearing deposits such as commonly occur veins in Tertiary volcanic rocks of the Southwest. They contain a little silr besides the gold. Outside the veins free gold in fine particles is widely istributed in nearly all the rocks, but it is not recoverable. The deposits ccur mostly in eight or ten veins or breccia zones, which in general contain but ttle quartz or gangue mineral other than wall-rock breccia. The deposits were rmed by hot ascending magmatic solutions that circulated through the rocks soon ter the eruption and consolidation of certain members of the volcanic group. ey were probably deposited mostly as argentite and gold. Since they were formed e deposits in the oxidized zone have been enriched by downward concentration of trital mineral, especially gold leached from the disintegrated veins and rocks high levels removed by erosion. For this reason the deposits pan well in free ld.

The Gold Bug mine, owned by the Gold Bug Mining Co., lies near the south end the district, at an altitude of about 5,400 feet, on a fault-breccia vein or that dips about 50° NE., in andesite. The vein, which was discovered by ry Knight in 1924, is 2 to 6 feet wide and 1,700 feet long. It is opened by 0° inclined shaft with two 50-foot drifts on the 50 and 100 foot levels and oxides. In places it is fairly siliceous, and its metal content, mostly free gold, is as much as $20 to the ton. The ore contains also a little argentite and cerargyrite.

In Branch Canyon, about 1½ miles north of the Gold Bug mine, are five or six prospects in the quartz latite, mostly owned by Messrs. Branch, Hunt, Smith, and Wilson. The Smith prospect, situated on a hill toward the east, consists of a fault-breccia ledge or zone 2 to 4 feet wide, dipping 70° E. It is opened by a 35-foot shaft which shows only brecciated country rock, with but little quartz, silicification, or indication of mineral. The rock, however, pans well in gold, which is in very small particles and most of which has probably been concentrated in the ledge by leaching from higher levels. The prospect does not seem to be of any commercial value. The Branch prospect, farther west, at the north edge of the bottom of Branch Canyon, is on a brecciated fault zone that dips 75° SE. It is opened by a 50-foot tunnel and contains more quartz than some of the other prospects in this canyon.

The Hercules prospect, in the northern part of the district, is owned by the Hercules Mining Co. It is said to be on a fault-breccia zone, a mile in length, and to have considerable mining machinery on the ground about ready for operation.

In the lower half mile or more of Branch Canyon are gold placers about 100 feet in thickness, and as the gravel is very angular and porous and the gold is very fine, the gold is concentrated almost entirely on or near bedrock, where the gravel is said to run from $2 to $3 in gold to the cubic yard. Several attempts have been made to recover the gold by the dry-washing process with machinery and otherwise, but the results were not successful. The deposits can probably be mined best by the room and pillar method.

The outlook for the Gold Basin district is not encouraging. The deposits on the whole are small and of low grade. Few, if any of them, can be profitably mined, even on a small scale, in the oxidized zone, much less in the sulphide zone below the levels of enrichment, where they are doubtless very much leaner. This statement seems to apply equally well to the remainder of the large rectangular area of volcanic rocks extending from the Fairview Mountains 5 miles eastward and from Bell Flat 10 miles northward, nearly to Westgate and the Lincoln Highway, of which the Gold Basin district is only a one-eighth part.

King District

The King district is in the northeast corner of Mineral County, 50 miles southeast of Fallon, 15 miles west-southwest of Quartz Mountain, about midway between Quartz Mountain and Rawhide, and just west of Mt. Anna, a prominent landmark. (See fig.2.) The region is underlain principally by tilted Tertiary volcanic rocks which rest on Mesozoic(?) limestone, diorite, and granite. Gold is said to be widely distributed in andesite and rhyolite for the extent of nearly a mile.

Here, in September, 1926, a stringer or small veing of rich gold ore was found by B.H.Donelly and Tex. Mondell at a depth of about 10 feet in an old shaft sunk in diorite porphyry. The strike soon attracted attention, and by October 20 a hundred men were camped on the ground. Soon after the discovery was made the principal properties, including the King and Queen claims, were taken over by the Desert Queen Mining Co. By November 10 two more strikes of high-grade silver-lead ore were made in parallel veins on the Queen claim. The ore is said to be associated with rhyolite, which intrudes the diorite. Some of it is said to run about 50% of lead and 250 oz. in silver and $2 in gold to the ton. By January, 1927, development showed the gold vein to carry 6 feet of ore on the 50-foot level, in April the Queen claim was reported to show 17 feet of mill-grade ore on the 100-foot level, and by June there had been