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ITEM 24 (87)

U.S. G.S. Bull. 715 1921

THE DIVIDE SILVER DISTRICT, NEVADA.

By Adolph Knopf.

SUMMARY.

The Divide district, one of Nevada's newest silver camps, centers at Gold Mountain, 5 miles south of Tonopah. The discovery of silver ore that started the great activity at this camp was made late in 1917, wholly by chance. A crosscut was being driven to cut a small gold vein that had been worked higher on the slope of Gold Mountain intermittently since 1902, and before it had been driven far enough to cut the gold vein it quite unexpectedly intersected a rich silver-

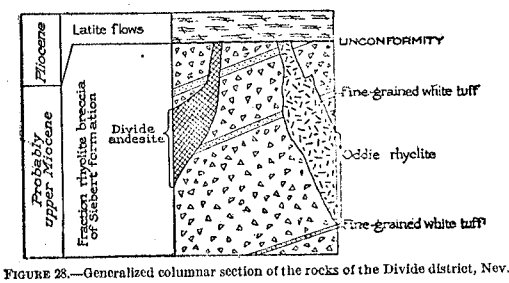


Figure 28.—Generalized columnar section of the rocks of the Divide district, Nev.

bearing lode. Further exploration indicated that a large and valuable ore body had thus accidentally been discovered. In February, 1919, Tonopah awoke to the possibilities of the new field and the boom began in earnest, and soon an area of 50 square miles surrounding Gold Mountain was staked. By midsummer between 80 and 100 hoists were in operation and a large amount of exploratory work was being done.

The prevailing rock in the Divide district is the Fraction rhyolite breccia. This is intruded by several stocks of the Oddie rhyolite and by a large mass of andesite. Later than all of these is a series of latite lava flows, which cap the highest peaks of the district. The distribution of the rocks of the Divide district is shown in Plate XIV, and a generalized columnar section of the rocks is shown in figure 28.

The ore bodies are zones of fracturing and shearing in the Fraction rhyolite breccia; strictly speaking they are lodes, not veins. The

chief silver-bearing mineral is cerargyrite (horn silver), which is commonly concentrated in rich masses along irregular seams of secondary that traverse the lodes. The primary metalliferous material is leanly mineralized rhyolite breccia carrying a small amount of disseminated pyrite and threaded by thin veinlets of exceedingly fine grained quartz. What the primary silver-bearing mineral has not been determined. The scarcity of quartz or of silicification is a noteworthy feature of the ores of the Divide district, especially in contrast with the high silica content of the ores in the adjoining district of Tonopah. The silver in the lean primary material of the lodes was concentrated by downward enrichment as soft "secondary" argentite, and subsequently most of this supergene argentite was converted to horn silver.

The chief producing mine is the Tonopah Divide, which yields ore averaging 25 ounces of silver and $2.50 in gold to the ton.

INTRODUCTION.

The Divide district lies just south of Tonopah, Nev., and is traversed by the main road that joins Tonopah and Goldfield. It can be said to center at the Tonopah Divide mine, the site of the first and chief discovery of silver ore, on the east slope of Gold Mountain a few hundred yards from the highest point on the Tonopah-Goldfield road. From the fact that this locality is near the divide the name Divide was given to the district in 1917. The area of the district is 50 square miles.

The district has a general altitude of 6,000 feet. Its prevailing aspect is that of a broad expanse of lowland, above which rise abruptly isolated hills or mountains, of which Gold Mountain is the best known. Southeast of the Tonopah Divide mine there is a fairly large mountainous area, the highest summit of which, said to be called Donovan Peak, attains an altitude of 7,000 feet.

The field work on which this report is based occupied two weeks during July and August, 1919. At that time the district was at its highest activity, although the crest of the boom had just been passed. To Mr. Jay A. Carpenter, who was able from his knowledge of the district to facilitate this work, I am especially indebted for many courtesies during this investigation.

DISCOVERY AND DEVELOPMENT.

The recent activity in the Divide district is the result of the accidental discovery of a rich silver lode on Gold Mountain in 1917. But the history of the district goes back farther than this, for gold was found on Gold Mountain in 1901, about the time of the beginning of Tonopah. Even some of the silver-bearing lodes in the Fraction rhyolite breccia attracted attention in those early days. At what is now the Crown Divide considerable work was done in 1905 and 1906

by Gavin Johnston, who shipped some ore, supposed to run 100 ounces in silver and 1 ounce in gold to the ton. The low ridge extending from the Belcher shaft to the Belcher Extension shaft was also the scene of prospecting in early times; some work was done here by the Lucky Baldwin Mining Co. in 1903, and small streaks carrying $110 to the ton, mainly in silver, were found. A shaft 300 feet was sunk, but further prospecting was abandoned during the Goldfield rush.

The gold veins on Gold Mountain continued to be worked in a small way by lessees during the intervening years, and the district became known as the Gold Mountain district. The most work was done on the Gold Mountain vein. In 1916 H. C. Brougher, one of the chief owners, decided to prospect this vein by means of a shaft sunk lower on the flank of the mountain. Sinking was started in April, 1917, and at a depth of 165 feet a crosscut was driven southwestward to cut the gold vein. At 145 feet from the shaft the crosscut reached a wide silver-bearing lode averaging $53.80 to the ton. Further exploration work was naturally concentrated upon this find, and by the spring of 1919 it began to appear that a large and valuable silver lode had been discovered. A great boom set in, and an area of 50 square miles was staked. The discovery was named the Tonopah Divide mine. The value of the find, its nearness to Tonopah, a great silver-producing center, and the psychologic setting all combined to cause an intense boom: the time was soon after the signing of the armistice, the find was the most promising strike that had been made in Nevada in years, and the price of silver was soaring. Some 350 companies were organized, nearly all with "Divide" as part of their designations.[1] A period of intense activity set in, and between 80 and 100 shafts, each with its own hoisting plant, were being sunk in the summer of 1919. Much money was spent in exploratory work, some wisely, much unwisely. The favorite method of prospecting was to sink a shaft to a considerable depth, commonly from 200 to 500 feet, and crosscut back to the lode, or to a supposed lode, or to a contact. Surface prospecting was little employed, although the country is admirably suited to this method, and bedrock is nearly everywhere exposed at the surface. The almost universal adoption of deep shafts and crosscuts from them as a method of prospecting was of course a reflex of the way in which the discovery had happened to be made. This remarkable reflex is one of the outstanding features of Divide as a mining camp. Generally a shaft was sunk first and surface prospecting and trenching were done afterward. Late in the summer of 1919, however, surface exploration began to become more common.

[1] Valuable accounts of the history and development of the district are given by J. A. Carpenter (The Divide district: Eng. and Min. Jour., vol. 107, pp. 859-861, 1919) and by G. J. Young (Divide silver-gold district of Nevada: Eng. and Min. Jour., vol. 109, pp. 62-66, 1920).

Electric power was brought to the Tonopah Divide mine in September, 1918, and subsequently was extended to most of the prospects that began operations in 1919. There is no water in the district, nor has water level been reached in any of the shafts, and all water must be hauled from Tonopah.

As a result of the exploratory work undertaken up to the time of my visit one ore body had been partly blocked out, the possibility of another one was indicated, and indications of silver were found at a large number of places. Subsequent work has not greatly altered this state of affairs; indeed, there has been a drastic downward revision of the amount of ore indicated in the Tonopah Divide mine from 330,000 tons of ore containing 9,000,000 ounces of silver, to 52,000 tons, containing 1,000,000 ounces, and the boom in the Divide district has very materially subsided.

GENERAL GEOLOGY.

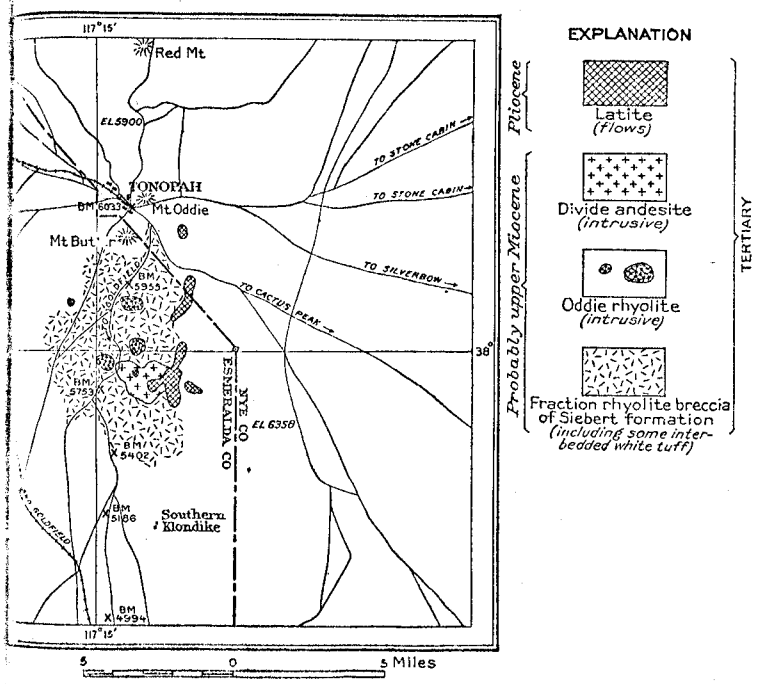
FRACTION RHYOLITE BRECCIA OF THE SIEBERT FORMATION.

GENERAL FEATURES.

Rhyolite breccia predominates throughout the Divide district. Because it incloses practically all the silver-bearing lodes that give the district its prominence it is the rock of chief economic interest. It underlies the low country that surrounds the isolated hills or mountains of the district, such as Gold Mountain and Hasbrouck Mountain. It forms characteristic smooth, gently rounded surfaces of light-yellowish color and commonly barren of vegetation.

The breccia on fresh fracture is an ash-gray rock carrying numerous broken crystals of quartz and glassy feldspar, sporadic flakes of biotite, and angular fragments of darkish andesite and pumiceous rhyolite. In general it is fine or moderately coarse in texture, but locally it contains fairly large angular fragments of various rocks. Unusually good outcrops of the breccia north of the Dividend shaft show fragments of coarse granite 6 inches in diameter and of andesite resembling the Midway andesite, 12 inches long. The coarsest bed of breccia noted in the district is 800 feet north of the Northwest Divide shaft; it is 6 feet thick and contains angular blocks of andesite as much as 3 feet in diameter. Thick massive beds of breccia dipping westward are prominent features of the landscape near the Toggery Divide claims.

Beds of soft white tuff are interstratified with the breccia at many places in the district. They are not only common in surface exposures but have been cut underground in some of the mines, as the Tonopah Divide and Gold Zone. They serve to indicate the strike and dip of the formation, which would otherwise generally not be ascertainable, as the breccia that prevails throughout the district forms thick homo-



GEOLOGIC MAP OF THE DIVIDE DISTRICT, NEV.

geneous masses in which bedding is rarely recognizable. The interbedded beds of tuff range in thickness from a few inches to an observed maximum of 200 feet. Some thin beds of gritty tuff occur with the soft fine-grained tuffs; under the microscope tuff of this kind is found to consist largely of fragments of quartz and glassy feldspar (sanidine) crystals and volcanic rocks in a cement made up of minute sherds of volcanic glass. Locally the prevailing coarse breccia of the district is interbedded both with this gritty tuff and with the soft chalklike tuff.

The fine-grained white tuffs intercalated with the coarser breccias correspond in composition to Spurr's Siebert tuff of the Tonopah district, which beyond doubt represents a somewhat thicker accumulation of volcanic ash deposited during the same general period of eruptive activity.

Although the rhyolite breccia and especially the associated bedded white tuffs are soft, not highly indurated rocks, nevertheless locally there are exceedingly hard, tough, resistant rocks that are scarcely recognizable as part of the same series of beds. The induration of these rocks has resulted from silicification of various forms, chiefly through the growth of fine-grained quartz, or of chalcedony, or even of opal. The bulk of Hasbrouck Mountain consists of such silicified breccias and tuff. Locally, as near the Tonopah Hasbrouck mine, the breccia of this mountain has been opalized in such a way as closely to resemble a massive rhyolite. In places the induration of the tuff is clearly connected with the wide zones of shattering, which evidently were pathways of the silicifying solutions, as is well shown near the Grimes Divide prospect.

ASSOCIATED IGNEOUS ROCKS.

Some flows of rhyolite occur with the breccias. They contain so many fragments of various rocks which they have picked up during flowage that they are veritable flow breccias and are extraordinarily like the Fraction rhyolite breccia in appearance. A flow of this kind on the north flank of the mountain northwest of the Mizpah-Divide prospect was particularly examined. It is a light-gray rock containing crystals of feldspar, quartz, and biotite and fragments of various volcanic rocks. Sanidine (a clear glassy potassium feldspar) is seen under the microscope to occur in numerous large crystals, being in fact the predominant porphyritic constituent. Quartz, oligoclase, and biotite are the other porphyritic minerals. They are embedded in a porous matrix of spherulitic glass. Inclosures of various rock fragments are common, as already noted. If it were not for the spherulitic nature of the glass it would hardly be possible to distinguish this flow rock from an ejection breccia.

Dikes of rhyolite and andesite cut the Fraction rhyolite breccia. The rhyolite is of two kinds—a white rhyolite carrying phenocrysts of quartz and sanidine and a darker variety crowded with inclusions, so that it resembles a breccia. The white rhyolite is identical in appearance and composition with the rhyolite that forms the main mass of Gold Mountain, and the dikes obviously were injected at the time when that mass was intruded. Dikes of this rhyolite cut the Fraction rhyolite breccia near the Tonopah Divide mine and in the workings of the Gold Zone mine, and doubtless others occur in the district. A rhyolite differing markedly from these, at least in appearance, forms a dike extending along the low ridge between the Belcher and Belcher Extension shafts. This rhyolite incloses innumerable fragments of white rhyolite resembling the Oddie rhyolite, and these inclusions are held in an aphanitic matrix of a color considerably darker than their own. Such a rock, were its field relations not known, would be difficultly distinguishable from a breccia made up of rock and crystal particles blown from volcanic vents.

In addition to the large mass of Divide andesite intrusive into the Fraction rhyolite breccia, isolated dikes of andesite occur at various places in the district. They differ somewhat from the Divide andesite, and some of them may have been injected at a different time from that of the Divide andesite. The narrow dike of gray andesite carrying numerous porphyritic crystals of plagioclase and biotite that cuts the Fraction breccia west of the Brougher shaft is probably of the same age as the Divide andesite, but the dikes of andesite near the Mizpah Divide prospect appear to represent a different period of igneous injection. The andesite near the Mizpah Divide is highly porphyritic, the phenocrysts, which consist of plagioclase, biotite, and hornblende, equaling the groundmass in volume.

CORRELATION.

The Fraction rhyolite breccia extends continuously from the adjoining Tonopah district southward into the Divide district, where it is areally the predominant rock. In the Tonopah district, where it is of subordinate interest, it was called by Spurr[2] the Fraction dacite breccia, but the recent study of the Divide district, where it is the the rock of chief economic interest, indicates that it is more accurately termed a rhyolite breccia. The prevailing feldspar in the breccia, as found under the microscope in numerous specimens from widely separated localities throughout the district, is sanidine (a glassy potassium feldspar), which occurs commonly in broken crystals. Plagioclase is comparatively rare and proves to be albite and oligoclase. The abundance of broken quartz crystals in the breccia has

[2] Spurr, J. E., Geology of the Tonopah mining district, Nev.: U. S. Geol. Survey Prof. Paper 42, p. [illegible], 1905.

already been mentioned. In conformity with these petrographic features the rock is here renamed the Fraction rhyolite breccia.

The southern part of the Divide district was studied in a reconnaissance way in 1905 by Ball, who mapped the rhyolite breccia occurring there as "Siebert lake beds" and stated that these beds comprise "tuffaceous sandstone, conglomerate, and clays.[3] He correlated them "with the Siebert lake beds of Miocene age at Tonopah described by Spurr."[4] As a matter of fact Spurr did not describe explicitly a series called the "Siebert lake beds," but he did describe a formation of white tuff at Tonopah which he named the "Siebert tuff (lake beds)." Ball tacitly assumed that what in the present report is called the Fraction rhyolite breccia and the tuff are members of a larger stratigraphic unit, which he named the Siebert lake beds. That in this assumption he was undoubtedly correct is believed to be proved by the occurrence of white tuffs at various horizons in the Fraction rhyolite breccia identical with those on Siebert Mountain. This larger unit was called by Ransome[5] the Siebert formation in his report on the Goldfield district, where it consists of bedded tuffs, tuffaceous sands, pumiceous ash, conglomerates, and some thin beds of diatomite. It is likely that the Siebert formation, according to Ransome, "was laid down with at least a part of the Esmeralda formation in a common basin."[6] The age of the Esmeralda formation has recently been determined by the careful work of Merriam[7] and shown to be approximately upper Miocene. From the foregoing discussion the conclusion is reached that the Siebert formation is very probably of upper Miocene age.

STRUCTURE AND THICKNESS.

The general dip of the Fraction rhyolite breccia is at a low westward angle, 20° being the average. Locally, however, the beds have been considerably disturbed, as around the intrusive necks of rhyolite, such as Gold Mountain. Here the rocks have been tilted up to angles as high as 70° and in places the dip is even reversed. These features are exactly like those prevailing around the volcanic necks at Tonopah, notably around Butler Mountain, which have been so well described by Spurr.[8]

[3] Ball, S. H., A geologic reconnaissance in southwestern Nevada and eastern California: U. S. Geol. Survey Bull. 308, pl. 1, 1907.

[4] Idem, p. 32.

[5] Ransome, F. L., Geology and ore deposits of the Goldfield district, Nev.: U. S. Geol. Survey Prof. Paper 66, pp. 66-68, 1909.

[6] Idem, p. 98.

[7] Merriam, J. C., Tertiary vertebrate fauna from the Cedar Mountain region of western Nevada: California Univ. Dept. Geology Bull., vol. 9, pp. 171-172, 1916.

[8] Spurr, J. E., Geology of the Tonopah mining district, Nev.: U. S. Geol. Survey Prof. Paper 42, p. 47, 65.

The breccia is broken by numerous faults, showing the southwa[illegible] extension of the conditions prevailing at Tonopah. As Spurr[9] sa[illegible] in discussing the faulting at Tonopah, "the phenomena within t[illegible] small, carefully studied area are typical of the unstudied similar v[illegible]canic region beyond the limits of the map." Adequate delinea[illegible] of the faults in the Divide district would accordingly require mapp[illegible] on the scale employed at Tonopah, namely, a scale of 4 inches to [illegible] mile. The complex nature of the faulting that will be found by s[illegible] detailed mapping of the Divide district is apparent on inspectio[illegible] Plate VII of Spurr's Tonopah report.

The rocks that underlie the Fraction rhyolite breccia are nowh[illegible] exposed in the Divide district, but in the Tonopah district the bre[illegible] is known to rest on the later andesite (now called the Midway andes[illegible] and the Heller dacite.[10] Because the base of the breccia is nowh[illegible] shown in the Divide district and because of the complex faulting, t[illegible] thickness of the Fraction rhyolite breccia can not be estimated. A[illegible] the Tonopah Divide shaft the breccia is at least 600 feet thick, b[illegible] the total thickness will probably be found to be many times th[illegible] figure.

ODDIE RHYOLITE.

Rhyolite in intrusive masses occurs throughout the district, form[illegible] the bulk of many of the hills and mountains that stand above t[illegible] lowland. Gold Mountain is the chief of these. The rhyolite h[illegible] many of the earmarks of lavas erupted upon the earth's surface, s[illegible] as conspicuous streakiness, banding, and flowage lamination, but t[illegible] contacts show that most of the rhyolite, if not all, is intrusive in[illegible] the breccias and tuffs of the Siebert formation. The extreme il[illegible]tration of an intrusive rhyolite that resembles an extrusive rock [illegible] afforded by a remarkable outcrop in the hill northwest of the R[illegible] Divide prospect. The rhyolite of this extensive outcrop, becau[illegible] its pronounced flowage lamination, closely resembles a series of th[illegible] bedded, steeply dipping, folded sedimentary strata resting un[illegible]formably on an underlying more steeply tilted series; but the rh[illegible]lite breaks through the underlying rocks, which are bedded t[illegible] dipping 60° N., and the contact is marked by a selvage of g[illegible] several feet thick. Such glassy contacts are well exposed on G[illegible] Mountain, also, and at other places in the district. They are like[illegible] notable features of the volcanic necks at Tonopah, especially [illegible] Butler Mountain. Flow layering also is conspicuously develope[illegible] the intrusive rhyolite of Siebert Mountain. These features of t[illegible] rhyolites of Divide and Tonopah indicate that they were intrude[illegible] shallow depths, with consequent rapid cooling, and the speed [illegible]

[9] Spurr, J. E., Geology of the Tonopah mining district, Nev.: U. S. Geol. Survey Prof. Paper 42, p[illegible] 82-83, 1905.

[10] Idem, p. 40.

cooling was doubtless hastened by the water content of the porous breccias and tuffs in which they were intruded.

The rhyolite is a white or pale cream-colored rock studded with abundant small phenocrysts of quartz and glassy feldspar and containing a few tablets of biotite. Under the microscope the feldspar phenocrysts in the rhyolite of Gold Mountain prove all to be sanidine, and in this respect, as also in appearance, the rhyolite resembles exactly the Oddie rhyolite of Mount Oddie at Tonopah. The rhyolite from the summit of the 6,600-foot peak east of the Knox Divide prospect carries, in addition to the quartz, sanidine, and biotite phenocrysts, some plagioclase, thus approaching in composition the rhyolite (or quartz latite) of Brougher Mountain and Butler Mountain of Tonopah. In the earlier report on the Tonopah district the rock of these two last-mentioned volcanic vents was termed the Brougher dacite by Spurr,[11] although their essentially rhyolitic nature was recognized. In his later report[12] Spurr refers to the Brougher dacite as dacitic rhyolite or rhyolite-dacite, but it can more simply and with gain in precision be termed a quartz latite. Spurr has pointed out that although the rhyolite of Mount Oddie differs perceptibly from that of Brougher Mountain, transition phases that bridge the gap between the end members occur in neighboring vents. In the Divide district the rhyolite of Gold Mountain is clearly the equivalent of the Oddie rhyolite, and the other masses in the district shown on the geologic map (Pl. XIV) are nearer to the Oddie rhyolite in composition than they are to the quartz latite of Brougher Mountain. The rock of the rhyolitic vents in the Divide district has therefore been shown on the map under the name Oddie rhyolite.

DIVIDE ANDESITE.

A large mass of andesite that lies southeast of the Tonopah Divide mine forms the main bulk of the largest and highest mountainous area in the district. The andesite is excellently shown at the highest point on the Tonopah-Goldfield road—the divide from which the district received its name—and accordingly it is here named the Divide andesite.

The andesite is a gray porphyritic rock carrying numerous crystals of glassy striated feldspar and biotite. Its weathered exposures tint the landscape a characteristic lilac-gray. East of the Goldfield road, south of the divide, it weathers exactly like a horizontally bedded formation, but at the divide it weathers like a bedded formation standing on edge. Despite this appearance it is found to be intrusive into the Fraction rhyolite breccia. A long, sinuous offshoot extends

[11] Spurr, J. E., U. S. Geol. Survey Prof. Paper 42, pp. 57-60, 1905.

[12] Spurr, J. E., Geology and ore deposition at Tonopah, Nev.: Econ. Geology, vol. 10, p. 74[illegible], 1915.

from the main mass more than 200 feet into the breccia near the Argonne Divide prospect. The contact is well exposed south of the Gold Zone prospect and shows the chilling of the andesite against the white tuffs which it intrudes. Locally the intruded rocks are disturbed near the contact and tilted from their normal dip of 20° W. up to 70°. In places also the andesite adjoining the contact is intensely autobrecciated, as near the Operator Divide prospect, where the newly congealed andesite along the contact was evidently shattered and brecciated by flowage of the unconsolidated portion.

Under the microscope the feldspar phenocrysts of the Divide andesite prove to be a sodic labradorite ($Ab_{50}An_{50}$). In a specimen from the prominent knob south of the Gold Zone shaft the plagioclase is largely altered to calcite. The biotite, too, is generally altered. The groundmass is cryptocrystalline and in the autobrecciated facies is hyalopilitic. The accessory minerals are magnetite, apatite, and zircon. The light color of the andesite suggests that the rock may have latitic affinities, but the specimens collected, although apparently fresh, proved on examination under the microscope to be too much altered to put this supposition to chemical test.

The Divide andesite appears to have no equivalent in the Tonopah district. As the Oddie rhyolite and the Divide andesite have not been found in contact, it is not known whether the andesite is older or younger than the rhyolite. It is provisionally held, however, that the andesite is the younger of the two.

LATITE LAVAS.

The youngest rocks of the district are a series of latite lavas that cap the high peaks in the area southeast of the Tonopah Divide mine. The base of the lavas consists of a black glass. The bottom of the glass flow is well shown in a prospect tunnel at an altitude of 6,[illegible] feet south of the Allied Divide prospect. The glass, here 20 feet thick, with horizontal layering, has flowed over the Divide andesite and is crowded with fragments from that rock. Manifestly it flowed over a stony soil derived from the disintegration of the underlying Divide andesite, and as it moved along it incorporated fragments of the andesite in great numbers and permeated the interstices of the stony rubble, so that the contact between the flow and the Divide andesite is somewhat suggestive of intrusion.

The black glass is overlain by an exceedingly streaky, highly vesicular pitchstone. Above this are lithoidal lavas, some of which have a characteristic irregularly corrugated, thinly platy structure. These lavas are very sparsely porphyritic, and their general appearance suggests that they belong to the more siliceous varieties of andesite. Lava from the highest summit is markedly porphyritic

and resembles the Divide andesite rather closely, except that it is more or less pitted with gas cavities.

The latite flows attain a maximum thickness of 300 feet. They weather to a much darker color than the characteristic lilac-gray of the Divide andesite, which is the chief rock on which they rest. Where the black glass predominates because the superposed lavas have been stripped off by erosion the capping, as viewed from a distance, resembles the basalt cappings so common in Nevada.

The latitic character of these lavas, the youngest rocks in the district, is suggested by their flow streakiness, a feature rarely seen in true andesites. To verify this conjecture the following partial analysis was obtained. It fully confirms the inference as to the latitic character of the rock, but it shows an unexpectedly high percentage of silica.

Partial analysis of latite from the Divide district, Nev.

[R. C. Wells, analyst.]

SiO_2	69.97
CaO	1.[illegible]7
K_2O	5.02
Na_2O	4.20

The rock selected for analysis is a faintly banded dark-gray lava carrying small sparse phenocrysts of plagioclase, biotite, and hornblende. Under the microscope the plagioclase crystals are found to be a sodic andesine ($Ab_{65}An_{35}$) near oligoclase in composition. The biotite and hornblende show no unusual features. The groundmass is a glass crowded with obscure microlites of feldspar and dusted with minute grains aggregated as globulites and margarites, most of them suggestive of incipient forms of biotite. Magnetite and apatite are the accessory minerals. It is noteworthy that in spite of the high silica content of the rock as disclosed by the chemical analysis no quartz has crystallized out, either as porphyritic crystals or in the groundmass.

The series of latite lavas of the Divide district is not represented in the Tonopah district. They have been traced, however, to a point within less than a mile south of the Belmont mine of Tonopah, where the occurrence of a great mass of coarse agglomerate and cinders associated with the lavas indicates one of the volcanic centers from which the latites were erupted.

East of the Divide district the latites overlie rhyolite vitrophyres carrying numerous phenocrysts of quartz and sanidine and sporadic tablets of biotite. The rhyolites have a marked flow structure and contain steam cavities which are filled with opal or chalcedony or both. The spherulitic obsidian occurring north of the Ben Hur prospect probably belongs with these rhyolites. These rhyolite

lavas extend northward into the Tonopah district in the area south of the Belmont mine, where they have been mapped by Spurr as Brougher dacite. On account of the prevalence of gas cavities in these rocks, their marked flow layering and the occurrence of glassy and spherulitic layers at various horizons, they are regarded as the extrusive equivalents of the magmas that solidified in the volcanic necks forming Brougher Mountain and Butler Mountain.

SILVER-BEARING LODES.

OCCURRENCE AND CHARACTER.

The ore deposits are silver-bearing fracture zones in the Fraction rhyolite breccia. The filling between the walls of these zones—the ore, in short—is not greatly sheared but consists of fractured rhyolite breccia, in general inconspicuously mineralized; and the ore bodies, as they are not tabular fillings of preexisting open spaces, are strictly not veins but lodes. The walls of the lodes as a rule are excellently defined, and at least some of them can be demonstrated to mark zones of faulting. Evidence of notable displacement is most clearly shown in the Gold Zone workings, where well-stratified tuffs intercalated in the rhyolite breccia are cut off by the Tonopah Divide lode.

The Tonopah Divide lode strikes northwest and stands vertical. Other mineralized fracture zones subsequently found have this same general trend, but still others strike at various azimuths—for example, the Divide Extension, which strikes N. 10° E., so that most azimuths are now represented. No systematic arrangement of the fracturing is yet discernible, and that none exists seems probable in view of the complexly faulted condition of the Fraction rhyolite breccia demonstrated by the detailed mapping of the Tonopah area.

The outcrops of the lodes are rather lightly iron stained by disseminated limonite, and this staining is the only evidence likely to suggest that the fracture zones are mineralized.

In depth pyrite appears in the lodes and in the adjacent wall rock. In places the lode matter is netted with a few thin veinlets of fine-grained quartz resembling chalcedony in appearance, but chalcedony does not occur. These veinlets, which are short and discontinuous and do not exceed a small fraction of an inch in thickness, are more abundant in some lodes than in others, though they can not be said to be really abundant in any, but they in no way influence the tenor of the ore. They are not common, for example, in the ore of the Tonopah Divide or the Divide Extension lodes. The almost complete absence of vein quartz and of silicification, contrasting with the siliceousness of the ores at Tonopah, caused the Divide ores in the early history of the camp to be viewed with skepticism by engineers familiar with the ore deposits of Tonopah.

A characteristic feature of the Tonopah Divide lode is that it is traversed by white gouges. The gouges range from a film up to masses several inches thick and consist of the so-called talc, a soft white fine-grained unctuous material, in many places visibly containing brown horn silver. Assays running up to hundreds of ounces of silver to the ton are commonly obtained from such gouges. Under the microscope the material was found to be of great purity, to be brilliantly birefringent, and to resemble sericite in every respect. The refractive indices were then determined and found to be $\gamma = 1.575$ and $\alpha = 1.55$. They differ somewhat from those recorded for sericite[13] ($\gamma = 1.597$ and $\alpha = 1.560$), but chemical analysis establishes conclusively that the mineral has the composition of sericite, to which it is therefore referred. Like minerals of the leverrierite group (micaceous hydrous silicates of aluminum), it slacks in water and becomes plastic and sticky.[14]

The chemical composition of the sericite from one of the so-called talc gouges in Tonopah Divide lode is as follows:

Analysis of sericite from the Divide district, Nev.

[J. G. Fairchild, analyst.]

SiO_2	48.16
Al_2O_3	34.00
FeO (reported from total iron)	2.07
K_2O	9.62
H_2O+ (total water)	5.84
TiO_2 (approximately)	.20
	99.89

The silver in the lodes of the Divide district is chiefly in the form of cerargyrite. Except in the sericite gouges, where in places the cerargyrite occurs in particles large enough to be recognizable, the cerargyrite is indistinguishably disseminated throughout the ore. In consequence the appearance of the ore gives no clue to its tenor, and the determination of what is ore must depend wholly on assays. Although cerargyrite is the main silver-bearing mineral in the ore, some soft black pulverulent argentite, the so-called sooty argentite, has been found. The most notable find of this kind was in some ore cut on the 100-foot level of the Divide Extension mine, where argentite occurs together with pyrite, which it has partly replaced.

Some rare molybdenum minerals occur in the Tonopah Divide lode at the point where it was cut by the discovery crosscut, but so far they have not been found elsewhere in the lode or elsewhere in

[13] Rogers, A. F., Sericite, a low-temperature hydrothermal mineral: Econ. Geology, vol. 11, p. 120, 1916. The determination of the refractive indices of sericite by Rogers appears to be one of the few on record; strictly the indices of other sericites should be measured.

[14] Larsen, E. S., and Wherry, E. T., Leverrierite from Colorado: Washington Acad. Sci. Jour., vol. 7, p. 208-217, 1917.

the district. At the discovery point the lode contains a considerable amount of the brilliant yellow mineral molybdite (hydrous ferric molybdate), crystallized in aggregates of minute needles. The molybdite diminishes in depth, and at the corresponding position on the next lower level powellite (calcium molybdate) occurs abundantly.

The lean primary silver-bearing material found in depth is a light gray rock that is not conspicuously mineralized. It contains numerous crystal fragments of quartz and sanidine and fragments of rhyolite and andesite, is sparsely impregnated with pyrite, and is traversed by a few thin veinlets of fine-grained quartz nearly resembling chalcedony. Under the microscope much of the sanidine is seen to be more or less thoroughly replaced by quartz; where it has been completely replaced the resultant aggregate resembles a quartzite fragment, but the outlines of some of the sanidine crystals are perfectly retained. Some of the feldspar is chloritized and some is sericitized. The wall rocks contain disseminated pyrite, and under the microscope they show that the sanidine has been partly replaced by calcite, instead of by quartz, as in the lodes.

The outcrops of the lodes are either barren of silver or are of low grade. The pyrite in the upper part of the lodes has been oxidized and is represented by limonite, but at depths of 100 feet or so it begins to appear. The barrenness of the tops of the lodes in silver has led to the general policy in exploring new lodes to sink shafts to considerable depths—as much as 500 feet—before crosscutting from the shafts to the lode. Experience has now amply demonstrated that this is not good practice, and that crosscutting to the lode should be commenced at the 100-foot level, or at most the 200-foot level. To ignore the plain lesson of the district may cause unnecessary and wasteful expenditure in useless prospecting.

The only considerable body of ore that had been developed in the district at the time of my examination is that in the Tonopah Divide mine. It forms a shoot pitching steeply southward in a vertical lode; it is 450 feet long, 500 feet high, and 21½ feet wide. The silver is irregularly distributed within this shoot, which contains, according to the estimate of Mr. E. A. Julian, 52,000 tons of first-class ore averaging 20 ounces of silver and 0.08 ounce of gold to the ton. Because a knowledge of this shoot is of paramount importance to an understanding of the ore deposits of the district it is described in some detail on pages 165–167. In August, 1919, the downward limit of the shoot had not been determined, nor had the water level been reached at the greatest depth then attained (581 feet). It then appeared probable that water level would be reached at a depth between 800 and 1,000 feet.

Some rich ore has been found at the Divide Extension mine, as described on pages 167–168, and high assays have been obtained at scores of places in the district, sufficient to justify well-considered prospecting. It is undeniable, however, that a number of lodes having all the obvious features of the famous Tonopah Divide lode have failed to disclose ore in depth, even after extensive prospecting. Nevertheless the possibility that other ore bodies comparable in value to the lode may yet be discovered is not exhausted.

ORIGIN OF THE ORE.

Although by far the most of the silver-bearing lodes under development are in the Fraction rhyolite breccia, some are in the Divide andesite, and the gold lodes are in the Oddie rhyolite. Therefore possibly more than one period of mineralization has occurred, but the most recent must have been later than the intrusion of both the Oddie rhyolite and the Divide andesite. The results of the mineralization were to produce in the fracture zones in the Fraction rhyolite breccia a low-grade silver-bearing material—the "protore"—carrying disseminated pyrite. What the primary (hypogene) silver-bearing mineral in the protore is has not yet been determined.

The silver in the outcrops of the lodes was oxidized, taken into solution, and carried downward, where it was precipitated as soft black argentite by reaction with the pyrite of the protore. Thus the outcrops were leached of their silver, and a zone of rich supergene silver sulphide was formed lower down. Subsequently, evidently in response to a climatic change, the composition of the descending oxidizing surface waters changed; they became charged with chlorides. As a result the supergene argentite was oxidized and converted to chloride (cerargyrite), and the ore thus formed is the ore now being mined or developed by exploration.

The barrenness of the outcrops in silver, although the chief metalliferous mineral in the lodes in depth is silver chloride, is one of the outstanding features of the geology of the Divide district. At first thought it would seem that on account of the insolubility of silver chloride the outcrops of the lodes should contain as much silver as the ore beneath them, but the reason for this apparent anomaly, as previously explained, is that a period of downward enrichment preceded the formation of the cerargyritic ore. During this earlier period the surface waters were evidently not charged with chlorides and the silver was consequently dissolved and largely or completely removed from the outcrops; subsequently, owing to the increasing aridity of the region in late Quaternary time, the surface waters became charged with chlorides and, sinking through the lodes, altered the earlier-formed supergene argentite to cerargyrite.

GOLD VEINS.

A few narrow gold veins occur in the Oddie rhyolite of Gold Mountain. The best known of these is the Gold Mountain vein, on the property of the Tonopah Divide Mining Co., as it was this vein that led to the discovery of the silver lode. The vein filling consists of angular fragments of rhyolite cemented by an exceedingly dense bluish quartz. It contains considerable disseminated pyrite, which is the only visible metalliferous mineral. Under the microscope the ore shows in addition to the quartz and pyrite a little adularia and considerable of a thinly tabular hexagonal mineral closely resembling apatite (but tabular instead of prismatic), which has not been identified.

The ore that was extracted is reported to have carried from $18 to $40 in gold to the ton, but the ore occurred in quantities so small that the lessees who worked the vein intermittently after 1902 made barely more than wages.

Another vein of this same character—that is, consisting of angular fragments of rhyolite in a matrix of bluish chalcedony-like quartz—occurs near the northwest end of Gold Mountain. Under the microscope the ore also shows adularia, locally abundant, and hexagonal tablets of the apatite-like mineral that has not been identified.

The Kernick vein, which traverses silicified tuffs on the west flank of Hasbrouck Mountain, resembles closely the gold veins. The vein filling consists of angular fragments of silicified tuff inclosed in a cement of dense bluish, extremely fine grained quartz. Although in appearance so similar to the filling of the gold veins, it is nevertheless a silver ore, recent shipments of sorted ore having averaged 20 ounces of silver to the ton. The resemblance of this silver-bearing vein to the gold veins suggests that this vein, the silver-bearing lodes upon which the activity of the district is centered, and the gold veins are all of the same age. On the other hand, the complete absence of sericitization in connection with the gold veins and its prevalence in the main silver-bearing lodes would indicate that the gold veins were deposited during one epoch of mineralization and the silver-bearing lodes during another, and this interpretation has at present the balance of evidence in its favor.

COMPARISON OF THE GEOLOGY OF THE DIVIDE DISTRICT WITH THAT OF TONOPAH.

The dominant rock at Divide is the Fraction rhyolite breccia. It is an extension southward of the same breccia as it occurs at Tonopah, where, however, the rock does not inclose any ore bodies. The chief productive veins at Tonopah are in the Mizpah trachyte, a formation that does not occur in the Divide district. Another

and younger but far less productive group of veins is genetically related to the later intrusive West End rhyolite, also not known to occur at Divide. Younger than both the Mizpah trachyte and the West End rhyolite and later than the veins associated with them is the Midway andesite, which flowed over and covered the veins. This rock also is not represented in the Divide district.

Subsequent to the formation of all these older rocks and the mineral veins associated with them the Fraction rhyolite breccia was ejected and the interbedded white tuff was deposited. These stratified rocks were later intruded by rhyolitic magmas, part of which consolidated as a highly autobrecciated glass, termed the Tonopah rhyolite by Spurr, and as massive rock, such as that forming Mount Oddie and known as the Oddie rhyolite.[15] According to Spurr "the Tonopah rhyolite-Oddie rhyolite intrusions were followed by the third period of vein formation, which produces usually small but occasionally very large quartz veins, with small amounts of the metals, and, so far as known, commercially valueless."

It is obvious from the foregoing sketch that if the mineralization at Divide corresponds to any period of vein formation at Tonopah it can only correspond to the last period—that subsequent to the intrusion of the Tonopah and Oddie rhyolites. However, it probably represents a still younger period of mineralization and is genetically related to the intrusion of the Divide andesite, a rock not known to occur at Tonopah. Spurr [16] was inclined to correlate the gold veins on Gold Mountain with those of the then newly discovered gold veins at Goldfield, but since that suggestion was made Ransome [17] has shown that the Goldfield veins are of a very specialized type, distinguished by their abundance of alunite and probably related genetically to an intrusion of dacite. The most reasonable conclusion, in view of what scant evidence is available, is that the Divide mineralization is not to be correlated with any of the recognized periods of vein formation at Tonopah or at Goldfield, but that, as already stated, it is probably linked with the intrusion of the Divide andesite.

The results of the primary mineralization at Divide were to produce in the Fraction rhyolite breccia wide bodies of low-grade silver-bearing material. By the concentrating action of downward-moving surface water this primary material was enriched to form the high-grade silver ore now being developed by mining. The chief silver mineral is cerargyrite, though some "sooty" argentite has been found.

At Tonopah cerargyrite occurred in considerable abundance in those veins that outcropped at the surface. According to Burgess,[18]

[15] Spurr, J. E., Geology and deposition at Tonopah, Nev.: Econ. Geology, vol. 10, p. 750, 1915.
[16] Spurr, J. E., U. S. Geol. Survey Prof. Paper 42, p. 99, 1905.
[17] Ransome, F. L., U. S. Geol. Survey Prof. Paper 66, 1909.
[18] Burgess, J. A., The halogen salts of silver and associated minerals at Tonopah, Nev.: Econ. Geology, vol. 6, pp. 13-21, 1911.

who made a careful study of its occurrence, the silver chloride and related halides persist downward as far as the oxidized ore extends, that is, to the 700-foot level. Below the zone of cerargyrite occurs an ill-defined zone of silver bromide, and below this silver iodide. This succession of zones is the reverse order of what at first thought would be expected to occur as the result of deposition from descending waters, as the iodide is by far the most insoluble of the silver halides, but this order is determined by the reversible reaction between iodide and ferrous and ferric iron,[19] as is practically proved at Tonopah, where one of the prominent minerals associated with the silver iodide (iodyrite) is the hydrous basic sulphate of ferric iron, jarosite.[20] In few places at Tonopah, however, was the larger part of the silver present as cerargyrite, but most of it was in the unaltered sulphides. In this respect the mode of occurrence differs from that at Divide, where most of the silver occurs as cerargyrite. Burgess found that the silver was nowhere carried far from the original sulphide ore, and the silver halides were deposited almost immediately after the oxidation of the sulphide from which the silver was derived.

As part of the silver in the unoxidized sulphides represents an enrichment by downward-moving waters of surface origin, its conversion into cerargyrite was therefore subsequent to the supergene enrichment. Evidently the alteration to cerargyrite was not as complete at Tonopah as at Divide, but the fact that during this conversion of the silver-bearing sulphides to cerargyrite no noteworthy redistribution of the silver in the ore bodies was effected is important as corroborative evidence in confirming the deductions drawn as to the distribution and genesis of the silver in the lodes at Divide, namely, that it was concentrated in the form of supergene argentite, and that argentite was subsequently changed to cerargyrite.

MINES AND PROSPECTS.

In August, 1919, ore was being shipped steadily from the Tonopah Divide mine for treatment at Tonopah, and small shipments were being made occasionally from two other properties. These three mines, which are described in the following paragraphs, illustrate the salient features of the geology of the ore deposits of the district. In addition to these there were several scores of prospects under active development, at some of which much exploratory work had been done. Shafts from 200 to 500 feet deep are common. To describe each property separately, however, would not add much to the knowledge of the district gained from those in which ore had been developed, so the description of these prospects is omitted.

[19] Knopf, Adolph, Occurrence of the silver halides in the oxidized zone of ore deposits: Econ. Geol., vol. 13, pp. 622-624, 1918.

[20] Burgess, J. A., op. cit., p. 19.

TONOPAH DIVIDE MINE.

The Tonopah Divide mine is on the east flank of Gold Mountain, a few hundred yards west of the divide on the main road between Tonopah and Goldfield. In the rhyolite, well up on the side of the mountain, is a narrow, erratic gold vein, which was worked by lessees more or less continuously after its discovery in 1901. The gold occurred in this vein in short, irregular shoots of ore, carrying from $18 to $40 a ton, and the lessees mined this ore in a small way, making little more than wages. In 1916 H. C. Brougher, one of the principal owners, decided to sink a shaft lower on the flank of the mountain, crosscut southwestward from it, and prospect the gold vein in depth. Sinking was started in April, 1917, and at a depth of 165 feet a crosscut was driven southwestward to cut the gold vein. In November the crosscut, then out 145 feet from the shaft, to the great surprise of the owners intersected a wide silver-bearing lode. This find naturally altered the company's plans, and its main energy was thenceforth devoted to exploring and developing the new discovery. The company increased its capital stock to 1,250,000 shares (par value $1) and acquired additional ground on the northwest. The property now consists of nine patented claims of 112 acres and four claims of 38 acres in process of being patented, a total of 150 acres.

The mine in July, 1919, was developed by a vertical two-compartment shaft 581 feet deep, from which crosscuts have been driven to the lode at depths of 165, 265, 365, 470, and 580 feet. Drifts have been run along the lode northwest and southeast from these main crosscuts. Electric-power equipment was installed in September, 1918, and in October the mine began to ship ore. Up to July 1, 1919, 7304 tons of ore, carrying $24.88 a ton, had been shipped, most of it to the mill of the Tonopah MacNamara Mining Co. in Tonopah. This ore was obtained chiefly as the result of development work. During the first six months of 1919 the ore treated amounted to 6,464 tons, averaging $28.24 a ton, from which a total net profit of $57,757, or $8.96 a ton, was realized.[21]

The silver lode of the Tonopah Divide mine crops out prominently 150 feet southwest of the shaft, but on account of the feeble iron staining and the absence of silicification, sericitization, or other pronounced evidence of the action of mineralizing solutions, the outcrop would not be suspected as the top of a large and valuable ore body. In fact, its significance was unappreciated by the present owners until after ore had been struck underground, when it immediately became of very lively interest. It was then seen that at one place in the outcrop a prospector had sunk a shaft 10 feet deep; this work, according to report, had been done in 1902 by Dick Rochelle,

[21] Tonopah Divide Mining Co., report of July 1, 1919.

one of the original locators in the district. Careful sampling of the outcrop showed it to be barren, except for a narrow streak against the wall of the old prospect shaft, which yielded, according to Superintendent William Watters, 100 ounces of silver to the ton.

The lode is inclosed in the Fraction rhyolite breccia and is a few hundred feet northeast of the intrusive mass of Oddie rhyolite of Gold Mountain. The contact between the Oddie rhyolite and the Fraction rhyolite breccia is exposed in the crosscut on the 265-foot level at a point 250 feet southwest of the footwall of the lode. It is marked by a fault gouge from 6 inches to 1 foot thick dipping 75° N. the contact, originally that of an intrusion, having been a locus of movement subsequent to the intrusion of the rhyolite. A rhyolite dike in the Fraction breccia is well shown in an open cut at the end of the dump at the main shaft, and a rhyolite dike has been cut on the 365 and 470 foot levels.

The lode trends northwest and stands practically vertical. The walls are generally well defined and mark a zone of faulting, as is well shown in the Gold Zone prospect, where conspicuously bedded tuffs abut against and are cut off by the lode. In the upper levels of the mine the material between the walls of the lode—the ore—is iron-stained rhyolite breccia. In depth the lode filling becomes lighter in color, being nearly ash gray, like that of the normal rhyolite breccia of the district, and carries disseminated pyrite, and the few thin veinlets of fine-grained quartz that traverse it become apparent. In places, especially on the higher levels, the lode is irregularly traversed by seams of extremely fine grained sericite, the so-called talc, the largest several inches in thickness. These seams commonly contain visible amounts of horn silver and yield assays running up to several thousand dollars a ton. In the leaner ore there is less oxidation, fewer sericite streaks, and more pyrite.

The ore at the place where the lode was first cut, on the 165-foot level, differs notably in one respect from any other since found in the mine. It contains a considerable quantity of the brilliant yellow mineral molybdite. The molybdite disappears in depth, and at the corresponding position in the next lower level powellite (calcium molybdate) occurs abundantly. Molybdenum minerals have not been noted elsewhere in the mine. At the discovery point the lode is 20 feet wide and averages $53.80 a ton across this width. Although pyrite is more abundant in depth, owing to decreasing oxidation, some occurs even in the ore at the discovery point. In places throughout the mine the ore has a blackish cast, suggestive of the occurrence of sooty argentite through it, but this mineral has not been definitely identified as occurring in the mine, although known to occur in the district.

The exploration so far accomplished shows that the ore occurs in a shoot approximately 400 feet long that pitches southward at a steep angle. The fissuring continues in full strength both northwest and southeast of the known ore, and the lode has been explored on the 500-foot level of the Gold Zone property, adjoining the Tonopah Divide on the southeast, where it averages $6 a ton across the width of 40 feet on the Tonopah Divide side of the end line. Between this point and the face of the drift on the 580-foot level, 200 feet southeast of the main crosscut, there remained in August, 1919, a length of 800 feet on the course of the lode to be explored.

The lode averages 21½ feet in width, and the ore averages $27.60 a ton, according to the report of the Tonopah Divide Mining Co. In computing the value of the ore the gold was figured at $20 an ounce and the silver at $1 an ounce. The ratio of gold to silver as shown by the assay returns of all samples is 1 ounce of gold to 200 ounces of silver.

According to the report of A. I. D'Arcy, formerly consulting engineer to the company, under date of July 1, 1919, "the mine has not been sufficiently developed to measure the ore reserves, but as a matter of speculation the openings now existing in the mine if taken to represent the true average over a width of 21½ feet, a length of 400 feet, and a depth of 500 feet would produce 330,000 tons of ore, and if the value as indicated by sampling is taken as $27.60 per ton the mine could be expected to produce $9,108,000 gross from the present workings." Further development failed to substantiate this estimate, however, and E. A. Julian, who succeeded Mr. D'Arcy as consulting engineer, estimates in the second annual report of the company a probable reserve of 52,000 tons of first-class ore averaging 20 ounces of silver and 0.08 ounce of gold to the ton.

The main crosscut on the 265-foot level after cutting through the silver lode was continued southwestward, penetrating the rhyolite stock of Gold Mountain, and at 450 feet from the silver lode it cut a narrow gold vein, probably the downward extension of the gold vein formerly worked higher on the mountain. The vein strikes N. 40° W. and dips 80° W.; it was followed a short distance southeastward to a point where it is cut off by a fault. The vein is 6 inches thick and is reported to carry in places $40 a ton in gold. It has also been cut on the 370-foot level, but there it was found to contain no ore.

DIVIDE EXTENSION MINE

The claims of the Divide Extension Mining Co. adjoin those of the Tonopah Divide Co. on the north. Early in the history of the district a shaft, known as the Kendall shaft, was sunk near the southwest corner of the property in order to prospect the northwest extension of the Tonopah Divide lode. At a depth of 150 feet a

crosscut was driven southwest, but it reached the side line of the cla without cutting the extension of the Tonopah Divide lode. By gr good fortune, however, it was found at this time, when the Tonop Divide lode had thus been shown not to traverse the ground of t Divide Extension Mining Co., disproving the supposition under wh the company had been organized and named, that a wide ore zo unknown when the company had been formed, crops out seve hundred feet north of the Kendall shaft. This mineralized zone o lode trends N. 10° E., making therefore an angle of 60° with th course of the Tonopah Divide lode.

The country rock is typical Fraction rhyolite breccia, and the ou crop of the newly discovered lode, consisting of somewhat altered a iron-stained rhyolite breccia, resembles in all respects the similar unpromising-looking material of the Tonopah Divide lode. A shaf called the Caldwell shaft, was sunk in the middle of the outcrop o this lode; in July, 1919, it had reached a depth of 100 feet and w being deepened. A crosscut, at a depth of 45 feet, was driven w and at 20 feet from the shaft reached 7 to 9 feet of ore lying agai a well-defined wall, supposedly the footwall of the lode. A crossc was also run eastward to the hanging wall, where 7 feet of ore carryi 40 to 60 ounces of silver to the ton was cut. The intervening ro between these two belts of ore on the footwall and hanging wa averages 2 ounces in silver to the ton. The total width of the lode, as shown by the crosscuts, is 50 feet, indicating a thickness of 40 feet but as crosscuts had not been extended into either wall it is n certain that the full thickness of the mineralized zone has bee determined.

On the 100-foot level a crosscut was run east, intersecting a bod of ore that is reported to assay $200 a ton across 12 feet. This bod of ore is probably the downward extension of the hanging-wall b of ore found on the 45-foot level; if this supposition is proved tru by further development work, then the ore body dips 57° E. A winze was sunk here, 6 feet deep at the time of my visit, and or rich in sooty argentite was found. The lode was developed for feet along the strike, the width being 16 feet and the dip 60° E Although argentite, which is associated with pyrite, was found in the winze, as already mentioned, the prevailing ore is highly oxidized and the silver occurs as cerargyrite. The lode is traversed by mar well-defined slips that strike and dip in various directions, evidently having been formed by irregular movements of adjustment wit the mineralized zone.

A crosscut was being driven from the bottom of the Kendall shaft the 425-foot level—to cut this lode on its projected strike and d N. 10° E. and 57° E.

TONOPAH HASBROUCK MINE.

The Tonopah Hasbrouck mine is in the western part of the strict, on the west slope of Hasbrouck Mountain. It is one of the lest properties in the district, having been located about 1902, d has been worked intermittently ever since. The ore shipped date is reported to aggregate 1,000 tons, whose value was chiefly silver and to a minor extent in gold, the average being 1 ounce gold to every 100 ounces of silver. Recent shipments to Tonopah eraged about 20 ounces of silver to the ton.

Most of the workings are on the vein known as the Kernick, which cut at a moderate depth by an adit at 500 feet from the portal. e adit was continued for 700 feet beyond the vein and in the last 0 feet penetrated a silicified rhyolite tuff, which is in the condition an iron-stained rubble and was said to carry $4 in gold to the ton. Northwest of the portal of the adit a shaft has been sunk to a pth of 230 feet. From the 200-foot level the former operators n a crosscut, which cut a vein that they thought was the extension the Kernick; because of its low tenor interest in the mine lan- ished thereafter. It is now believed that this vein is a separate in, and it has been renamed the McKane. From the bottom el the present operators are running crosscuts south and also rtheast. The country rock in these workings is all Fraction yolite breccia in unshattered condition, in marked contrast to the hly broken state of the rocks on the 200-foot level. In the face the south crosscut at the time of visit was a thin intercalated yer of banded fine gray tuff, whose attitude proves that the mation dips 20° W. here, in conformity with the general dip roughout the district.

The Kernick vein, as seen in the upper workings (above the main it), trends nearly due west, dips 70° N., and averages between and 4 feet in width. It consists of angular fragments of the untry rock, highly silicified, inclosed in a cement of exceedingly e grained bluish quartz. It is an extremely hard, tough ore. e walls are fairly well defined in places but as rule are rather gh, as if not much movement had taken place on them. The untry rock inclosing the vein is a silicified well-bedded tuff, locally wing cross-bedding.

The main adit affords an instructive section across the stratified s, showing their change from comparatively soft strata to ex- mely hard silicified rocks near the vein. At the intersection of vein by the adit a fair shoot of ore 50 feet long was stoped out ve the level. The vein is a few feet wide, but only a few inches postminerally crushed and oxidized gouge pays to extract. In ces 10 inches of such material on the footwall will, it is claimed,

yield $50 a ton. The former operators broke out 3 to 4 feet across the vein and sorted out the material of the footwall streak; this rejected material is said to carry, according to recent sampling, 12 ounces in silver to the ton and a little gold. Under present conditions ore is material carrying at least $15 a ton in precious metals. According to the manager if a mill were at the mine considerable ore of average Tonopah grade—that is, about $14 a ton—would be available.

THE MOGOLLON DISTRICT, NEW MEXICO.[1]

By Henry G. Ferguson.

INTRODUCTION.

The Mogollon (mo-go-yohn′) or Cooney district is in the southwestern part of Socorro County, N. Mex., about 14 miles from the Arizona line. (See fig. 29.) Silver City, the nearest available railroad point, is about 85 miles to the southeast. The district lies near the western border of the Mogollon Range, which here presents a

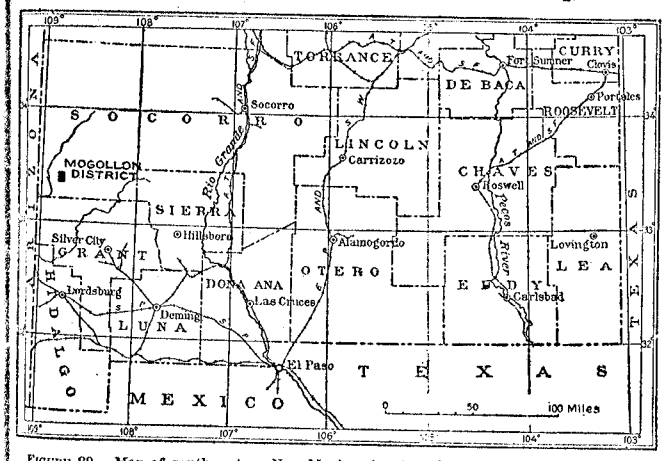


Figure 29.—Map of southwestern New Mexico showing the location of the Mogollon district.

steep front facing the valley of San Francisco River, to the west. The crest of the range, marked by a line of high peaks, is a few miles to the east. To the south the change from mountain to valley topography is less abrupt, and the steep rock cliffs facing the valley are not so prominent a feature of the landscape as they are near the Mogollon district.

[1] This paper was transmitted for publication prior to the appearance of an excellent article on the ore deposits of the Mogollon district by David B. Scott in Mining and Metallurgy, No. 158, section 33, February, 1920. The writer has, however, added a few notes drawn from Mr. Scott's paper.