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(SHORT PAPERS AND PRELIMINARY REPORTS)

1934-36

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Bulletin 847—A

THE CONTACT MINING DISTRICT NEVADA

BY

F. C. SCHRADER

Contributions to economic geology, 1934-35

(Pages 1-41)

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ILLUSTRATIONS

CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1934-35

THE CONTACT MINING DISTRICT, NEVADA

By Frank C. Schrader

ABSTRACT

This report summarizes the results of a reexamination, in 1930, of the Contact mining district, in Elko County, northern Nevada. A report published as a result of a visit in 1910 summarizes the major features of the geology of the district, and the principal new data in the present paper pertain to mining development occasioned by the completion of a railroad through the camp in 1925.

The district contains a stock or laccolith of granitic rock, which intrudes and arches Carboniferous limestone with some argillaceous and quartzitic beds. There are a number of dikes of alaskite and other rocks. Tertiary volcanic and sedimentary beds locally cover the older rocks. Ore deposits are rather closely spaced around the border of the main granitic mass and also associated with alaskite dikes that locally cut the granitic rock. The ore deposits are principally valuable for copper and in general are of contact-metamorphic type, although some are controlled in part by fractures and contain little or no lime silicate material. Mining has been carried on intermittently since the seventies, and it is estimated that over 300,000 tons of ore has been produced, most of it partly or wholly oxidized material from fairly shallow workings. Here, as at most other copper camps, operations have had to be greatly curtailed in recent years.

INTRODUCTION

SCOPE OF REPORT

The present report brings up to 1930 information regarding the Contact copper mining district, in northeastern Elko County, Nev. A reconnaissance of this district was made by the writer[1] in 1910 during a period of revived interest in this old camp. The coming of the railroad in 1925 again stimulated activity, and in order to study recent underground developments a brief reexamination of the district was made in October 1930. As there was little oppor-

[1] Schrader, F. C., A reconnaissance of the Jarbidge, Contact, and Elk Mountain mining districts, Elko County, Nev.: U. S. Geol. Survey Bull. 497, pp. 99–157, 1912.

tunity during this brief trip to reexamine the surface geology of the district, the reconnaissance map accompanying the earlier report is here reproduced with slight revision (pl. 2).

The geographic, historical, and geologic data given in the original report are summarized here, with such modification as is required by later information. Details regarding individual properties published in the earlier paper are repeated here only as far as required for adequate presentation of the new information.

ACKNOWLEDGMENTS

Valuable information and aid were generously given by the several mining companies, especially the Gray Copper Corporation and the Nevada-Bellevue Copper Mining Co., and by the mining men in general. In the laboratory study of the more difficult rock and ore specimens the work has received the hearty cooperation of the Geological Survey's specialists in chemical mineralogy, petrography, and metallography. The author is especially indebted to Mr. C. P. Ross for his critical review and revision of the manuscript.

GEOGRAPHY

LOCATION

The Contact mining district comprises the developed portion of the Salmon River mining district, legally established in 1909. Contact, the principal settlement, is close to the center of the area, on a branch of the Union Pacific Railroad, about 60 miles south of Twin Falls, Idaho, and 50 miles north of Wells, Nev. The district is about 300 miles by rail from the smelters at Salt Lake City, Utah. (See fig. 1.)

TOPOGRAPHY

The district is in one of the numerous small groups of mountains along the northern boundary of Nevada. It is drained by Salmon Falls Creek,[2] locally also called the "Salmon River." This stream rises in mountains close to the State boundary, flows southward and southeastward for nearly 30 miles, swings sharply to the northeast about 5 miles south of Contact, and continues northward to the Snake River at Lees Ferry, Idaho. Above Contact the stream flows in a narrow valley. Measurements made by the United States Geological Survey in 1914 at a point in this stretch of the stream above the diversion ditches indicate a mean annual flow of 134 second-feet. Below the town the valley widens where Meadow Creek enters.

[2] Decision of U. S. Geographic Board. This usage avoids confusion with the Salmon River that drains much of Idaho.

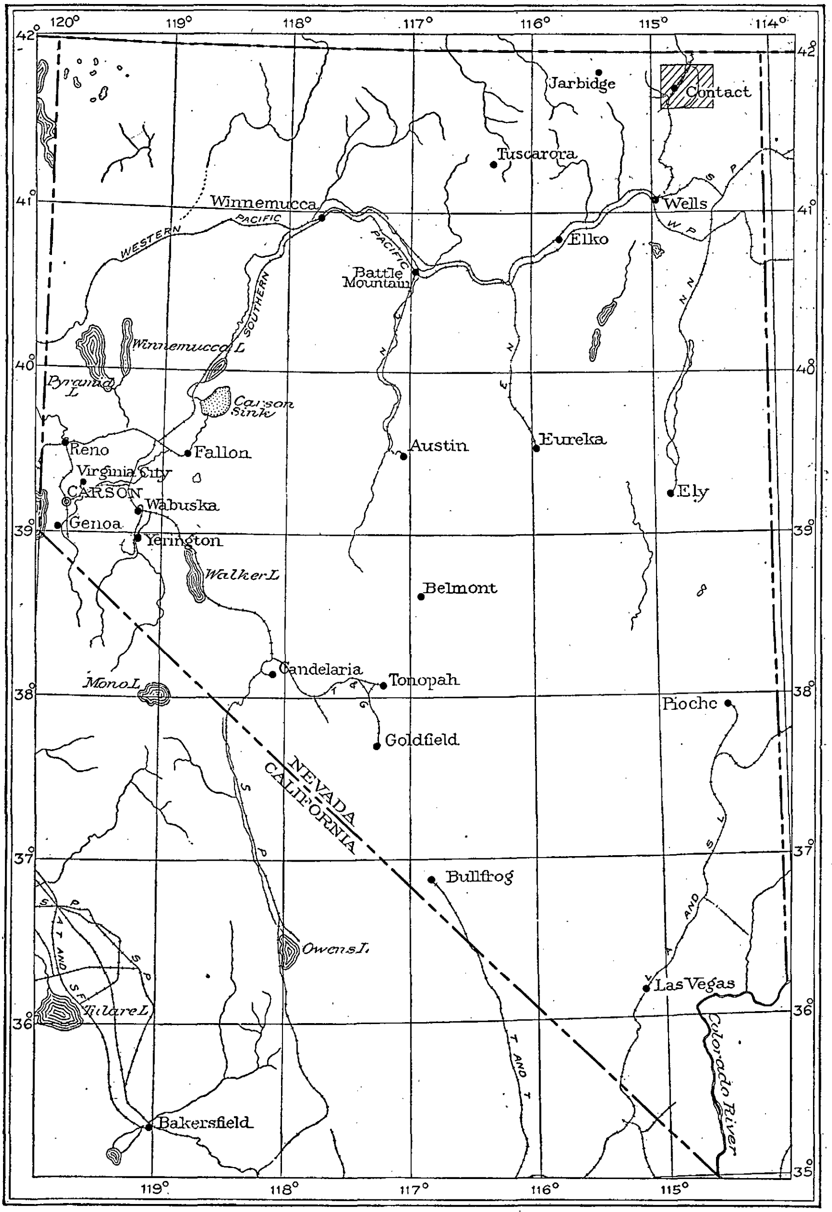

FIGURE 1.—Index map of Nevada showing location of the Contact district.

Farther north the valley is sharply contracted by a spur from Middle Stack Mountain, and downstream it widens again into a broad flat where Trout Creek joins Salmon Falls Creek. Most of the valley is somewhat more than 5,300 feet above sea level.

To the west there are rolling hills culminating in Ellen D. Mountain, over 8,200 feet high. (See pl. 1.) To the east there is a ridge, concave toward the main valley, with China Mountain, about 8,000 feet high, at the southwest end and Middle Stack Mountain, about 7,800 feet, near the northeast end. This ridge is cut off from high ground farther east by the curving valleys of Trout and Knoll Creeks. Along the central part of the ridge it is scarped on the side toward Salmon Falls Creek. The crest of the next ridge to the east, the H. D. Range, only a little of which is included in the area shown on plate 2, forms part of the divide between the Great Basin and the Snake River Basin.

The region is semiarid, and most of the scanty precipitation falls as snow. Vegetation is sparse on the mountain slopes, but on favorable slopes, especially in the area underlain by granitic rock, forage grasses grow. Willows and cottonwoods line the larger creeks. The flats along Salmon Falls Creek are utilized for grazing and for raising hay.

HISTORY AND PRODUCTION

Contact was founded in the early seventies. At first only gold was sought, but it soon became evident that copper was the principal valuable constituent of the ore of the district. Since 1876 there has been intermittent development and production, each period of activity being about 5 years long. It has been estimated that shipments from the district aggregate over 300,000 tons of copper ore, mostly from shallow workings. A smelting furnace was built in 1897 but ceased operations after three test runs, in which 14 tons of 98 percent copper was produced. There was considerable development in 1905 to 1910. During this period the site of the settlement was shifted about a mile east, to its present position. The World War brought another period of production. In 1918 the Vivian Tunnel Co. began to drive a long tunnel under the principal properties in the part of the district known as the "north contact zone," to facilitate their development. By 1930 only a relatively small part of this projected tunnel had been driven. Activity in the district was resumed in 1925, after the branch railroad from Twin Falls to Rogerson, in Idaho, had been extended through Contact to Wells, Nev. This branch provides easy access to points on the Union Pacific, Southern Pacific, and Western Pacific Railroads. It and a new highway have largely eliminated the transportation difficulties from which the camp had long suffered. As a result in 1930 the total cost of shipment to Salt

Lake City had been reduced to $2.75 a ton on 5 percent copper ore. Like many other copper camps, the Contact district has had to curtail activities greatly during the recent period of exceptionally low copper prices.

Production of the Contact district, Nevada, 1915–30

[Compiled from Mineral Resources of the United States]

Year	Ore	Gold	Silver	Copper	Lead	Total value	Value per ton of ore	Number of producers
	Tons		*Ounces*	*Pounds*	*Pounds*			
1915 [a]	36	$37	278	12,386	--------	$2,346	$65.16	5
1916 [b]	3,327	2,314	14,852	688,564	3,295	181,701	54.61	13
1917 [c]	253	38	746	65,655	5,215	--------	--------	8
1918 [d]	555	234	431	198,222	--------	49,626	89.42	4
1922 [e]	71	--------	--------	--------	--------	--------	50.46	2
1923 [f]	--------	--------	--------	--------	--------	--------	--------	1
1925 [g]	350	228	1,374	70,788	--------	11,234	32.10	--------
1928 [h]	4,142	2,060	7,933	418,645	1,000	67,044	16.19	4
1929 [i]	5,786	1,997	11,135	606,660	55,628	118,209	20.43	10
1930 [j]	1,253	954	4,399	133,810	71,269	23,606	18.84	8
	15,773	7,862	41,148	2,655,175	136,407	457,766		

[a] From Delano, Champ Clark, High Ore, and Copper Shield.
[b] Mostly from Delano; some from Mammoth, Bonanza, Palo Alto, and Hanks.
[c] From Bellevue, Champ Clark, Bonanza, Blue Bird, and Hanks.
[d] Mostly from Bellevue; some from Green Monster, Palo Alto, and Bellevue.
[e] Copper ore containing considerable silver from Delano and Blue Bird.
[f] Two lots of oxidized copper ore from Delano.
[g] Mostly from Delano.
[h] The ore shipped included one lot of copper precipitate from a leaching plant operated experimentally.
[i] The Seattle Contact Copper Co., operating the Delano group, was the principal producer of copper ore, shipping 3,924 tons to the copper smelters near Salt Lake City. The Gray Mining Co. shipped to the smelter 456 tons of copper ore; 220 tons additional went to the smelter from the Arizona, Brooklyn, Hanks, Lewis, Liberty Bell, and Queen of the Hills groups.
[j] Most of the production was made by the Seattle Contact Copper Co. and the Gray Copper Corporation.

NOTE.—In most years not listed small amounts of ore were produced.

In 1930 the new town of Contact had been laid out and electric power supplied from a Diesel plant installed by the Vivian Tunnel Co. and a water supply piped from nearby springs, in anticipation of an expansion, which was delayed by the depressed copper market. The town had a population of 260 people.

GEOLOGY

THE ROCKS

The rocks of the district include quartzite, limestone, and shale of Paleozoic age, intruded by granodiorite of probable Mesozoic age. Tertiary rhyolitic flows rest unconformably on the older rocks, and the principal valleys are floored by Tertiary lake beds covered by Quaternary alluvium. The general distribution of the rock units is shown in plate 2, but many details are necessarily omitted from this sketch map.

PALEOZOIC SEDIMENTARY ROCKS

Character.—The Paleozoic strata form an irregular belt 1 mile to several miles wide, surrounding the central granodiorite mass, They consist largely of blue limestone, mostly thick-bedded, with intercalated white beds, and quartzite and slaty quartzite, mostly near the base of the exposed sequence. The greatest exposed thickness is probably 2,000 feet or more in the area north of Ellen D. Mountain and Contact. The composite section below, compiled in part from data kindly supplied by J. V. Marshall, illustrates the general succession of the Paleozoic beds in the district, but it seems clear from the observations of Purington,[3] Bailey,[4] and the writer that lateral variation exists.

Section of Paleozoic rocks in Contact district

	Feet
Bluish limestone	1,100
White limestone	
Bluish limestone	
Thick-bedded quartzite	
Black limestone	
Reddish limestone and shale	
Slate or dark slaty to shaly quartzite	300
Quartzite, basal (?)	200
	1,600

The lower quartzitic and argillaceous beds have been examined in the vicinity of the Bryan tunnel, north of Contact, and on the Sue group of claims, 5 miles southwest of the town. (See fig. 4.) In both localities the basal quartzite is a thick-bedded pinkish-gray rock, and on the Bryan ground it has a total thickness of about 200 feet. The rock just north of the granodiorite contact, from the Nevada-Bellevue mine nearly to the portal of the Vivian tunnel, is quartzite and slate. Between the Bryan and Brooklyn claims there is a mass of dark slate or slaty quartzite about a mile long and 350 feet wide, enclosed in granodiorite[5] and cut by tongues of the intrusive rock. The slaty rock is deformed, silicified, and metamorphosed. Its most conspicuous lamination stands vertical, but there is an imperfect transverse cleavage, so that the rock weathers into irregular blocks with smooth faces. Near the Bonanza mine the rock for 400 feet from the granodiorite contact is limestone, but above this most of the rock is dark quartzite or quartzitic slate. There are also some quartzite and slaty beds in the limestone along Knoll Creek and on Middle Stack Mountain.

The limestone along the granodiorite contact is disturbed and broken. Locally large blocks of the limestone are included in the

[3] Purington, C. W., The Contact, Nevada, quaquaversal: Colorado Sci. Soc. Proc., vol. 7, pp. 127–138, August 1903; The ore deposit at Contact, Nev.: Eng. and Min. Jour., vol. 76, pp. 426–427, 1903.

[4] Bailey, J. T., The ore deposits of Contact, Nev.: Eng. and Min. Jour., vol. 76, pp. 612–613, 1903.

[5] Idem, p. 612.

granodiorite, and elsewhere sill-like apophyses of the granodiorite and dikes of related porphyritic rocks intricately intrude the main limestone mass. On the south slope of Ellen D. Mountain between the Silver Circle and Bonanza mines, a distance of about 2½ miles, the limestone in a zone 100 to 200 feet wide along the contact is especially broken. Several steeply inclined blocks of limestone appear to be detached and enclosed in granodiorite. These blocks and the main mass of sedimentary rock are cut by apophyses of granitic rock, both parallel and transverse to the bedding. Along some sections of the contact, such as the area east of the Brooklyn mine,[6] there is no noticeable contact metamorphism of the limestone, but in most parts of the contact this feature is conspicuous.

The contact-metamorphosed portions of the limestone are silicified and replaced in varying proportions by actinolite, garnet, chlorite, and diopside, together with less amounts of scapolite and other silicates. Axinite is locally conspicuous. (See also p. 15.) In places, such as the east slope of Ellen D. Mountain, some distance above the granodiorite contact, certain beds in the limestone are converted into a light-colored aphanitic rock, locally called "quartzite", which consists largely of diopside with a moderate amount of wollastonite and quartz. Rock of this sort is exposed in the face of the Helen B. Smith tunnel, on the Brooklyn claim west of the workings, and is abundant at the Hickey mine, 2½ miles east of the crest of Ellen D. Mountain, and on its north slope.

The most extensive area of contact metamorphism in the limestone is in the so-called "west contact zone", about 6 miles southwest of Contact. In this vicinity most of the limestone in a zone 1,200 to 1,600 feet wide along the granodiorite contact contains abundant lime silicates and related minerals and is intricately intruded by dikes and sheets of granodiorite and alaskite.

One of the masses of metamorphosed limestone of especial economic interest extends from the Brooklyn mine through the Silver Circle to the Rattler, a distance of about a mile. In this zone actinolite is the dominant mineral. Ore bodies are closely spaced within the zone except for a gap of about 1,000 feet between the Silver Circle and Brooklyn mines, in which as yet little development work has been done.

Age.—In the original report[7] it was suggested that the strata above described were probably of Carboniferous age, on the basis of similarity to strata of known or probable Carboniferous age exposed in several of the mountain masses in the surrounding region. In 1930 the writer found abundant crinoid remains in gray limestone on the divide between Trout and Knoll Creeks, in the south-

[6] Bailey, J. T., op. cit., p. 612.
[7] Schrader, F. C., op. cit., p. 106.

eastern part of the area shown on plate 2. G. H. Girty identified these as Carboniferous forms, thus establishing the age of at least part of the limestone sequence.

GRANODIORITE

Character.—The granodiorite mass has an exposed width of 6 to 7 miles and a length of about 18 miles in the central part of the area mapped on plate 2. It continues east of the mapped area to a total exposed length of over 25 miles. Along its border apophyses, not shown on plate 2, radiate into the surrounding sedimentary rocks.

The granitic rock at the Brooklyn mine is typical of the mass as a whole. It is a gray speckled rock of hypidiomorphic texture. Most of the grains have maximum dimensions of 1 to 2 millimeters. The rock contains about 55 percent of zoned plagioclase of the approximate average composition of oligoclase-andesine, 20 percent of granular interstitial quartz, 10 percent of perthitic potash feldspar which tends to lie between and wrap around the plagioclase crystals, 10 percent of pale-brown biotite, and 5 percent of green biotite. Here and there are small amounts of myrmekitic intergrowths of quartz and plagioclase. Apatite and titanite are abundant accessory constituents. Most of the rock is fresh, but there are knots and flakes of sericite in some of the plagioclase, and the ferromagnesian minerals are locally somewhat chloritized.

In some localities, especially along the borders, the granodiorite shows the effects of pressure. Crystals are bent and broken, and the quartz shows strain shadows. At the Johnson property, near the head of Trout Creek, the granodiorite close to the contact is distinctly gneissic. The larger plagioclase crystals and the ferromagnesian minerals, which are somewhat more abundant than in most of the rock, have their long axes parallel. Much of the interstitial material is finely granulated quartz and feldspar.

The granodiorite appears to have been extensively and deeply weathered. It is friable and so porous as to absorb water readily, as is shown by the numerous springs in the areas underlain by it.

Age.—The granodiorite is younger than the Carboniferous beds and older than the Pliocene (?) volcanic strata that rest on its eroded surface. In the earlier report[8] it was suggested that the granitic rock of the Contact district and the similar rock of the Jarbidge district belong to the same general period of intrusion as the batholiths of California and western Nevada, which came to place near the end of the Jurassic or early in the Cretaceous. Recently Anderson[9] has suggested that the somewhat similar Cassia batholith, about

[8] Schrader, F. C., op. cit., pp. 34, 108.

[9] Anderson, A. L., Geology and mineral resources of eastern Cassia County, Idaho: Idaho Bur. Mines and Geology Bull. 14, pp. 55–56, 1931.

50 miles northeast of Contact, is of late Cretaceous or early Tertiary age. The exact age of the granitic rocks of this region is still subject to debate.

ALASKITE DIKES

Character.—The dikes termed in the earlier report [10] "syenitic or siliceous", which cut both the granodiorite and the Paleozoic beds, seem on further study to be best designated "alaskite." Nearly all the dikes mapped on plate 2 are of this character. A few may be andesitic. Most of these dikes are less than 5 feet wide, but some are much wider, and locally, as on the Salt Lake ground, near Contact, and on the Camp Bird claim, 2 miles east of Salmon Falls Creek, they attain widths of 200 feet or more. Some of the dikes are so resistant to erosion as to stand up above the surface of the surrounding granodiorite. Only the larger and more persistent dikes are mapped on plate 2. Most of them are pale pink or flesh-colored, especially where weathered. Some are light gray to iron-gray. The rock is somewhat porphyritic, and phenocrysts are most conspicuous on weathered surfaces. In some dikes the component grains are rounded; in others they show crystal form. Commonly the grains have maximum dimensions of 1 to 2 millimeters; some phenocrysts are larger. Some of the dikelets an inch or so wide are composed of elongate grains perpendicular to the walls, approximating comb structure. In places there are small cavities, some of which contain chalcedonic or hyaline silica.

The rock is composed mainly of potash feldspar and oligoclase in roughly equal proportions, with less than 10 percent of quartz, less than 5 percent of biotite and hornblende, and titanite, apatite, zircon, and magnetite as accessory minerals. The titanite is conspicuous, some grains being as much as 2 millimeters wide. Many of the dikes, especially near ore deposits, contain considerable sericite, and in these dikes the ferromagnesian minerals are largely chloritized.

Age.—These dikes cut the granodiorite and surrounding Paleozoic rocks. They appear to represent a late phase of the igneous activity that produced the granodiorite mass and hence to be of comparable age.

ANDESITE DIKES

Characters.—Some of the dikes, termed "lamprophyric or basic" in the original report [11] and locally called "birdseye porphyry" or "felsite", have andesitic habit and composition. Dikes of this kind were observed chiefly in the western and northern parts of the district, where they cut the granodiorite and Paleozoic rocks and are said

[10] Schrader, F. C., op. cit., p. 110.
[11] Idem, p. 111.

to cut the alaskite dikes also. In the gulch southeast of the Bryan shaft, near Contact, there is a dike of this kind nearly 8 feet wide. Another crops out on the southeast flank of Ellen D. Mountain, and this or a similar dike is exposed at the top of the mountain. These dikes are iron-gray to nearly black, with feldspar and hornblende phenocrysts, commonly about 2 millimeters long, in a groundmass composed largely of irregular, zoned feldspar laths about 0.2 millimeter long with a tendency to parallel arrangement resulting from flowage. In some dikes the laths are as much as 0.5 millimeter long. The average composition of the feldspar is about that of andesine. The ferromagnesian minerals commonly make up 25 percent or more of the rock. They are hornblende and biotite with occasionally a little augite. Quartz is nowhere abundant and where present appears to be of late introduction. There is some titanite. The rock was hydrothermally altered, probably during and just after consolidation. The ferromagnesian minerals are so thoroughly chloritized that the original character of many grains is indeterminate, and the feldspar is sericitized.

Age.—These dikes appear to be younger than the alaskite just described. As their texture resembles that of volcanic rocks, it is suggested that they may be of Tertiary age. They might be related either to the more calcic varieties of the Pliocene(?) flows of the Contact district or to the somewhat older Tertiary flows that are plentiful in neighboring areas.

TERTIARY VOLCANIC ROCKS

Character.—Tertiary silicic lava flows and pyroclastic rocks cover the older rocks on the borders of the Contact district and in small erosion remnants in the central part of the district, some of which have not been shown on plate 2. Obviously these volcanic strata once covered the whole area and have been eroded from much of it. The maximum known thickness in the Contact district is about 500 feet, on the northwest slope of Ellen D. Mountain.

Most of the beds are dense rocks through which minute feldspar grains are sparsely disseminated. They are bluish to brownish gray on fresh surfaces and reddish brown where weathered. Some of these rocks are fine-granular rhyolitic or latitic lava containing alkalic feldspars (in part oligoclase), subordinate tridymite and quartz, a few small grains of augite, and a little epidote. Many are welded pumice built up principally of fragments of glassy pumice that were ejected during explosive eruptions and fell while still hot enough to coalesce and flow to some extent. These contain a few crystals of quartz and alkali feldspar, rarely more than 0.2 millimeter wide, and a little augite and epidote.

Age.—The scanty information available regarding the area between the Contact and Jarbidge districts suggests that the rhyolitic rocks above described are practically coextensive with the young rhyolite flows of the Jarbidge district, which have been tentatively referred to the Pliocene.[12] Petrographically there is much resemblance between the rock in the two areas. Similar rhyolitic flows and pyroclastic rocks appear to be widespread in northern Nevada and southern Idaho. In the latter area, also, the younger flows of this kind are regarded as Pliocene.[13]

TERTIARY LAKE BEDS

Character.—The larger valleys of the district are floored by gray tuffaceous sandstone beds, which rest unconformably on an irregular surface carved on representatives of each of the rock units described above and are in large part covered by alluvium. The tuffaceous beds are particularly well exposed along upper Knoll Creek. They underlie much of the alluvium in the valley of Salmon Falls Creek and in the large, gently sloping embayment between Meadow Creek and Middle Stack Mountain and extend nearly to the heads of Knoll and Trout Creeks.

Erosion in the soft tuffaceous beds tends to produce bluffs and miniature badland forms. The present known thickness of the formation ranges from a maximum of about 400 feet on Knoll Creek to a knife-edge. In undissected parts of the formation along Salmon Falls Creek the thickness may be materially greater. In most places the beds lie nearly horizontal, but in some places they are gently folded.

The tuffaceous sandstone is thought to be material deposited in ash showers and somewhat sorted by water. The bedding is variable and not sharply defined. Most of the beds are composed of minute elongated particles of volcanic glass with a little biotite and hornblende. Along Trout Creek there are local deposits of calcareous tufa or marl containing fragments of the older rocks. Near Contact there is a thickness of 100 feet or more of coarser, angular volcanic tuff. At the old site of Contact a 72-foot well is entirely in medium-grained tuffaceous sandstone. In the present town a well 90 feet deep is almost entirely in tuffaceous sandstone, with some argillaceous material. This well is bottomed in granodiorite, 60 feet below the level of Salmon Falls Creek.

The tuffaceous sandstone has been used to some extent in buildings in Contact. The principal quarry is about 1½ miles north of the town.

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[12] Schrader, F. C., op. cit., pp. 42–47.

[13] Stearns, H. T., and others, Geology and ground-water resources of the Snake River Plain in southeastern Idaho (manuscript report).

Age.—The tuffaceous sandstone is younger than the rhyolitic beds previously described. No fossils have been found in it. The beds were tentatively correlated with the Humboldt formation (Pliocene) in the earlier report.[14]

STRUCTURE

The Paleozoic sedimentary rocks are flexed into a gentle dome with an intrusive mass of granodiorite at its core. The doming and intrusion are probably interrelated. Unlike most of the folds in the surrounding region, this dome has a long axis trending almost due east. In this respect and in the apparent relation between folding and intrusion the structure of the Contact district resembles that of the Raft River Mountains, in northwestern Utah, about 50 miles away.[15]

In the Contact district the sedimentary beds dip away from the granodiorite on all sides at low angles, rarely over 20°. In the immediate vicinity of the contact there is much contortion and fracturing. In several places near and west of the old town of Contact and also in the west contact area the limestone dips steeply toward the granodiorite, as a result either of overturning or of faulting. A fault has been tentatively mapped in the sedimentary rocks near and parallel to the granodiorite contact on the south slope of Ellen D. Mountain, and similar faults probably exist at other points. Cross faults affecting the contact have been mapped near the Johnson mine above the head of Trout Creek. Detached masses of sedimentary rock enclosed in the granodiorite commonly stand vertical. The granitic rock has in places been injected along the bedding, and locally, as in the vicinity of the Bryan tunnel and in parts of the west contact area, such injected, sill-like masses are interconnected by dikelets filling fractures in the intervening sedimentary rocks. The granodiorite of the main mass, especially along its margins, is jointed and more or less closely sheeted.

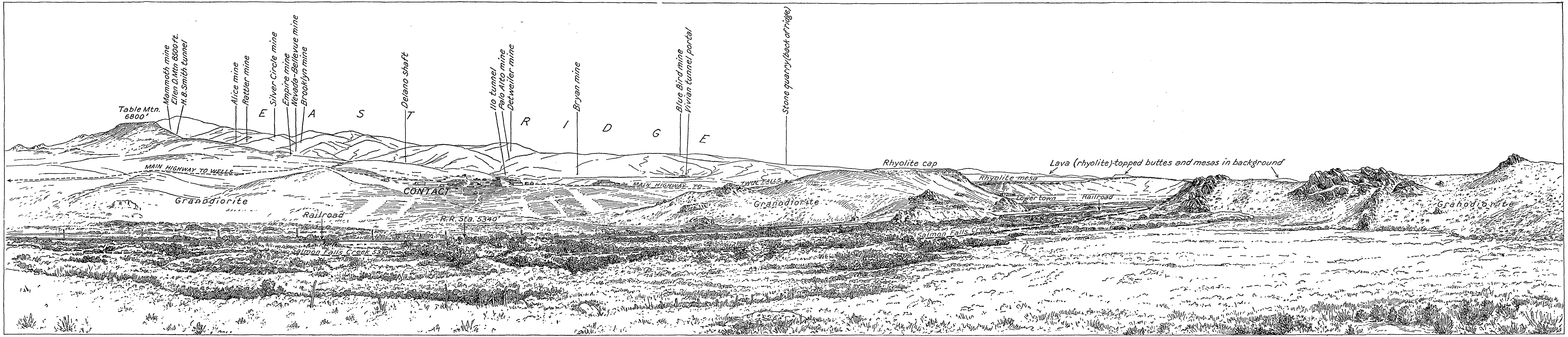
The alaskite dikes intruded shortly after the granodiorite came into place are remarkably long and straight and follow a conjugate fracture system affecting both the granodiorite and the surrounding Paleozoic beds. One set of dikes trends mainly N. 30°–45° E.; the other N. 45°–60° W.; a few in both sets trend somewhat outside of the limits indicated. Apparently both sets stand essentially vertical.

The data outlined above point strongly to some genetic relation between folding, faulting, and intrusion. It has been suggested[16]

[14] Schrader, F. C., op. cit., pp. 31–32.

[15] Butler, B. S., and others, The ore deposits of Utah: U. S. Geol. Survey Prof. Paper 111, pp. 496–499, 1920.

[16] Purington, C. W., op cit., pp. 130–132. Bailey, J. T., op. cit., p. 612.



THE WESTERN PART OF THE CONTACT DISTRICT, NEVADA, LOOKING NORTHWEST FROM THE FOOTHILLS EAST OF SALMON FALLS CREEK.

GEOLOGIC RECONNAISSANCE MAP OF THE CONTACT DISTRICT.

that the granodiorite mass is a laccolith intruded between the Carboniferous beds that it arches and underlying older strata, such as are known in several places in the surrounding region. This is a possible but by no means a necessary explanation of the observed facts. The hypothesis that the intrusion has the form of a stock which crosscut the buried older rocks fits the available data equally well. Although, as can be seen from plate 2, erosion has cut several thousand feet into the central part of the grandiorite below the probable original upper surface, no evidence of a floor is known. Probably the relatively deep erosion over the central part of the granitic mass was facilitated by fracturing related to the intrusion, and the Paleozoic rocks along the margins are preserved in part because they were rendered harder and more resistant as a result of the igneous metamorphism. They were baked and more or less completely replaced by quartz and lime silicate minerals.

The Tertiary strata have been disturbed, probably in two periods of deformation. Neither the rhyolitic beds nor the tuffaceous sandstone shows much folding. Locally, as on upper Knoll Creek, the lake beds are inclined as much as 30° and may have been faulted. The distribution of the rhyolite as mapped on plate 2 suggests either that it was deposited on an irregular surface or else that there has been subsequent faulting of some magnitude.

MINERAL DEPOSITS

TYPES AND DISTRIBUTION OF THE LODES

The ore deposits of the Contact district are valuable mainly for copper. They contain also some gold and silver and locally enough lead to be of value. The lodes are of three related intergradational kinds. These are (1) deposits in or closely related to contact-metamorphosed limestone, commonly in close association with the border of the granodiorite mass; (2) fissure veins with local enlargement by replacement, especially in the limestone; (3) deposits along fissures in or near alaskite dikes or disseminated in fractured parts of such dikes. All three kinds of lodes have features in common, as will be seen from the descriptions below. The distinguishing characteristics appear to result from differences in the wall rocks and in structural details rather than from any fundamental difference in genesis. Most of the lodes of the first two kinds are in a narrow zone along the roughly horseshoe-shaped contact between the granodiorite and the Paleozoic rocks.

The principal development to the date of writing is in the area about a mile wide extending from the vicinity of the present town of Contact almost due west for about 7 miles. This area is commonly known as the "north contact zone." It is also sometimes called the "east ridge area," because much of it is on the eastern spur of Ellen D. Mountain. Another group of properties is in an area about 4 miles long and 1 mile wide known as the "west contact zone", from the fact that it lies along the most westerly part of the granodiorite contact. Although contact metamorphism is more widespread here than in any other part of the district, and numerous prospects have been opened, past production and recent activity are much less here than in the north contact zone. In both zones the deposits belong to the first two kinds defined above.

Most of the deposits of the third type, associated with alaskite, are in the granodiorite area between the west contact zone and the present town of Contact. Similar lodes occur in the granodiorite northeast of China Mountain.

Most of the scattered and for the most part slightly developed prospects on both sides of the granodiorite mass east of Salmon Falls Creek are associated with contact-metamorphosed limestone and hence are of the first type. Some of them differ from the deposits of this type farther west in that they are not quite so close to the contact and appear to conform essentially to the bedding of the limestone without much shearing.

The parts of the granodiorite contact traversed by Salmon Falls Creek and Meadow Creek are hidden by Tertiary beds and by alluvium. They have consequently not been prospected, but they may contain buried lodes similar to those on each side. Lodes in these valleys would be at somewhat greater depths below the crest of the granodiorite mass than those that have been prospected and might therefore be mineralogically somewhat different. Moreover, present ground-water level here is obviously nearer the surface than it is on the mountain slopes, and any ore found beneath the young deposits would be expected to be comparatively free from the effects of oxidation and enrichment. To what extent this is true, however, depends largely on the geomorphic history of the region, which has not been worked out.

CHARACTER

LODES RELATED TO CONTACT METAMORPHISM

Some of the lodes intimately associated with contact-metamorphic minerals are directly on the contact of the main mass of granodiorite. The deposits in the Brooklyn and Nevada mines are typical of this variety. In such deposits and in some of those within the sedimentary rocks there is evidence of fissuring and fracturing that doubtless aided the circulation of the mineralizing solutions. It seems likely that in most or all places where a lode has formed directly on the contact the mineralization was localized by previous faulting, possibly as a result of settling and readjustment following the intrusion of the granodiorite.

Certain of the lodes, such as the minor deposits in the west contact zone, are distributed through contact-metamorphosed limestone with little apparent relation to fissuring. Others, as in the Boston mine, in Middle Stack Mountain, are in beds of contact-metamorphosed material essentially conformable to the surrounding less altered limestone.

The proportions and relations of the different minerals vary somewhat, but it appears that generally the limestone was first silicified and then replaced by contact-metamorphic minerals. Commonly actinolite, diopside, or wollastonite or two or more of these minerals constitute most of the metamorphosed rock. Garnet, axinite, epidote, and chlorite are present in varying proportions in many of the lodes. Axinite, a rather rare borosilicate of aluminum and calcium with some iron and manganese, has been shown to occur in a number of the lodes, but much of the material locally regarded as axinite is composed mainly of actinolite and other silicates. Garnet, also, is not as abundant as is commonly supposed. Part of the carbonates in the original limestone remain unchanged. There is also some recrystallized calcite and locally apparently dolomite as well. In most of the lodes, especially those associated with shearing, glassy vein quartz is conspicuous, and most of the sulphides are in such quartz. Later veinlets of quartz and locally of calcite cut the lodes. The complex silicates are mostly in the limestone, but some have replaced the adjoining granodiorite. Similarly the quartz and sulphides are chiefly in the limestone but enter the granodiorite, especially in places where apophyses of the granodiorite are intercalated in limestone.

The principal hypogene copper mineral is chalcopyrite. Bornite is commonly present and may in part be hypogene. In several of the lodes molybdenite, magnetite, and specularite are present but not in sufficient quantity to be of economic interest. It is noticeable that pyrite is rare or absent in the lodes of the district.

In many of the lodes, particularly those along the granodiorite contact, there is a rough, irregular banding arising in part from shearing, in part from original interlamination of different kinds of rock, and in part from variations in the degree of contact metamorphism and of deposition of the valuable minerals. Most of the lodes of apparent economic interest are 15 to 30 feet thick, but commonly only certain bands within the lode contain much copper.

The copper content of the ore ranges from 3 percent or less to rarely as much as 50 percent. Probably much of the ore so far exposed contains materially less than 10 percent of copper. Several ore bodies of this grade have much of their copper in certain narrow high-grade bands. Essentially all the ore in the present workings has been affected by supergene processes (pp. 17–18), so that it is impossible to judge the average content of the original ore. In places, however, considerable massive chalcopyrite is present, and therefore some of the hypogene material is evidently of high grade.

Both in these lodes and in the others in the Contact district the content of precious metals varies with the copper. Except in certain bands of nearly massive sulphide, the amount of silver and gold is too small to be of much commercial consequence.

FISSURE VEINS

The lodes of the second type are typified by most of the veins in the north contact zone east of the Brooklyn mine. They follow lines of fissuring and brecciation in either granodiorite or sedimentary rocks. A few, such as the Nevada-Bellevue, lie in the granodiorite contact in localities where contact metamorphism is inconspicuous. Some, such as the Junction and Old Abe veins, in the western part of the north contact zone, cut diagonally across the granodiorite contact. Certain of them, such as the Old Abe, are enclosed in part in contact-metamorphosed limestone and here resemble lodes of the sort previously described. The veins that contain notable amounts of lead minerals, such as the Silver King and others east of Salmon Falls Creek, show much more intricate and abundant brecciation of both country rock and quartz with recementation by later quartz than is present in the more common variety of veins valuable mainly for copper. In those copper veins that extend into relatively unmetamorphosed limestone there is local enlargement by replacement of the limestone in the walls of the fissure zone.

The veins of this type are rudely banded, largely as a result of shearing. Most of them range from 1 foot to 10 feet in thickness. There has been some alteration of the country rock and deposition of silicates, but the principal introduced gangue mineral is quartz. Much of the quartz is coarse-grained and vitreous, but in places, especially in the brecciated parts of the veins, there is jasperoid silica. The copper sulphides are the same as in the other lodes in the district. Some lodes contain 3 to 10 percent of copper and small amounts of precious metals, largely in supergene minerals. Certain of the lodes, low in copper, evidently originally contained galena, a little sphalerite, and possibly some argentite, but these hypogene minerals have been largely destroyed by oxidation. The small amount of arsenic reported in ore from the Hickey mine suggests the original presence of arsenopyrite or a sulpharsenide. Most of the lead ore so far exposed contains 10 to 20 percent of lead, 4 to 20 ounces of silver to the ton, and from a trace to 3 ounces of gold to the ton. In most of it the amount of zinc is small, but some of the Silver

King ore is reported to carry 20 percent of zinc. In the lead mines that have been opened to depths of more than about 100 feet copper is present on the lower levels.

VEINS RELATED TO ALASKITE DIKES

The veins of the third type differ little in character of ore from the copper-bearing variety of the fissure veins just described. Most of them follow fissures in and parallel to alaskite dikes, and locally the ore minerals are disseminated widely through fractured and altered dike rock, so that the whole dike is more or less mineralized. The principal hypogene minerals are quartz, chalcopyrite, molybdenite, and specularite. None of these veins have yet received much development.

OXIDATION AND ENRICHMENT

Oxidation is prevalent in most of the lodes of all three kinds down to depths of 150 to 250 feet below the surface, although the ground-water level is reached in most of the mines at shallower depths. In some places, notably in the western part of the north contact zone and in the west contact zone, considerable chalcopyrite remains in the outcrop. Locally in dense contact-metamorphosed rock containing abundant actinolite much or all of the original sulphide has been preserved from oxidation, even in the immediate vicinity of the surface.

Chrysocolla, malachite, azurite, copper pitch, cuprite, and native copper constitute much of the valuable content of the copper ore so far mined. Hematite and limonite are fairly plentiful. Pyrolusite, psilomelane, and probably other oxidized manganese minerals are locally conspicuous. Cerusite is the principal oxidized mineral in the lead ore, but mixtures of oxides containing lead and zinc are also present. Kaolin and chloropal or nontronite are derived from weathering of the silicate minerals, and the chloropal is locally abundant. Chalcedony is present in places, probably as a result of redistribution of silica by meteoric water. The oxidized copper minerals, especially chrysocolla, have impregnated both the original lode matter and neighboring wall rocks. In several places there are large masses of low-grade ore consisting of chrysocolla in limestone or granodiorite with little or no indication of hypogene mineralization. Such widespread staining of the rocks by the brightly colored copper minerals gives the impression of very extensive ore deposition.

Underground exploration is as yet hardly adequate to give much of an idea of the extent of sulphide enrichment. Bornite is present in most of the copper deposits that have been opened to depths of much more than 100 feet and to a less extent nearer the surface. Most of the narrow, high-grade streaks contain abundant bornite associated with chalcopyrite. Presumably part or all of the bornite is of secondary origin, but the available evidence on this point is inconclusive. A little covellite and locally considerable chalcocite are present, and there can be little question that both are formed by supergene solutions which derived their copper from oxidized ore near the surface. Some of the chalcocite, like the chrysocolla previously mentioned, has been deposited in what apparently would otherwise be barren country rock. The 300-foot zone in the limestone of the middle part of the Helen B. Smith tunnel, reported to contain 1½ percent of copper as chalcocite, is probably of this nature.

OUTLOOK

The future of the Contact district depends largely on the progress of the copper industry in the United States. Although the railroad has improved its situation markedly, the district remains one of small production and high costs as compared to the areas from which most of the world's copper ore is derived. Development has progressed far enough to show that several ore bodies of small to moderate size exist here, although some are irregular and discontinuous. Apparently much of the ore contains 5 percent or less of copper and not enough of other metals to add greatly to its value. It is reasonable to suppose that shoots of enriched sulphide ore of higher tenor exist. A certain amount of such ore has already been found, but it has not yet been extensively developed. Below the enriched ore, at levels not yet reached by any of the workings, bodies of hypogene chalcopyrite ore, perhaps comparable in grade to the oxidized ore that has been mined, are to be expected.

MINES AND PROSPECTS

In the following descriptions the properties are grouped geographically. Those in the north contact zone, economically the most important, are described first. As the group of lodes from the Brooklyn east to the Antelope are interrelated and include some of the most productive mines, they are described before the lodes in parts of the north contact zone to the north and west. After these come the prospects in the west contact zone, followed by those in the granodiorite area between that zone and Contact. Next come the properties near China Mountain, followed by those near Blanchard Mountain and the heads of Trout and Knoll Creeks. Finally mention is made of the properties near Middle Stack Mountain and along the nearby slopes of the valley of Trout Creek. Plate 3 shows the distribution of the claims according to the best information available in 1930.

As little work has been done since the writer's previous visit, in 1910, on many of the deposits in the west contact zone and most of those in the other areas here described, only some of the salient points in regard to them are here given, and the reader is referred to the earlier report[17] for more detailed descriptions.

NORTH CONTACT ZONE

BROOKLYN

The Brooklyn property is about a mile west of Old Contact, at an altitude of about 6,300 feet. It was first located about 1890, and the principal development work was done in 1901 to 1904. Recent operations include the shipment in 1928 of a small amount of picked

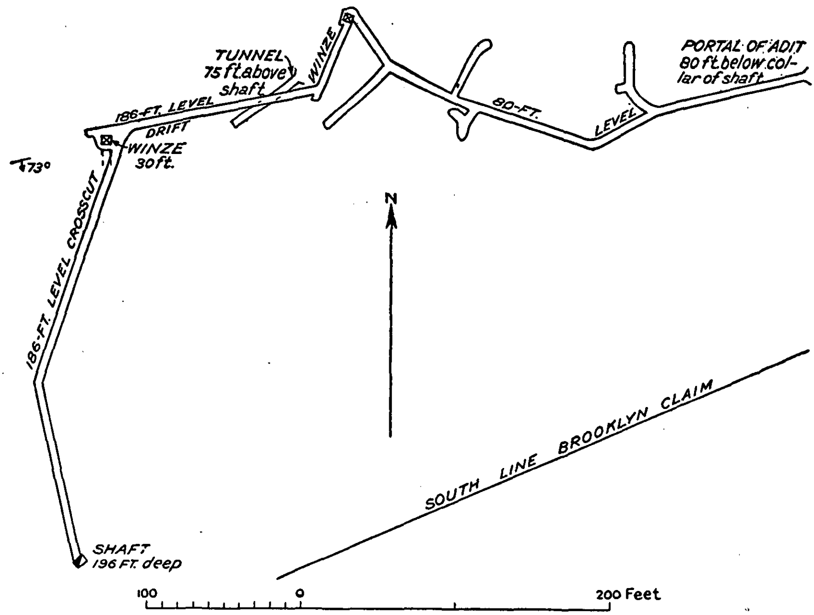


FIGURE 2.—Diagrammatic sketch of Brooklyn workings. From map furnished by the Brooklyn Mining Co.

ore from the dump and some mining by a lessee in 1930, mainly in a tunnel 80 feet below the shaft collar.

The property comprises 2 full and 4 fractional claims. As is shown in figures 2 and 3, it is developed by a shaft 196 feet deep with a crosscut at a depth of 186 feet which extends 276 feet from the shaft to the lode. There are short drifts both ways from the end of the crosscut, and a 30-foot winze sunk in sulphide ore of good grade close to the end of the crosscut. A tunnel 332 feet long is driven along the lode, entering the hill 80 feet vertically below and about 550 feet northeast of the shaft. This tunnel is connected with the lower workings by a winze.

[17] Schrader, F. C., op. cit., pp. 129–150.

The shaft and crosscut are in granodiorite, and the lode is on the contact between that rock and Paleozoic strata, here mainly white limestone. The contact trends N. 80°–85° E. and dips 73° toward the granodiorite, apparently as a result of fault movements subsequent to the intrusion. The walls of the lode on the 186-foot level are parallel, clean, and smooth. The vein is 18 feet wide. The limestone here is silicified close to the lode, and the granodiorite on the hanging wall has a coarse, almost pegmatitic texture for a width of 2 feet. At the mouth of the tunnel at the 80-foot level the lode is 8 feet wide in sheeted granodiorite, apparently with associated alaskite dikes.

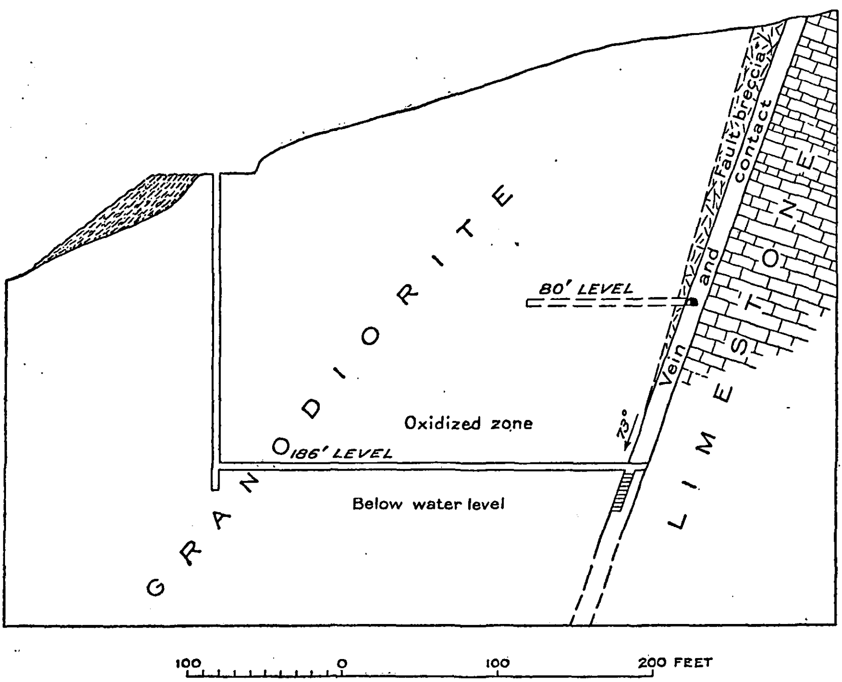
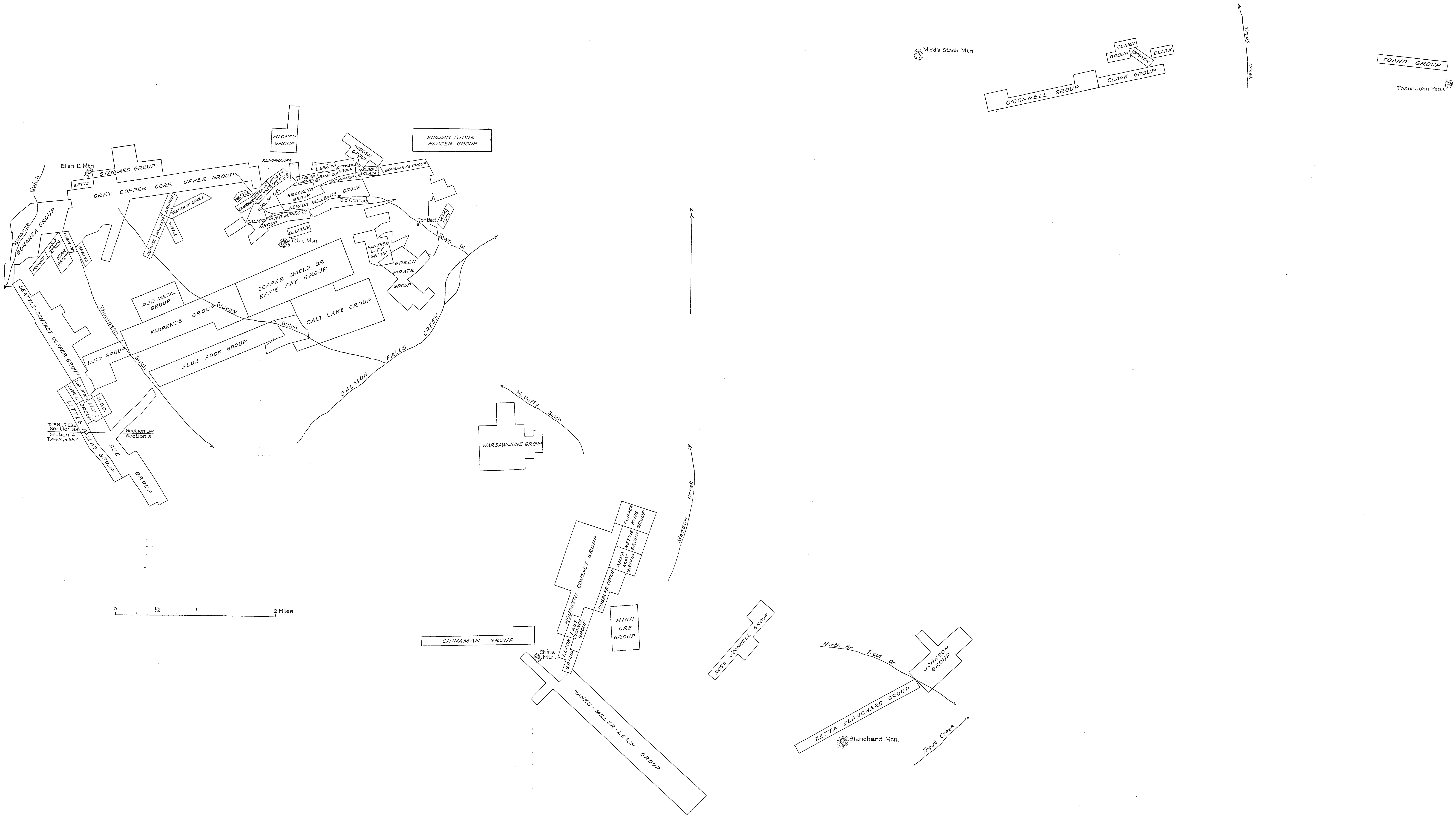


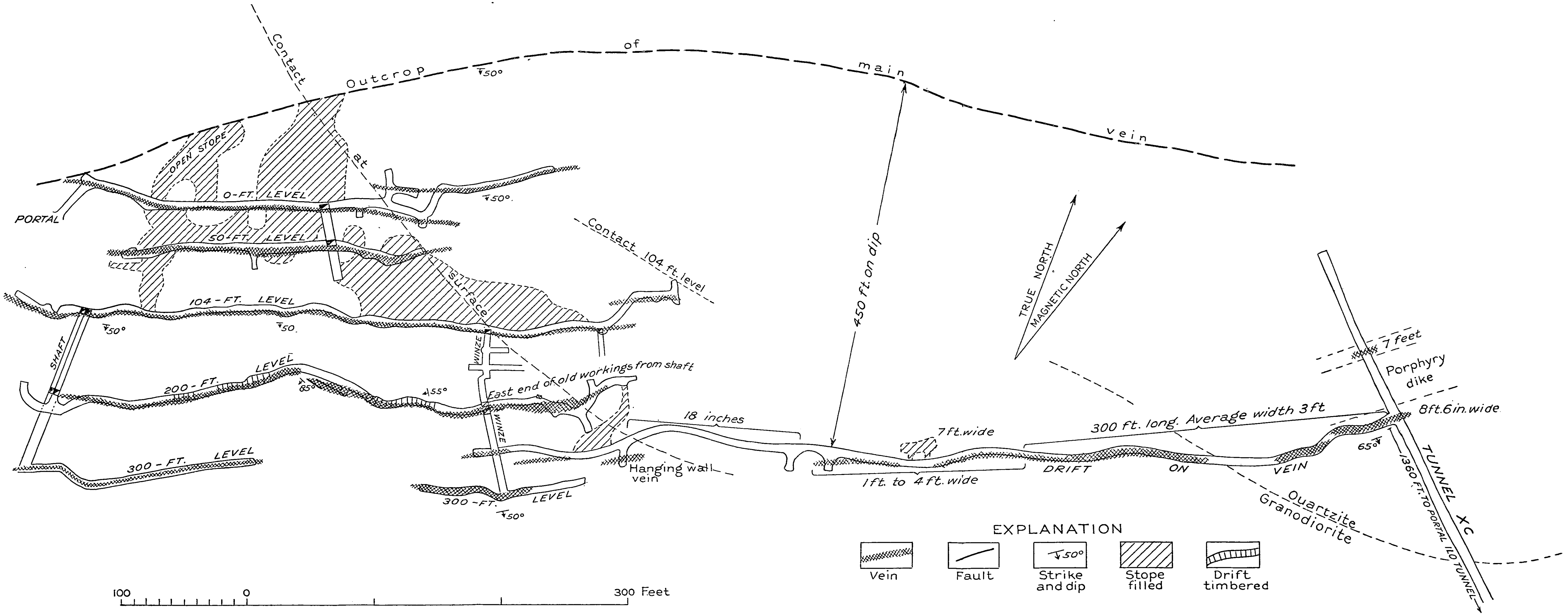
FIGURE 3.—Diagrammatic geologic section through the Brooklyn mine.

The gangue minerals of the lode include glassy white quartz, garnet, calcite, actinolite, and axinite. Down to about the 186-foot level the metallic constituents of the lode are largely in the form of carbonates and other oxidized minerals, although at present ground-water level is about 96 feet below the collar of the shaft. In the winze connecting the 80-foot and 186-foot levels the ore is oxidized and leached and contains seams of native copper. Much of it is reported to contain about 3 percent of copper.

Seams of native copper are reported in the granodiorite near the lode in the lowest workings. On and near the 186-foot level the metallic minerals are bornite, chalcopyrite, and pyrite with little oxidation. One 15-inch seam of bornite ore, much of which contains



CLAIM MAP OF THE CONTACT DISTRICT.



GEOLOGIC SKETCH MAP OF THE NEVADA-BELLEVUE MINE.

46 percent of copper, is reported. The bornite appears to be secondary. The lode over a width of 16 feet, including the high-grade seam, is reported to average 4 percent of copper and 1.5 ounces of silver and 0.01 ounce of gold to the ton.

At the end of the crosscut on the 186-foot level there is 2 feet of chalcopyrite ore of commercial grade in a garnet-axinite gangue on the footwall, followed by a 20-inch high-grade band containing alternate seams of bornite and chalcopyrite ore. Beyond this is nearly 3 feet of chalcopyrite-pyrite ore of commercial grade with quartz gangue, followed by 8 feet of similar material averaging about 3 percent of copper, and, on the hanging wall, 2 feet of vein matter with some chalcopyrite and pyrite.

The following analysis of the gangue of the Brooklyn vein has been kindly supplied by the Brooklyn Mining Co.:

Analysis of the gangue of the Brooklyn vein

Silica	53.50	Soda	5.00
Alumina	8.24	Potassa	.40
Iron protoxide	6.22	Water	.20
Lime	16.60		
Magnesia	9.26		99.42

Specific gravity, 3.1251.

The following analyses help further to give an idea of the composition of the vein:

Analyses of Brooklyn vein and adjacent material

	Silver (ounces to the ton)	Copper (percent)	Silica (percent)	Iron (percent)	Lime (percent)
Gangue near footwall	0.6	2.7	80.6	5.2	2.4
Average of 10 feet of footwall side of vein	1.4	9.2			
Footwall	.5				2.6
Picked sample of bornite	14.14	48.5	13.6	14.5	
Average waste of vein from big dump	1.60	3.66	8.2	7.1	4.5

The average smelter returns of several small shipments of ore to the American Smelting & Refining Co. at Garfield, Utah, are: Copper, 4.08 percent; iron, 12 percent; silver, 1.25 ounces to the ton; gold, 0.01 ounce to the ton. Returns by the same company dated August 23, 1929, on 44½ tons shipped by W. A. Southard, give copper, 4.5 percent; silver, 1.25 ounces to the ton; and gold, 0.015 ounce to the ton.

For some time Mr. Harrington, a lessee, has been working with encouraging results on a northeast-southwest vein associated with a granodiorite dike or sill cutting the limestone on the Valley View claim, about 1,000 feet north of the Brooklyn mine. Returns on 10½ tons of this ore shipped to the Garfield Smelting Co. at Salt Lake City are about 3.5 percent of copper and 1.3 ounces of silver to the ton. From a point near his shaft, which is some 60 feet deep, a ledge of garnetiferous gossan extends northeastward on the Green Monster claim, where also some good copper carbonate (malachite) ore was mined in or near the gossan.

SALMON RIVER MINING CO.

The Salmon River Mining Co., of Butte, Mont., incorporated in 1896, owns 13 patented claims, in part surrounding the Brooklyn property, just described. The principal development is on the Empire and Lena claims.

The Empire mine is on the south side of Town Gulch, half a mile southwest of Old Contact and about 1,000 feet south of the Brooklyn mine. The Empire contributed some ore from shallow workings, now caved, to the local smelter in 1896 but has long been idle. The principal development is a 260-foot shaft sunk in soft, altered granodiorite in the hanging wall of a fissure vein similar to that on the Delano (Nevada-Bellevue) ground. The vein dips steeply south. In shallow early workings it was about 3 feet wide. The shaft caved before a crosscut could be driven to the vein. On the surface the vein appears to continue northeastward through the Arkansas and Western Union claims of the Nevada-Bellevue group and southwestward through the Empire extension.

The Lena shaft, about half a mile southwest of the Empire, was sunk in 1896 and 1897. The shaft is 200 feet deep and has a 50-foot crosscut at the bottom driven southward to tap a vein that crops out at the surface. The shaft and workings are in weathered granodiorite. They are now caved, and the data here given were kindly furnished by V. S. Kemper.[18] An ore body was encountered 60 feet below the collar of the shaft. This body, which dips 60° S., appears to be a local enlargement by replacement of the vein, which continues below it. About 50 tons of oxidized shipping ore, assaying 14 percent of copper, was obtained from this body. The crosscut at the bottom of the shaft disclosed nothing of value.

NEVADA-BELLEVUE COPPER MINING CO.

The property of the Nevada-Bellevue Copper Mining Co. (organized about 1917) comprises 10 claims (fig. 4) on which there are 12 small mines and some prospects. The area containing the principal mine of the group, the Nevada-Bellevue, was described in the

[18] Letter of Oct. 21, 1931.

earlier report[19] as the Delano and Copper King groups of claims. This mine is about 1,500 feet northeast of the old town of Contact. Another mine, the Bellevue, is about 3,000 feet west of the Nevada-Bellevue and 600 feet south of the Brooklyn mine.

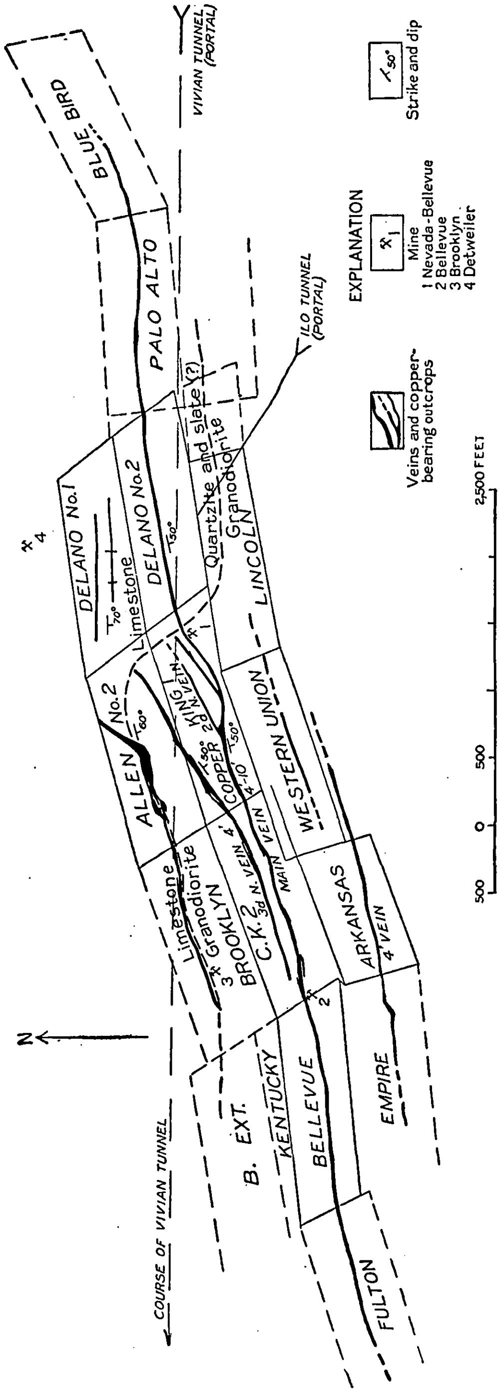


FIGURE 4.—Geologic sketch map of the Nevada-Bellevue group of claims, showing approximate relations of the veins. Base from data supplied by the company.

Most of the group was acquired by the present company for $250,000. The Bellevue claim cost an additional $20,000. It is reported that $350,000 was expended by the company prior to 1925 in developing and equipping the property.

Although most of the deposits have been known since the late eighties, there appears to have been little production prior to 1913. The shipments from 1913 to 1930 aggregated over $2,500,000. In 1913 to 1917 roughly $125,000 was produced, mainly from ore averaging about 10 percent of copper. In 1918 the group produced 12,000 tons containing 22 percent of copper, 75 cents in gold to the ton, and a little silver, valued in all at $65,000. In 1920, 300 tons was shipped, and in 1926 two lots of

[19] Schrader, F. C., op. cit., pp. 121–122.

oxidized ore were shipped by lessees. In 1928 to 1930, 180 cars or 2,000 tons of ore was shipped. Of this total, 55 cars contained freshly mined ore, and the rest was obtained from the dump. The average content of 20 cars that came from the Ilo tunnel was 9 percent of copper and 4 ounces of silver and 70 cents in gold to the ton. The remainder averaged 6 percent of copper and 23 ounces of silver and 60 cents in gold to the ton. Much of this ore came from the raise on the 100-foot level of the Nevada-Bellevue mine, the winze on the zero level, and the upper tunnel of that mine. The Allen claim yielded 8 cars of ore. The Bellevue mine yielded $50,000 in 1917 to 1925 (apparently included in the total above given). Some lots contained as much as 26 percent of copper. The material from the dump averaged 5 percent of copper.

In 1926 to 1928 an attempt was made to leach the ore in place. About $7,500 in copper was recovered, but the cost of pumping and loss of solution in fissures and other openings made the undertaking so unprofitable that it was abandoned. Water was pumped from Salmon Falls Creek, a distance of 8,000 feet, with a lift of 600 feet to the upper tunnel of the Nevada-Bellevue. A solution of 3 percent sulphuric acid was allowed to percolate from this tunnel through the oxidized ore and collected in and near the Ilo tunnel, some 250 feet below.

The Bellevue mine contains a 200-foot shaft, a 120-foot crosscut tunnel, and 1,000 feet of drifts, mainly on the 100-foot and 200-foot levels. In the ground lying between the Nevada-Bellevue and Bellevue mines there is a prospect crosscut tunnel 300 feet long from which 150 tons of high-grade ore has been shipped. On the Allen no. 2 claim there is a 40-foot crosscut tunnel and other minor workings.

The Nevada-Bellevue mine, like the Bellevue, develops the lode commonly termed the "main vein" (fig. 4). The principal workings (pl. 4) comprise the zero, 50-foot, 104-foot, 200-foot, and 300-foot levels. The zero level connects directly with the surface, and the other levels are reached by winzes. This part of the mine develops the vein to a depth of more than 400 feet vertically below the outcrop and an average distance of about 500 feet along the strike. On the 250-foot level a drift extends 700 feet eastward on the vein to connect with the Ilo tunnel at a point 1,360 feet from its portal. The Ilo tunnel was driven for purposes of development and drainage about 1926.

As shown in figure 4 and plate 4, the group lies along the boundary between the granodiorite and Paleozoic beds at a place where there is a sharp bend in the contact. It is possible that the bend results from faulting, but direct evidence of this has not been found. At and close to the bend the Paleozoic rock is quartzite and slate, whereas in most other places it is limestone. The difference in behavior during intrusion resulting from this fact may have had an influence on the shape of the contact. In the part of the irregularity in the contact explored by the Nevada-Bellevue mine the contact dips steeply northeast down to the 104-foot level and more gently below. Close to the intersection between the drift on the 250-foot level and the Ilo tunnel (pl. 4), a 30-foot dike of porphyritic alaskite cuts the quartzite in the footwall of the vein. Similar dikes cut the granodiorite on Copper King no. 2 claim.

The mineralized zone along the granodiorite contact extends east from the Brooklyn ground (p. 23) into the Allen no. 2 claim, where shallow workings expose it for a width of 120 feet. This zone consists of alternating bands of altered and mineralized granitic rock and thin layers of limestone, capped with gossan. A 10-foot tunnel in the eastern part of the Allen no. 2 claim shows carbonate ore containing 8 percent of copper. The mineralized zone does not appear to persist eastward beyond the bend in the contact. The two discontinuous veins in white limestone on the Delano no. 1 claim (fig. 4) may possibly mark extensions of the fissuring along the contact. These veins average about 5 feet in width, and the ore consists of red and black oxides, carbonates, and some bornite. It is reported to average 3½ percent of copper, but some of it is said to contain as much as 50 percent.

South of the claims above described there are four or more veins that have yielded most of the ore so far mined in the Nevada-Bellevue group. These veins trend somewhat north of east, parallel to the general trend of the granodiorite contact, but at least one of them cuts across the part of the contact with southeasterly trend (fig. 4). Their average dip is about 50° SE. The veins range in thickness from 1 to 10 feet. Much of the oxidized ore in them contains about 4 percent of copper. The longest one, known as the "main vein", has been traced on the surface for nearly 10,000 feet and opened in the Nevada-Bellevue mine to a vertical depth of about 400 feet.

On the Copper King no. 2 claim the main vein is about 6 feet wide, dips about 50° S., and consists largely of copper oxides and carbonates in a quartz gangue. A similar vein, called the "third vein", approximately parallels the main vein about 120 feet to the north. This vein is nearly 2,000 feet long and about 3 feet wide.

The main vein in the Nevada-Bellevue mine trends about N. 70° E. and dips about 55° SE. The ore above the 250-foot level is largely oxidized. Ore shoots tend to pinch in passing from the granodiorite into the quartzite, as is well shown on the 104-foot level. According to data supplied by the company, much of the vein on the 200-foot level is 3 to 8 feet wide, and assays range from about 2 percent of copper and 1 ounce of silver to the ton to 10.14 percent of copper and 8.4 ounces of silver to the ton. Most assays show less than 5 percent of copper. On both sides of the winze near the northeast end of this level there is a shoot of higher-grade ore with a length of about 60 feet along the drift. Assays here range from 5.46 to 25.48 percent of copper and 4.1 to 13.1 ounces of silver to the ton. In a shoot of chalcocite ore nearly 100 feet long and 2 to 4½ feet wide on the 300-foot level assays range from 4.77 to 15.09 percent of copper and 2.28 to 11.89 ounces of silver to the ton, and the average of 16 consecutive samples is 9.05 percent of copper and 3.09 ounces of silver to the ton.

East of the Nevada-Bellevue mine the main vein can be traced on the surface through the Delano no. 2 and Palo Alto claims and part of the Blue Bird claim. (See p. 23.) The rock here is quartzite and slate, and the vein in consequence tends to be pinched and interrupted. It averages about 4 feet in width, however, and on the Delano no. 2 claim much of the ore is reported to contain about 3½ percent of copper.

PALO ALTO

The Palto Alto mine is about two-thirds of a mile north-northwest of the town of Contact, on the Palo Alto claim, which joins the Bellevue and Delano group on the east, at an altitude of about 5,850 feet (pl. 2). The deposit was discovered in 1894 and was owned by the Nevada Copper Mining, Milling & Power Co. until about 1926, when it was acquired by the present owner, the Gray Copper Corporation. The mine is credited with the production of about 1,700 tons of ore, of which most of the 300 tons produced prior to 1910 is said to have averaged about 30 percent of copper and $3 in gold and 8 ounces of silver to the ton, and 200 tons produced in 1914 and 1,200 tons produced in 1928 ran 5 percent of copper and 3 ounces of silver to the ton. Most of the latter ore was obtained in sinking the winze from the tunnel or 150-foot level to the east drift.

The mine is developed by a 292-foot shaft, a 150-foot crosscut tunnel, 300 feet of drifts, and 100 feet or more of crosscuts and stopes, distributed on 4 levels. The whole workings are said to have cost more than $8,000. The 50-foot level contains the crosscut tunnel, 150 feet of drift, 50 feet of crosscut, and a 60-foot winze; the 100-foot level contains 30 feet of drift and 50 feet of crosscut; the 290-foot level, 125 feet of drift and 25 feet of crosscut; and the 250-foot level, 30 feet of stope.

The mine is in dark-colored coarse slate with some pinkish quartzite a few hundred feet north of the main granodiorite body. The Paleozoic beds are upturned and dip toward the contact at angles of about 75°. They are cut by numerous granodiorite apophyses, mostly along the steep cleavage planes in the slate, as shown diagrammatically in figure 5.

The principal lode here is a small fissure vein in one of the granodiorite tongues, about 40 feet wide, in the upper part of the mine. The shaft shown in figure 5 follows this vein, which pinches downward and ends at the contact with the enclosing slate. Hence the

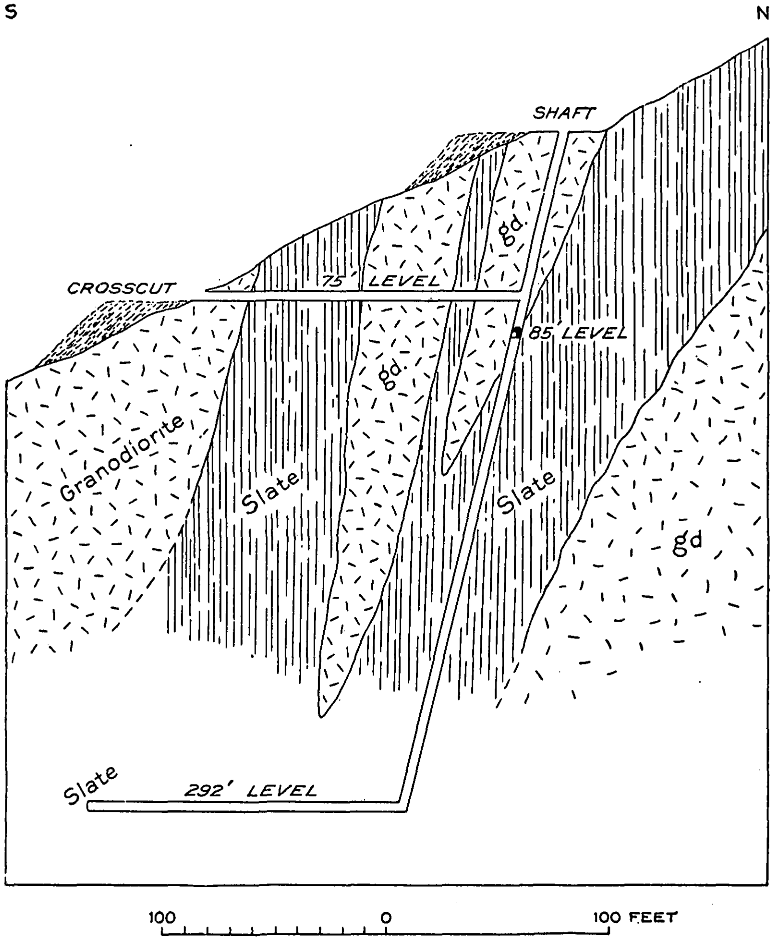


FIGURE 5.—Geologic cross section through the Palo Alto shaft. After J. T. Bailey, Eng. and Min. Jour., vol. 76, p. 613, 1903.

workings in the lower 200 feet of the mine are in barren slate. This vein is paralleled by a smaller, blind vein in the slate, which was found in a crosscut driven as a result of a suggestion made orally by the writer in 1910. The blind vein has yielded a fair tonnage and still contains some good ore. The vein followed by the shaft is likewise reported to contain ore as yet unmined. Some of this ore contains about 30 percent of chalcocite.

In the southeastern part of the Palo Alto claim the slate is cut by a quartz vein striking N. 60° E. and dipping 70° SE. Pits show it to contain sufficient red copper oxide and carbonate to suggest that further prospecting is warranted.

BLUE BIRD

The Blue Bird property comprises 10 claims immediately east of the Palo Alto and is two-thirds of a mile almost due north of the present site of Contact. It is owned by the Gray Copper Corporation.

The mine, which is on the Blue Bird claim, at the west end of the group, was located in 1884. Its early production is not known. Prior to 1910, 100 tons of ore from an ore heap here was shipped to smelters at Selby and Contact. The ore sent to the Selby smelter is reported to have contained 32 percent of copper, and that smelted at Contact is said to have contained 17 percent of copper and about 20 ounces of silver and $2 in gold to the ton. About 300 tons of lower-grade ore remains in the ore heap. Since 1910 the Gray Copper Corporation has mined and shipped 1,000 tons said to have averaged 6 percent of copper and 3 ounces of silver to the ton. The principal shipments were made in 1928, and most of the ore came from around the collar of the shaft. The shaft is inclined 70° SW., and chambers and short crosscuts lead off from it.

The mine is in white limestone with intercalated quartzite and slate about 1,000 feet north of the granodiorite contact. North of the lode there is a band of quartzite, and to the south and southeast there is considerable dark siliceous slate or slaty quartz, which dips steeply south and is cut by northward-trending dikes of granodiorite and similar rocks.

The lode appears to be the eastward extension of the main vein on the Nevada-Bellevue group (p. 23), with local enlargement by replacement of limestone. It strikes northeast, dips about 60° SE., and is intersected by a fault of northerly trend. West of the cross fault the limestone dips steeply south. East of it the dip is steep to the north, and some of the rock appears to be quartzite. These conditions indicate considerable displacement. Mineralized ground extends laterally along the bedding planes of the limestone and quartzite on both sides of the fault near the surface. On the 60-foot level the vein terminates against the cross fault, in and near which considerable quartz and calcite have been deposited.

The main ore body in general has a width of 3 feet but in places is much wider. The ore contains malachite, chrysocolla, red, brown, and black copper oxides, and some chalcocite and is said to average over 3 percent of copper. Replacement deposits of oxidized ore occur in and along the cross fault and in the limestone north of the mine.

BRYAN

The Bryan mine is about 1,200 feet southwest of the Blue Bird mine, on the southwest end of the Bryan claim, which joins the Blue Bird claim on the south. It is opened by a shaft and tunnel. The tunnel is in granodiorite just under quartzite, in or just above which three or more granodiorite sills that apparently follow the bedding of the sedimentary rocks crop out several feet above the surface and in places are connected by cross dikelets. The shaft is said to have in the bottom ore averaging 4.78 percent of copper, but so far as learned the mine has not made any shipment.

ANTELOPE

The Antelope mine is about one-third of a mile northwest of the new site of Contact, south of the Palo Alto and Bryan mines. The deposit was discovered about 1898 and worked on a small scale until 1910, but nothing appears to have been done there recently. The production is very small.

The Antelope vein is in the main mass of granodiorite about 600 feet south of the contact and is one of the few promising deposits so situated. The granodiorite is sheeted approximately parallel to the vein, which strikes northeast and dips 80° SE. The vein is about 2 feet thick and contains glassy quartz and oxidized copper minerals, with some sulphide showing in the bottom of a 60-foot shaft, the deepest working on the property. A parallel vein with nearly vertical dip about 75 feet to the north is reported to contain high-grade ore where opened by a shaft on Antelope ground.

DETWEILER

John Detweiler, of Contact, has recently opened a new prospect on two claims about 2,000 feet north of the old site of Contact, south of the Nevada-Bellevue property. At the time of visit in 1930, 30 tons of ore had been shipped and 20 tons lay on the dump. The property is developed by a tunnel with a short crosscut 50 feet from the portal and a 40-foot inclined winze from the crosscut. Minor openings extend 100 feet or more farther up the hill. The workings are in limestone 800 feet north of the granodiorite contact. The limestone dips 40° a little south of east. There is an alaskite porphyry dike near the lode, which is a replacement deposit along a fracture zone trending N. 60° W. and dipping northeast, into the hill.

VIVIAN

The Vivian Tunnel Co., a subsidiary of the Gray Copper Corporation, proposed to drive a tunnel nearly 4 miles long that would pass under the principal properties in the north contact zone, drain them, and facilitate development at depth. When completed, this tunnel was intended to be made available as a haulageway for all mines along its route, on a toll basis.

The portal of the tunnel is on the Bobs claim close to the Bryan mine and about half a mile from the railroad at Contact. The tunnel trends due west. It is double-tracked and 7 by 9 feet in cross section. Between 1918 and 1930 it had been advanced 310 feet from the portal, but business conditions had compelled suspension of operations. The objective is a point 20,452 feet from the portal and 2,050 feet below the surface. This point is below the Helen B. Smith tunnel and other workings on the upper group of properties of the Gray Copper Corporation.

HICKEY

The Hickey mine, commonly known as the "Lead-Silver mine" and also as the "Jones mine", is on a group of four claims about a mile northwest of old Contact, in the canyon on the north side of the eastern spur of Ellen D. Mountain, three-fourths of a mile north of the main contact, at an altitude of 6,050 feet (pl. 3). It is the most northerly of all the north contact deposits. The deposit was located in 1887 by Thomas Gray, the present owner. For many years it was owned by M. F. Hickey. A small production was made prior to 1910, after which the mine lay idle until about 1929–30, when T. O. Jones, the present lessee, mined and shipped 600 tons of ore, of which 45 tons is said to have netted about $12 to the ton. The shipment was mostly yellowish and pink lead carbonate ore.

The ore is said to average about 18 percent of lead, 3 percent of zinc, 1.5 percent of arsenic, and 12 ounces in silver to the ton, and it contains also a little copper, which rapidly increases below the 100-foot level. Some of the ore mined was very rich in silver.

The deposit is opened to a depth of 150 feet, mainly by a shaft and drifts aggregating 600 feet of new work. The first 50 feet of the shaft is vertical and is timbered; the next 50 feet inclines 80° E., down to the 100-foot level, below which the shaft is again vertical to the bottom of the mine. The old workings consist principally of a short tunnel driven southward, from which lead-silver ore was mined in the early days.

The deposit is a north-south quartz vein 2 to 5 feet wide, with an epidotelike mineral and nontronite. It dips steeply eastward in limestone on or near the hanging wall of a bed of gray quartzite

50 feet wide and seems to be mostly a replacement deposit in a finely comminuted siliceous fault breccia.

No igneous rock was observed at the mine, although the limestone nearby is largely altered to a greenish-gray silicate rock composed chiefly of diopside about 60 percent, quartz 30 percent, wollastonite 10 percent, and some sericitic mica. The wollastonite occurs mostly in small grains and stout prisms, and the quartz in very irregular small areas, crystals, and grains.

The vein is said to extend through the length of two claims. The principal ore mineral down to the 100-foot level is argentiferous cerusite, probably derived by oxidation from the primary ore minerals, argentiferous galena and argentite, which are still present in the ore.

The formation is said to have changed to calcareous shale on the 100-foot level, possibly a result of faulting. From this point to the bottom of the mine copper carbonate is increasingly abundant, with the result that the ore in this deeper part of the mine is changed from the yellowish lead carbonate or cerusite ore to a brownish-red material known locally as "binoxide ore", which seems to consist principally of carbonate and oxides of iron, lead, and copper.

About 300 feet west and uphill from the mine a quartz vein containing copper and a little gold dips 80° E. in dense light-colored shattered quartzite. Nearby the quartzite is cut by a north-south alaskite porphyry dike, which on the north passes beneath a mass of rhyolitic lava (not shown on pl. 2) and on the south is said to extend to the west end of the Brooklyn property.

SILVER CIRCLE

The Silver Circle mine, formerly the Queen of the Hills,[20] is about a mile west of the old site of Contact. It is now owned by Dominick Quilici, of Wells, Nev., and operated under lease by the Silver Circle Mining Co., of Salt Lake City, Utah. Little was done here prior to 1928. From then to the middle of the summer of 1930, 1,000 tons of sulphide ore containing about 11 percent copper had been mined and shipped. Some of this ore contained 29 percent of copper and a little lead and silver.

The mine is opened to a depth of 250 feet by a shaft inclined 50° S., with drifts and stopes and two tunnels, 80 and 100 feet long, both driven northeastward. At the time of visit in 1930 a bulkhead at the 150-foot level prevented access to the lower part of the mine.

The mine is on the main granodiorite contact about half a mile west of similar mineralized ground in the Brooklyn mine. Most of the ore is in the metamorphosed limestone north of the contact.

[20] Schrader, F. C., op. cit., pp. 123–124.

Nearby there is a granodiorite dike of northerly trend and a dike of porphyritic alaskite. The zone of metamorphosed limestone along the granodiorite contact is about 100 feet wide, and the principal ore zone within it is 4½ to 10 feet wide. Some ore is present here and there in other parts of the metamorphic rock. The limestone has been silicified and later replaced by actinolite, diopside, chlorite, tremolite, biotite, axinite, a little garnet, and other minerals. The proportions vary in different places, but commonly actinolite is the most abundant mineral. In the ore zone glassy vein quartz is abundant and veinlets of later quartz cut the ore. The principal sulphide minerals are chalcopyrite and bornite. Magnetite is locally conspicuous. In places a little chalcocite is present, and the lower workings show a little galena.

Unlike most other lodes in the district, the Silver Circle contains sulphide even in the outcrops. This is thought to be due to the imperviousness and resistance to weathering of the actinolite masses. Oxidized minerals are conspicuous at the surface, however, and are present in minor amount in the lowest or 250-foot level. The oxidized minerals include iron and copper oxides, malachite, and cuprite. Shallow workings in the granodiorite nearby expose areas 8 to 10 feet wide and 40 to 50 feet long in which the granodiorite is stained and penetrated by copper carbonate. Locally along fracture planes the carbonate is sufficiently abundant to constitute 8 percent copper ore.

UPPER GROUP OF PROPERTIES OF THE GRAY COPPER CORPORATION

Most of the deposits along the granodiorite contact between the Silver Circle and Bonanza mines are now owned by the Gray Copper Corporation. Most of this ground was formerly owned by the Nevada Mining, Milling & Power Co. The present owners refer to the 20 or more claims here as their "upper group" of properties. The principal development on this group is at the Rattler, Alice, Magnolia, Highland, Helen B. Smith, and Mammoth mines, described separately below.

Rattler.—The Rattler mine is a few hundred feet northwest of the Silver Circle mine, on the Rattler claim, on a mineralized belt or lode 120 feet wide, which seems to be a northerly spur or offshoot from the main granodiorite contact. This lode is mineralogically similar to the Silver Circle lode, in that the chief ore mineral is chalcopyrite in an actinolite-quartz gangue. The mine is opened mainly by a 40-foot cut and a winze and is said to have produced in 1928 100 tons of 6 percent copper ore that contained 3 ounces of silver to the ton.

Much of the ore consists of quartz fragments cemented by the oxide copper minerals—cuprite, melaconite, and malachite—with no trace of hypogene sulphides remaining.

Alice.—The Alice claim joins the Rattler claim on the west. According to returns of the Garfield Smelting Co., dated December 13, 1916, a shipment of 7½ tons of the Alice ore made by the Seattle Contact Copper Co. ran 14.8 percent of copper, 10.2 percent of iron, and 5.05 ounces of silver and 0.02 ounce of gold to the ton. In 1929 the mine produced and shipped 400 tons of ore containing 5½ percent of copper and 13 ounces of silver to the ton. The deposit is opened by a 12 by 12 foot shaft, 80 feet deep, sunk on the ore.

The lode is in light-colored, partly silicified limestone about 300 feet north of the border of the granodiorite mass. Both lode and bedding dip 70°–80° S., toward the granodiorite. A granodiorite dike cuts the limestone 100 feet west of the mine. The lode is about 8 feet wide and is the result of a replacement of limestone by diopside, with minor amounts of fine-grained quartz, wollastonite, and axinite. Within the silicate mass there are vertical bands and irregular stringers as much as a foot wide containing malachite, azurite, chalcopyrite, and locally chalcocite, bornite, covellite, and black copper oxide. Small amounts of molybdenite and specularite are present. The sulphides are most abundant in the more quartzose parts of the ore zone.

Magnolia.—Adjoining the Alice claim on the west is the Magnolia claim, which contains two east-west parallel lodes separated by 150 feet of granodiorite. The lodes dip steeply south near the granodiorite-limestone contact. The principal opening is a 40-foot tunnel, mostly in limestone, on the south lode. The north or main lode has a width of about 25 feet and consists mostly of a brownish to greenish gangue of actinolite, axinite, garnet, and nontronite, with good carbonate and copper oxide ore.

Mammoth.—The Mammoth and neighboring prospects in the middle part of the Gray Copper Corporation's upper group were described in some detail in the earlier report [21] and have not been extensively developed since. Prior to 1926 the corporation shipped from these prospects 240 tons of ore containing 7.7 percent of copper and about 8 ounces of silver and 82 cents in gold to the ton.

The principal deposits on the Mammoth and Blue Lode claims are similar in character to those of the Rattler and Silver Circle, described above. They have received only shallow development. To the south, within the granodiorite, there are several veins trending N. 10°–25° E., transverse to the contact. One of these, the Junction,

[21] Schrader, F. C., op. cit., pp. 124–126.

is reported to extend more than 2 miles southwestward, to the north end of the Ivy Wilson group. Another, the Old Abe, crosses the granodiorite-limestone contact but is mainly in the granitic rock. It is reported to be 3,500 feet long and 40 feet or more wide.

Helen B. Smith.—On the Helen B. Smith and neighboring claims in the vicinity of the deposits above mentioned relatively extensive development work has been done by the Gray Copper Corporation. The principal tunnel, driven in 1918–20, is known as the "Helen B.", from the claim in which it starts. This tunnel trends N. 62° W. It is 2,205 feet long, and its face is in the Highland No. 5 claim, at a depth of 600 feet below the surface and over 1,000 feet below the top of Ellen D. Mountain. Drifts are run 40 feet each way about 1,205 feet in from the portal. A raise 340 feet long at this point connects with the surface. From the face of the tunnel there is a 60-foot drift to the northeast and a 40-foot drift in the opposite direction. On the slope 515 feet above the Helen B. Smith tunnel an old tunnel, known as the "Mammoth", has been extended to a length of 580 feet. In the same vicinity there is a tunnel 520 feet long with its face at a depth of 375 feet, another tunnel 460 feet long, and a number of minor workings.

The Helen B. Smith tunnel starts in granodiorite and encounters the mineralized limestone at 1,205 feet and the Old Abe vein at its face. The ore body at the contact is about 20 feet wide and dips about 20° N. Six assays at intervals of 5 feet in the granodiorite along the main tunnel ranged from 0.96 percent of copper where ore is first encountered to 1.60 percent near the contact. Similarly spaced samples in the drift to the northeast along the contact averaged 1.50 percent copper and ranged from 3.18 to 0.38 percent. In the opposite drift the average for 15 feet was 2.69 percent of copper, and the range 4.59 to 1.35 percent. All assay data here quoted were supplied by the company.

Between the contact and the face the tunnel passed for 200 feet through a dark slate-colored, slightly laminated rock composed chiefly of diopside and quartz, with a little magnetite, hematite, and green garnet. In this part of the tunnel also beds consisting of wollastonite with some diopside and a little quartz with finely disseminated chalcocite are cut diagonally for a distance of 300 feet. This rock is reported to average about 1 percent of copper.

The extension of the Old Abe vein in the face of the Helen B. Smith tunnel strikes about N. 25° E. and stands almost vertical. It contains chalcopyrite and bornite and locally abundant chalcocite in a fine-grained reddish-gray banded rock, locally called "quartzite." This rock is limestone replaced by actinolite, garnet, quartz, and other minerals, as in the similar lodes described above. Some of the rock is dull olive-green and is composed of diopside with a little calcite, quartz, and green garnet. It is cut by veinlets of diopside and calcite. Part of the rock in the Old Abe vein is granodiorite containing specks of chalcocite and a little molybdenite, chalcopyrite, bornite, and covellite. The ore zone is about 30 feet wide. It has been sampled at 5-foot intervals along both drifts. The average of the 20 assays gave 4.25 percent of copper, 1.68 ounces of silver to the ton, and $2.90 in gold to the ton, and the range was 0.96 to 13.38 percent of copper, 0.68 to 8.02 ounces of silver to the ton, and a trace to $31.82 in gold to the ton. The Mammoth tunnel cuts across the Old Abe vein, 35 feet of the tunnel being in the lode. Assays here range from 2.4 to 3.4 percent of copper with some silver. The 520-foot tunnel nearby exposed bodies of chalcopyrite ore ranging from 3 to 7 percent of copper and as much as 7 ounces of silver to the ton. The 460-foot tunnel cut a body of 5-percent copper ore 30 feet wide. These tunnels are in the metamorphosed limestone, now mainly diopside, with nontronite and wollastonite locally plentiful.

STANDARD

The Standard prospect, a new discovery comprising a group of six claims owned by N. P. Nielson, is on the upper east slope of Ellen D. Mountain. It joins the Highland group of the Gray Copper Corporation on the north. No deep opening has yet been made on the property.

A specimen of the surface ore shows primary chalcopyrite disseminated and in streaks in a highly oxidized complex gangue of brownish massive actinolite and axinite, garnet, and bluish chalcedonic silica.

BONANZA

The Bonanza mine is the most westerly of those in the north contact area. It has been idle since 1910, and the reader is consequently referred to the earlier report for a full description of the property.[22] Small workings develop ore through a vertical range of 350 feet in the sides of a canyon. The ore consists of oxidized copper minerals with some copper sulphide and molybdenite in metamorphosed limestone containing garnet and other minerals. There is an alaskite dike, which is mineralized where it crosses the mineralized limestone.

WEST CONTACT ZONE

The deposits in the west contact area were described in the earlier report as the "Ivy Wilson group."[23] The more southerly claims, now termed the "Sue group", are the only ones that appear to have

[22] Schrader, F. C., op. cit., pp. 126–129.
[23] Idem, pp. 129–132.

received much recent development. For details regarding the other claims and early work on the Sue group the reader is referred to the previous report.

The early production was small, and the development not extensive. At the Nevada mine, on Ivy Wilson no. 5 claim, 500 tons of ore reported to contain 8 percent of copper and 60 cents in silver and $1.50 in gold to the ton, as well as a little lead, was shipped in 1929 and 1930. About half of this was sulphide ore. Since 1926 the Sue group has been owned by Mrs. D. G. McCulley, of Las Vegas, Nev., and the estate of W. T. McArolle, the former owner.

The principal recent developments on the Sue group comprise six tunnels averaging more than 400 feet in length, short shafts, raises, and winzes. Most of the ore produced at the Nevada mine is reported to have come from a raise 50 feet to the surface above a 270-foot tunnel and from a shaft close to the raise.

In the west contact area in general the granodiorite mass is bordered by greatly disturbed and steeply inclined limestone, with abundant metamorphic minerals in a zone 1,200 feet or more wide. Dikes, sheets, and irregular masses of granodiorite and alaskite cut the marmarized and replaced limestone and locally, as on Ivy Wilson nos. 3 and 4 claims, are exceedingly abundant. Bodies of ore, in some of which sulphides persist at the surface, are scattered through this zone, but the ore is not as closely related to the main granodiorite contact as it commonly is farther north.

In the Nevada mine the lode is 5 to 12 feet wide and dips steeply west. Most of the rock in the footwall is granodiorite, and most of that in the hanging wall is limestone. The lode matter is limestone extensively silicified and replaced by garnet, chlorite, and kindred minerals. There are also considerable limonite, hematite, nontronite, and secondary calcite. The calcite in part has a finely fibrous radiating structure. The principal ore minerals are chrysocolla and cerusite. Some of the ore is in pockets along cross fractures in the wall rock. In the bottom of a winze near the face of the tunnel there is a steeply inclined solution cavity 20 feet or more deep and in places large enough for a man to stand in. The cavity is lined throughout with calcareous sinter 4 inches or more thick.

LODES IN THE GRANODIORITE SOUTHWEST OF CONTACT

The deposits within the granodiorite mass between Contact and the west contact area, just described, have received little development since they were described in the earlier report.[24] Most of the lodes here are fissure veins in or near alaskite dikes. In places the ore is

[24] Schrader, F. C., op. cit., pp. 132–134.

disseminated in fractured alaskite. The deposits contain glassy quartz with chalcopyrite and bornite or their oxidized derivatives and small amounts of specularite and molybdenite.

The shallow shafts on the Florence group do not appear to have been extended in recent years. They expose several veins, most of which are in or close to alaskite dikes. No production is reported from this group.

The Copper Shield or Effie Fay group of claims, northeast of the Florence group, has been acquired by James Gerardet, who in 1930 was engaged in driving a crosscut tunnel, at that time 300 feet long. There are several alaskite dikes on this property, one of which is said to be 200 feet thick at one place. The dikes are mineralized at several places.

No new development is reported on the Salt Lake group, south of the Copper Shield property, or at the Yellow Girl mine, to the southwest. No production is recorded from any of these properties.

The Red Metal mine, a relatively new discovery, owned by the Five & One Mining Co., of Twin Falls, Idaho, is said to be on a porphyry dike 90 feet wide, running about 2½ percent in copper. It has 800 feet of development work with encouraging results.

CHINA MOUNTAIN AREA

There are numerous prospects in the China Mountain area, but none have yet attained much production, and most have only shallow workings. Most of them have changed little since they were described in the earlier report.[25] The deposits are grouped along the contact between the granodiorite and the Paleozoic strata. Most of them are in contact-metamorphosed limestone, but some are within the granodiorite in or near alaskite dikes. Most of the small shipments that have been made are reported to have been relatively rich in copper.

Since the previous report the Chinaman mine has been acquired by the Clark Mining Co., of Rupert, Idaho. This company has mined some ore from the old workings but has not shipped any. Its principal work consisted in extending a tunnel on the Skylark No. 1 claim to a point 1,800 feet from the portal and 250 feet vertically below the surface. Work here ceased in 1927.

At the old Truro-Sheckles mine, now termed the "Arizona", 50 tons of 10-percent copper ore was shipped in 1928–30 from work done by a lessee in extending the shaft to a depth of 165 feet. This mine is on a lode parallel to the bedding of whitish limestone with steep southerly dip, about 900 feet from the granodiorite contact.

[25] Schrader, F. C., op. cit., pp. 134–139.

BLANCHARD MOUNTAIN AREA

The present study has added nothing to the data on properties in the Blanchard Mountain area contained in the earlier report.[26] Most of the lodes here are in contact-metamorphosed limestone close to the granodiorite. Alaskite dikes crop out close to some of the lodes.

KNOLL MOUNTAIN AREA

HICE

The property owned by H. R. Hice & Son is near the head of Knoll Creek about 2 miles southeast of Blanchard Mountain. It is on a minor ridge composed of faulted and slickensided Tertiary lake beds, which in general parallel the ridge line and dip 20°–30° NW. A breccia composed of different kinds of Paleozoic sedimentary rocks with jasper, barite, quartz, and cerusite crops out at the upstream end of the ridge crest in an area 10 to 30 feet wide. This material is said to contain 60 percent of lead, 2 to 3 ounces of gold to the ton, and as much as 240 ounces of silver to the ton. Much of that in the outcrop is firmly cemented, but underground the breccia is in part only loosely coherent and is crudely stratified. A 130-foot shaft and other openings sunk on the croppings encountered no solid material, and a 300-foot tunnel that passes under the outcrop penetrated only the Tertiary beds. Hence the cap of mineralized breccia on the ridge crest appears to result from faulting or, perhaps more probably, from a landslide.

VULCAN

The Vulcan mine, owned by the Vulcan Mine Co., of Twin Falls, Idaho, is in the northern part of the Knoll Mountain area, on the east side of the head of Trout Creek (pl. 2). The company began developing the property in 1912 and has worked on it at intervals since, on a small scale.

The property is said to comprise a claim group of 400 acres. It is developed mainly by a 700-foot crosscut tunnel and shaft. The tunnel, at an altitude of about 7,000 feet, runs S. 60° E. into the mountain side and attains a depth of 300 feet at the face. The shaft is situated well in advance of and 260 feet higher than the tunnel and is accompanied by many lateral openings.

The country rock consists mainly of brown Paleozoic limestone and quartzite. The mine is about 2 miles out from the granodiorite contact. On the lower slopes the Paleozoic rocks are overlain by Tertiary lake beds. The first 200 feet of the tunnel is in the lake beds, and the next 500 feet in a breccia of dark-brownish Paleozoic

[26] Schrader, F. C., op. cit., pp. 139–143.

limestone and quartzite, which becomes more siliceous toward the face. Also near the face the tunnel intersects a 20-foot porphyry dike.

At 40 feet from the face of the tunnel occurs a 2½-foot quartz vein dipping 40° W., toward the portal. It carries a little gold and silver. At various points there are other streaks with a little lead carbonate and copper stain and some small bunches or pockets yielding good-looking specimens consisting of quartz, malachite, and red copper oxide. Several tons of ore on the dump is said to average 20 percent of copper and 20 ounces of silver to the ton. At the shaft there is said to be a 4-foot vein.

A brick-red boulder about 2½ feet in diameter, apparently from some other lode, was found on the ground near the tunnel dump. It consists of a breccia of small quartz grains, possibly with some feldspar, cemented by fine-grained quartz and earthy hematite, and is reported to carry a fair tenor of silver.

SILVER KING

The Silver King mine, formerly the Kratz, is 2 miles south of the Vulcan mine, on the west slope of Knoll Mountain at an altitude of 7,500 feet (pl. 2). The mine is on the northern part of the Silver King vein, which is said to extend 4 miles southwestward and to range from 5 to 20 feet in width.

The deposit was discovered and located about 1885 by Mr. Truro and partner, who sunk a shaft and took out some ore. It is now owned by the Silver King Mining Co., of which H. R. Hice & Son are leading members.

There are two main openings, about 1,500 feet apart. The north opening, situated well up the mountain side, consists mainly of an 80-foot shaft and a 20-foot incline. Here the deposits are contained mainly in a 5-foot vein in Paleozoic sedimentary rocks, which consist, in part at least, of slate-colored finely banded metamorphosed siliceous shale or quartz schist. The vein dips 70° SE., into the mountain. It consists mainly of finely comminuted quartz and rock firmly cemented in a siliceous matrix. It is crudely banded and is stained greenish, brownish red, and blackish with lead carbonate and iron and manganese oxides. Some of it shows also streaks of copper stain. About 4 tons of lead-silver ore, said to run $20 to the ton, lies on the dump.

The south opening is about 1,500 feet southwest of the north opening and several hundred feet lower, where the vein is exposed in the south bank of the ravine eroded across it. Here a shaft said to be 100 feet deep and 200 feet of adit tunnel, drifts, and crosscuts expose a vein about 15 feet wide. The vein stands about vertical or dips steeply northwest and contains much iron and manganese oxide in a siliceous gangue. The ore minerals are mainly argentiferous lead carbonate, galena, and possibly argentite. A considerable portion of the vein is said to carry 10 percent of lead and 8 ounces of silver to the ton. From substantial portions of the vein J. F. O'Byrne reports having obtained assays as follows: Manganese, 40 percent; copper, 2 percent; lead, 20 percent; silver, 4 ounces to the ton; and gold, a trace. A little zinc is also present. The ore in the bottom of the shaft is said to carry about 4 percent of copper.

In openings on the ridge 200 feet to the southwest and 80 feet higher than the shaft the vein is mostly coarsely banded quartz and stands about vertical or dips steeply northwest, with white quartz croppings standing 4 feet above the surface.

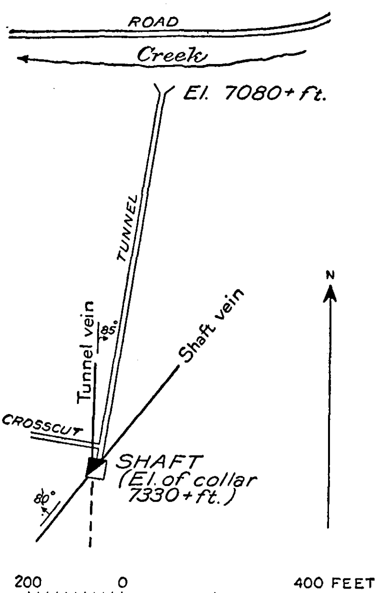


FIGURE 6.—Diagram showing relations of veins and workings in the Silkworm mine.

SILKWORM

The Silkworm mine, owned by Glen Moore, is about 3 miles southwest of the Silver King mine, approximately on the south boundary of the area shown in plate 2. It is in a steep hillside on Spring Creek, a south tributary of Knoll Creek, with the portal of the tunnel at an altitude of about 7,080 feet. The deposit was discovered by Mr. Moore about 1926. By 1930 he had shipped from it about 40 tons of good grade lead-silver ore. The property comprises the Silkworm group of 13 claims in a compact, nearly square block. It is developed by a 400-foot crosscut tunnel and a 50-foot shaft, 250 feet above the face of the tunnel (fig. 6).

Much of the country rock at the mine is a reddish or lavender dolomite, but some is a very fine grained black argillaceous quartzite. It is brecciated and recemented by quartz. A few hundred yards west of the mine a large north-south dike of diorite porphyry is exposed along the road and creek.

The shaft is sunk on the vein originally discovered, which is about 2 feet wide and dips 80° NW. Nearly all the ore so far mined has come from this shaft. A short distance to the right of the tunnel, near its face, as shown by a crosscut and drift, is what seems to be a second vein, which strikes nearly north and dips steeply east.

The ore is mostly oxidized and stained reddish or yellowish brown with iron oxide and lead carbonate and is calcareous. Much of it has a gangue of quartz and jasperoid material. It replaces the wall rock locally and contains a few bodies of galena as much as 3 feet in diameter. The ore shipped is said to have run about 20 percent of lead, 20 percent of zinc, and 20 ounces of silver to the ton. The ore minerals are chiefly cerusite, cerargyrite, and zinc oxide.

MIDDLE STACK MOUNTAIN AND TROUT CREEK AREA

There are numerous openings along the granodiorite contact near Middle Stack Mountain and on both sides of Trout Creek. Much of the development work here was done in the early days of the district, and the production has never been large. The lodes are essentially similar in character to those of the north contact area, except that alaskite dikes are more closely associated with them. The reader is referred to the earlier report [27] for descriptions of the different properties.

The Boston mine is the only one at which any considerable amount of work has been done since 1910. The deposit here is in contact-metamorphosed limestone, essentially parallel to the bedding. It has been opened to a depth of 190 feet by a tunnel, shaft, winze, and drifts and is 4 to 20 feet thick. In the few years preceding 1926 this mine is said to have made several small shipments of good-grade copper-gold ore, in which the principal ore minerals besides copper carbonates were bornite and chalcopyrite. In 1928–30 considerable additional development work was done in the mine, with encouraging results. At a depth of 90 feet in the shaft was found a 6-inch shoot of cerargyrite ore running about 300 ounces in silver to the ton. The drift on the 190-foot level had been extended 140 feet northward in the footwall side of the vein and showed there the same ore tenor as on the upper levels. The last 40 feet of the drift was all in ore that averaged 2 percent of copper and $1 in gold to the ton. An 8-foot crosscut started for the hanging wall showed increased tenor in the face.

Smelter returns dated June 10, 1930, on a carload of sorted ore shipped from this mine report 6.77 percent of copper and 6.6 ounces of silver and 0.265 ounce of gold to the ton—a total value of $19.18 to the ton.

[27] Schrader, F. C., op. cit., pp. 146–150.

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