THE GOLD QUARTZ VEINS

OF THE JULIAN DISTRICT, CALIFORNIA

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A THESIS

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Introduction and Acknowledgement

The gold veins of the Julian district, which includes also the Banner district, are of interest for numerous reasons. First, on account of richness of the ore in various localities particularly the upper workings of the mines. Second, the apparently capricious distribution of small high grade ore shoots and the abruptness of the transition from these shoots to nearly barren quartz. Third, the causal relation that exists between the general structure of the region and the gold veins.

The report is the result of four weeks of field work carried on in the spring of 1929. At that time the gold veins were mapped and geological data was obtained. The topographic map used for this region was the United States Geological Survey's Ramona topographic sheet enlarged four times. The original map was surveyed in 1901 on the scale of two miles to the inch with a 100 foot contour interval.

Grateful acknowledgements are due Mr. C. A. Ferrin of the Golden Chariot Mining Corporation for the privilege of examining the property. To Mr. G. Surprenaut, superintendent of the North Hubbard Mining Company, Mr. A. Frary and Mr. Tom Strick of Julian, and many other people of the region, acknowledgements are made for information, hospitality, and courtesy. The writer is especially indebted to Professor F. L. Ransome for advice and helpful criticism during the completion of the report, and to Mr. Rene Engel for pointing out fruitful lines of investigation.

Location and Accessibility

The district lies within the main mountainous range of San Diego

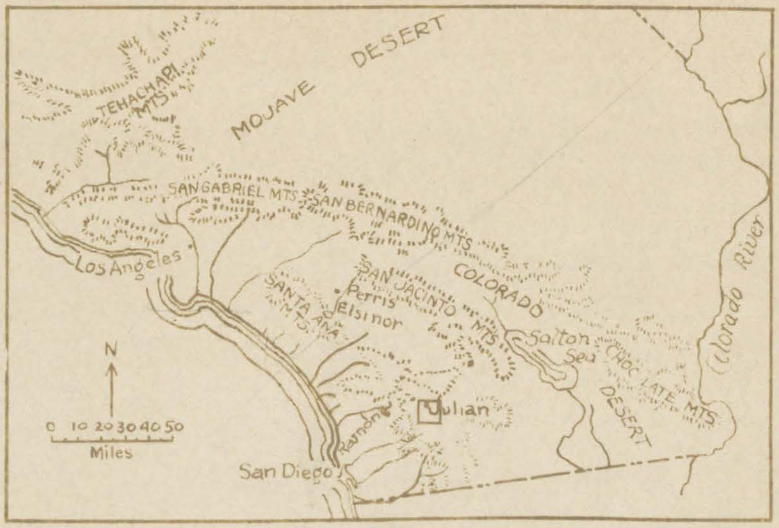

Fig. 1. Index Map.

County. It is situated in the northeastern part of the Cuyamaca region which embraces the Cuyamaca mountains. It is bounded on the north by Volcan mountain, on the east by San Felipe valley, and on the southeast by Granite mountain.

Julian is located on the drainage divide between the Salton sea and the Pacific ocean. It has a population of 115 and is the most important habitation in the region. The town of Banner, which is seven miles southeast of Julian at the foot of Banner grade, now contains less than a dozen residents. Both towns were once thriving mining centers, having between the years 1870 and 1882 a population of approximately 700 inhabitants for Julian and 300 for Banner. At present Julian is important as a trade center for farmers from nearby valleys. It is located sixty miles northeast of San Diego by county road which is traversed daily by busses. The old road from Julian to Banner, shown on the United States Geological Survey sheet, has been abandoned. The road now in use has been plotted on the map by the writer.

Climate and Vegetation

The range in relief generally is great, especially in Banner and Chariot canyons, although in the immediate vicinity of Julian the country is a gently rolling upland. The elevation of Julian is 4200 feet and of Banner 2700 feet.

Around Julian there is an open growth of pines, oaks, and manzanita with, in places a dense growth of chaparral. On the slopes of Banner and Chariot canyons the trees disappear and chaparral covers most of the area. From Banner to San Felipe Valley the vegetation becomes somewhat more scanty and takes on a desert-like appearance.

The average precipitation[1] in the region around Julian is 29.02

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[1] U. S. G. S. Water Supply Paper 446.

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inches while at Banner it is said to be about 12 inches. The maximum precipitation occurs during the winter months although there are occasional summer showers. During the rainy season the road between Julian and Banner is difficult to traverse but is seldom impassable.

Water is obtained in the region from wells, springs, and streams, but the latter are generally dry in the summer season.

In the early days the timber used for mining operations was principally derived from the vicinity of Julian and the adjacent mountains, but at the present time it is shipped from San Diego.

Bibliography

The number of publications on the Julian District is not large. The only previous systematic account of the geology is that by F. S. Hudson, who gave the gold veins only a cursory examination. The annual reports of the State Mining Bureau, particularly the reports of 1888, 1889, 1890, 1892, and 1914, record the facts concerning the properties, equipment, and geology in a general way. The following list contains the principal references found.

1886. Hanks, H. G., Sixth Annual Report of the State Mineralogist, part I, for year ending June 1, 1886, pp. 80-90.

1889. Goodyear, W. A., Ninth Annual Report of the State Mineralogist for the year ending Dec. 1, 1889, pp. 142-147.

1890. Preston, E. B., Tenth Annual Report of the State Mineralogist for the year ending Dec. 1, 1890, pp. 540-44.

1892. Storms, W. H., Eleventh Annual Report of the State Mineralogist for two years ending 1892, pp. 376-381.

1893. Fairbanks, H. W., Geology of San Diego; also portions of Orange and San Bernardino Counties. Eleventh Annual Report of the State Mineralogist, pp. 76-120. Map (1893.)

1894. Fairbanks, H. W., A Remarkable Folded Vein in the Ready Relief Mine, (Banner District, San Diego County, Calif.) Eng. M. J. vol. 57, pp. 321-322.

1896. Storms, W. H., Thirteenth Annual Report of the State Mineralogist for the two years ending Sept. 15, 1896, pp. 331-346.

1914. Merrill, F. J. H., Geology and Mineral Resources of San Diego and Imperial Counties. Calif. State Min. Bureau. pp. 23-30.

1922. Hudson, F. S., Geology of the Cuyamaca Region of California, with Special Reference to the Origin of the Nickeliferous Pyrrhotite. Univ. of Calif. Pub. in Geology, vol. 13, no. 6, pp. 175-252.

Geology

Summary:- The geologic map (fig. 2) of the region surrounding the Julian District is taken largely from Hudson's[2] geological report of the

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[2] Hudson, F. S., Geology of the Cuyamaca Region of California. Univ. of Calif. Pub. vol. 13, no. 6, pp. 175-252, 1922.

Cuyamaca region. Hudson's boundaries have been verified by the writer who has in addition traced out and mapped the gold veins.

The oldest rocks in the district are schists of undetermined age, which are presumably of the same age as the other schists in the peninsular range and may be of the same age as, or older than, the slates of the Santa Ana mountains, which are Triassic. These schists are intruded by a quartz diorite which is part of the peninsular batholith and is probably equivalent to the post-Mariposa intrusion of the Sierra Nevada.

Basic intrusives of norite, gabbro, and basic diorite intrude the quartz diorite and occupy a considerable area in the vicinity of the Cuyamaca mountains. Dikes of pegmatite and aplite occur cutting both schist and quartz diorite, and basic rocks.

Open valleys with flat rolling surfaces occur in the region around Julian and Cuyamaca mountain and are underlain by alluvium which is at the present time being removed by streams. In San Felipe valley both alluvium and lake beds occur.

Rock Formations

Julian Schist Series:- This series has been ably described in detail by Hudson, so that only a short resume will be given. The schist series extends through the district in a general north-south direction and varies in width from three-quarters to a mile and a half. Small isolated masses of schist are found outcropping in the quartz diorite surrounding the main mass.

The central portion of the main body of Julian schist is made up of a fine grained, fissile, quartz-muscovite-biotite schist. Intercalated within the schist series are found beds of bluish dense fine-grained quartzite. In many places it is associated with the quartz veins, particularly with the branch vein that runs between the Chariot and Ready Relief

GEOLOGIC MAP OF JULIAN DISTRICT, CALIF.

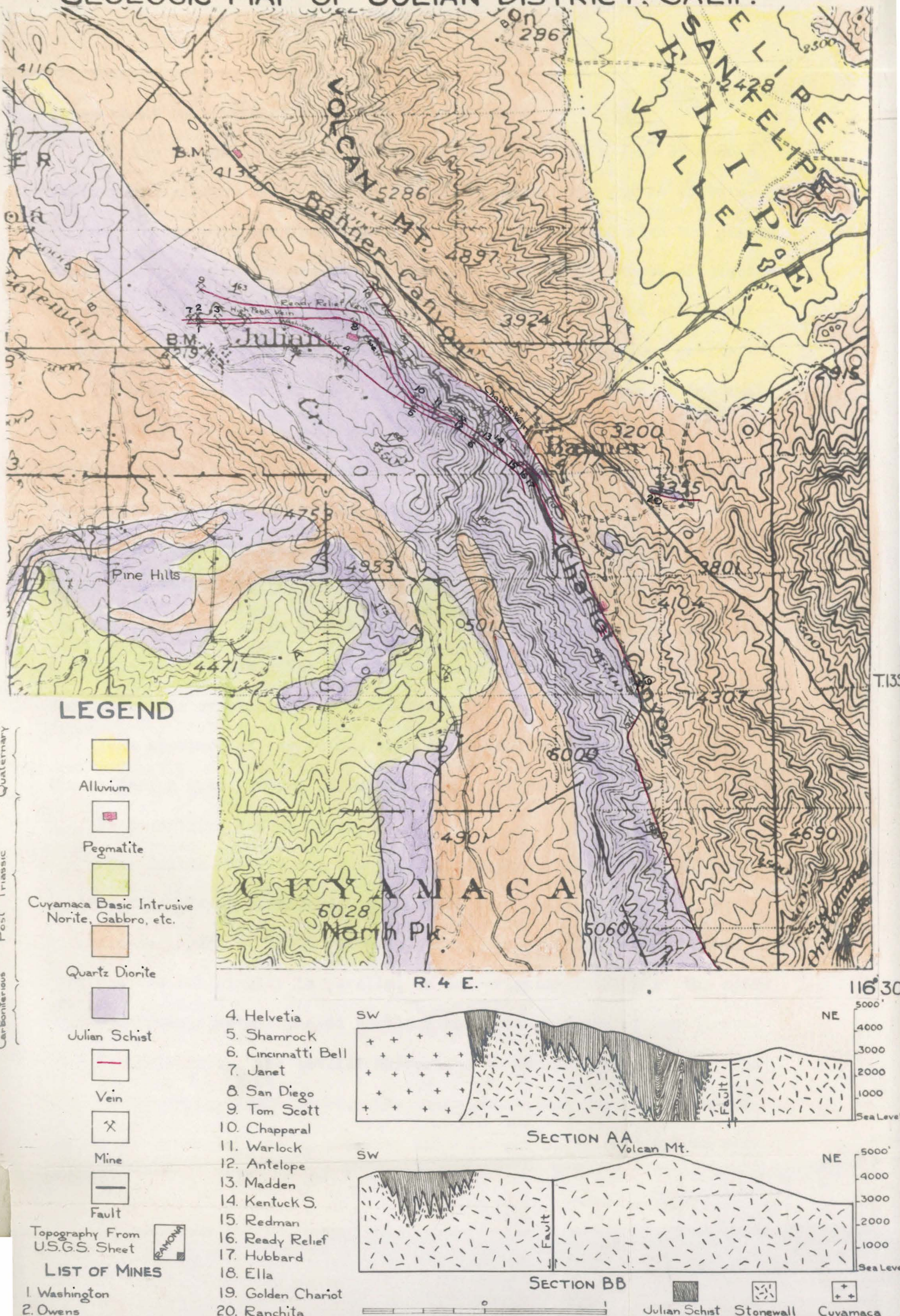

Fig. 2

veins about one-third of a mile south of Banner.

On the western border of the schist body there is a zone of coarse schists and paragneisses. The writer observed that the coarse schists in many places were conglomeratic in texture. Associated with the gnarly schists and gneisses on the border zone are found short lenses of quartzose rock. Near Cuyamaca reservoir in a few places are found sillimanite-quartz-mica gneiss with some tourmaline and andalusite-bearing gneiss.

Injection gneisses of varying composition are prevalent on the eastern border of the schist body and are made up in part of material of igneous or pegmatitic nature. Some of the injection gneisses contain tourmaline, sillimanite, andalusite, and coarse crystals of mica.

Subordinate layers of amphibolite schist and actinolite schist are found intercalated in the schist series. Actinolite schist is found at the Helvetia mine, while near Banner the amphibolite schist is found in a few isolated places. The actinolite schists are presumably derived from andesitic or basaltic volcanic rocks.

In a specimen of the folded vein at the Hollywood mine examined by the writer, a small amount of apatite was found associated with the schist.

As to origin, Hudson says:

"The Julian schists are the product of metamorphism of a series of shales, fine clayey sandstones, and nearly pure quartz sandstones, with subordinate layers of basic volcanic rocks. In the less metamorphosed portions the schistosity is parallel to the original bedding of the rock. In the intensely metamorphosed portions there is evidence of two directions of schistosity, the earlier conforming to the original bedding, the later at a varying angle to it. The rocks exhibiting the double schistosity, are characterized by peculiar minerals generally ascribed to contact metamorphic action, i. e., sillimanite and andalusite.

The intrusive quartz diorite is without doubt responsible for these contact minerals. There seems some reason, therefore, to attribute the later schistosity to the action of the intrusion. Further evidence that the rocks were schistose before the intrusion of the quartz diorite is found in the extensive development of lit-par-lit injection gneisses and the total absence of hornfels along the contacts."

Stonewall Quartz Diorite:- This rock, in the vicinity of Julian is typical of the plutonic rocks that are so widespread throughout the mountainous portion of San Diego County. There the intrusive is a quartz diorite cut by a number of acidic and basic dikes, which are found in greater proportion in the vicinity of Volcan mountain east of Julian and near Granite mountain southeast of Banner. A petrographic description of the quartz diorite has been made by Hudson, as follows:

"These rocks are medium to coarse grained aggregates of quartz, plagioclase, biotite, and rarely orthoclase. The plagioclase varies from albite to andesine, and in one specimen from a dark segregation, it is labradorite. Green hornblende occurs in dark segregations. Orthoclase is present in only three out of fourteen specimens examined and in these makes up less than ten percent of the rock."

The quartz diorite has a gneissoid character near the schist contact. The strike of the gneissoid structure is in general parallel to the neighboring schist and represents flow lines of a partially consolidated magma.

Cuyamaca Basic Intrusives:- These rocks, which are made up of gabbros, norites, and basic diorites, are described in detail by Hudson.

They lie west of the Julian schist belt and are of particular interest because of the occurence of nickeliferous pyrrhotite in norite at the Friday mine. The amount of nickel found has been of little economic value, but is of scientific interest.

Alluvium:- The alluvium in San Felipe Valley consists of unconsolidated rock debris, sand, and clay. In the southeastern part of the valley San Felipe creek and the road both cut the valley fill. The banks show evenly stratified fine sands containing great quantities of mica and considerable clay. Lee[3] suggests the possibility that this part of

[3] Lee, C. H., U. S. G. S. Water Supply Paper 446, p. 207.

the valley is occupied by lake beds. No direct evidence was obtained by the writer as to the verity of this theory. In the valleys situated in the open rolling country of Julian considerable thicknesses of bedded, unconsolidated, sandy alluvium are exposed as a result of stream cutting.

Physiography

The Julian district embodies two distinct physiographic features. In the vicinity of Julian, Cuyamaca Lake, and westward, the topography is a gently rolling surface floored by residual soil. East and southeast of these rolling tracts toward Banner canyon and San Felipe Valley there is a belt characterized by deeply dissected canyons with valleys separated by parallel mountain ranges.

A few mountain peaks such as North Peak (6,028), Middle Peak (5,750) and Cuyamaca Peak (6,515), project above the gently rolling surface. These isolated mountain peaks have been regarded as due principally to erosion. It is believed that the land prior to the elevation was a peneplain.[4] As the land was raised the streams were rejuvenated and cut their

[4] Fairbanks, H. W., The Physiography of California. Am. Bur. Geog. Bull., vol. 2, pp. 232-252, 329-350, 1901.

valleys to their present depth.

Faulting has contributed largely to the topography of the region east and southeast of Julian. Banner canyon owes its origin principally to a fault. On the fault map of California[5], San Felipe Valley and the

[5] Fault Map of the State of California, Seismological Society of America, 1922.

valleys adjacent to the east are outlined by faults. These faults run in a general direction parallel to the Banner fault and the San Jacinto fault.

Volcan mountain (5,570 feet) is extremely flat-topped and lies east of Julian. The existence of such a mountain east of the drainage divide and Banner fault points to a recent movement of the Banner fault which has resulted in a displacement of two old land surfaces. Further evidence substantiating this theory is: (1) the existence of an antecedent stream (Plate IV, Fig. 2) crossing the southern extension of Volcan mountain at Banner valley; (2) the difference in drainage pattern developed on both sides of Banner Canyon. East of Banner canyon on the slopes of Volcan mountain the streams are young, while west of Banner canyon the streams are mature. There is no difference in the hardness of the rocks on both sides of the canyon.

Structure

The major agencies that have determined the structure of the district are (1) compression, (2) igneous intrusion, and (3) faulting. A minor agent is that of landsliding.

Compression has played an important role in the development of the highly folded and contorted character of the schists and quartz veins. There have been three periods of compression. The first was before the intrusion, which developed the schistosity parallel to the bedding. The second accompanied the intrusion and caused a second schistosity to imposed upon the first. The third was subsequent to the formation of the quartz veins. This is exhibited by the folded quartz vein at the North Hubbard Mining Company and the crushed lenses of vein quartz caused by overthrust and reverse faults at the Golden Chariot Mine.

The "Preliminary geologic map of San Diego County, California,"[6]

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[6] Ellis, A. J., U. S. G. S., Water Supply Paper 446, pl.3.

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shows one major fault zone passing through the district that extends from the southwest flank of Agua Tibia mountain along the southwest boundary of San Jose Del Valle, and passes through Banner canyon. Hudson mentioned this fault in his report, but did not plot it on his geological map, probably because of the lack of sufficient evidence.

At the head of Banner canyon on the new Julian-Banner road, which was built since Hudson studied the area, a zone of brecciation was observed approximately a hundred feet wide and a quarter of a mile along the fault. This evidence along with physiographic evidence, proves that the Banner fault has been exceedingly active. An approximate estimate was made of the amount of vertical displacement effected by this fault. This was accomplished by finding the difference in elevation between the old erosion surface in the vicinity of Julian and the old erosion surface on Volcan Mountain. Correlation between these two surfaces was deemed advisable by the writer because of other physiographic evidence. The amount of displacement was found to be between 700 and 1300 feet.

Ellis considers that a fault might also follow Chariot Canyon, swing east at Banner and continue north along the western edge of San Felipe Valley. A fault may exist along the edge of San Felipe Valley, but it is not present in Chariot Canyon for the reason that several quartz veins cross the supposed fault without offset.

In the vicinity of the Blue Hill mine considerable landsliding has been effective so that the schists and veins now lie in a horizontal position. Parts of the vein have been displaced and scattered along the slope of the mountain about 200 yards from the original location.

Geologic History

In regard to the age of the Julian schist series a number of writers have had ideas as to its age and the age of other schists existing in the Peninsular range. Fairbanks[7] correllated the metamorphics of Santa Ana

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[7] Fairbanks, H. W., Calif. State Min. Rep. (XI), 1893.

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with those in San Diego County. He found Carboniferous fossils in the Santa Ana region.

J. P. Smith[8] concludes from fossil material found in limestone by

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[8] Smith, J. P., Middle Triassic Faunas of North America. U. S. G. S. Prof.

P. 141, 1927.

Fairbanks in the Santa Ana mountains, that the beds probably represent Upper-Middle Triassic age.

W. C. Mendenhall[9] believes that the slates in the Santa Ana mountains in general resemble the Mariposa slates of Central California.

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[9] Willis, Bailey, U. S. G. S. Prof. P., 71.

Merrill[10] regards the Julian schists as probably equivalent to the Calaveras group, described in the Mother Lode Folio of the United States Geological Survey, on the basis of structural position and lithologic characters.

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[10] Merrill, F. J. H., Geology and Mineral Resources of San Diego and Imperial Counties, Calif. State Min. Bur., 1914, p. 12.

Hudson[11] brings forth evidence, which is not entirely conclusive,

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[11] Op. cit., p. 190.

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of the finding of an imprint of an ammonite on an angular piece of quartzitic float from the schist series by D. D. Bailey of Julian, which was pronounced by Dr. J. P. Smith as Triassic.

The age of the quartz diorite that intrudes the schist series is presumably pre-Cretaceous and post-Triassic and probably equivalent in age to the post-Mariposa granitic masses of the Sierra Nevada. This is based upon the fact that in the Santa Ana mountains Cretaceous rocks rest upon the eroded surface of granitic masses of that general age. The Cuyamaca basic intrusives, which are younger than the schists and quartz diorite which they cut, are probably also prè-Cretaceous.

From the above data the probable geologic history of the region may be summarized as follows:

1. Deposition of marine sediments during late Paleozoic and Triassic time.

2. Uplifting and folding of the sediments before Cretaceous time.

3. During uplift and folding of sediments, batholithic intrusion of quartz diorite.

4. Intrusion of basic rocks followed by the formation of pegmatites, aplites, and gold-quartz veins.

5. Erosion of the region to low relief during most of Tertiary time.

6. A general uplift of the erosional surface in late Tertiary or early Quaternary time, leaving the region substantially in the condition as seen today, except for minor erosion.

Economic Geology

History of Mining:- Much of the early mining history contained in this paper was obtained by the writer from the State Mineralogist's reports and from Mr. A. Frary, a pioneer of the early days when the gold properties were most active.

In the early days, prospectors were first attracted to this region by the discovery of placer gold at Wynola, three miles northwest of Julian. The first mines were discovered at Julian shortly after the placers were found. They were the Van Wirt and the George Washington. Both were located on the same day, Feb. 22, 1870. In August 1870, gold was discovered at the Redman mine near the mouth of Chariot canyon at

Banner by a Mr. Redman. This was followed by the discovery of the Ready Relief by D. D. Bailey. The Golden Chariot mine located about three miles southeast of Banner was discovered in 1871 by a Mr. King.

From 1870 to 1880 great activity prevailed in the district and the total production of gold was estimated at that time at $2,500,000. According to a report made by the San Diego Chamber of Mines on the "Mines and Minerals of San Diego County," the total production up to the present time exclusive of the period between 1870 and 1880, has been approximately $7,500,000, which is probably much exaggerated.

At the outset of the early operations a substantial zone of rich ore was taken out near the surface. The gold was readily amenable to amalgamation. As the mines appraoched water level, the sulphide content of the ore increased, the gold values decreased, and, due to the hardness of the rock combined with the added cost of pumping, mining became much less profitable. With an increase in sulphides in the ore, amalgamation became impractical so that roasting of the ore was resorted to with little or no success.

Assays are rarely run on the ore by the prospectors. The grade of the ore is determined by grinding it in a mortar, washing the material in a miner's pan, and then noting the length of the string of colors.

At present the camp is very quiet, though many owners are keeping up assessment work in hope that financial conditions may change and that mining properties may again become saleable. Within recent years, since 1922, the Golden Chariot, Ready Relief, and Hubbard Mines have been worked intermittently.

Gold Quartz Veins:- There are four main veins in the region with several adjacent parallel veins, all conforming to the dip and strike of the schist. The main veins are in some localities accompanied by smaller parallel veins or stringers of no importance. The general strike of the veins is northwest and the dip is either to the northeast or southwest. Where landsliding has been effective, the dips are considerably flatter.

Where possible, the writer has adopted the name of the vein in current use, otherwise he has taken the name of the first mine located on the vein. The first vein, (see fig. 2) going from east to west is the Chariot vein, which is known also as the Contact vein. Followed by this in consecutive order are the Ready Relief, High Peak, and the Van Wirt veins. One mile southeast of Banner is located the Ranchita vein in an isolated schist mass surrounded by quartz diorite. The width of the gold quartz veins usually varies from a few inches to two or three feet. In one locality, about one third of a mile south of Banner where two veins come together, a width of about fifty feet is attained.

The structure of the veins in the district is exceedingly interesting because various areas have had different structural histories. The major factors controlling these various structures are compression and faulting.

At the Golden Chariot Mine, (see fig. 5.) crushed lenses of quartz predominate. This has been due to post-mineral overthrust faulting. Movement along the vein has been very pronounced and for the most part the vein, together with a certain amount of crushed country rock, lies between smooth walls. In certain places these walls leave the lode and pass as slips into the country rock, diverging at small angles to the dip and strike of the vein. At such places the lode for a short distance is without a well-defined footwall or hanging wall. It appears that the stress which produced the slickensided walls was exerted in directions that, in homogeneous material, would have resulted in fissures oblique to the vein. The angle of obliquity was found to be about fifteen degrees in most cases, although where the angle was smaller the movement took place along the vein. The grooving and slickensiding noted in some places on the walls of the vein indicate that the last movement was horizontal instead of vertical.

To the east of the Chariot vein on the Ready Relief vein at the Ready Relief and Hubbard mines, the vein has been folded (see fig. 6). This folded character can be seen in a few of the mines on the same vein to the north. The vein takes the form of a succession of "rolls," descending toward the hanging wall at a somewhat less angle to the northeast than the schist. The dip of the schist is 70 to 80 degrees to the northeast while the vein is somewhat flatter. As far as has been observed the schists are not folded to correspond with the vein, but simply bend around the kidney-shaped rolls or abut against them. The quartz cleaves away from the schist leaving smooth concave or convex surfaces. No gouge separates the quartz from these surfaces.

A number of hypotheses have been advanced regarding the origin of the "rolls," In referring to these "rolls," Hanks[12] says:

[12] Hanks, H. G. Sixth Ann. Rep. Calif. State Min. Bur. pp. 87, 1886.

"The vein is interstratified with the clay slate formation. The slaty cleavage of the country rock is undoubtedly due to lateral pressure, which has also distorted and plicated the veins, so that it is found in folds, which are technically called 'rolls'. I am inclined to the opinion that the vein was formed by solfataric action in plastic mud before the mountains were elevated and that the vein has been plicated by its own weight while still in soft condition."

This theory does not take into consideration that the other veins in the district could not have been formed under the same physical conditions.

Fairbanks[13] notes, as does Hudson, that the schists have a double

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[13] Fairbanks, H. W., A Remakkable Folded Vein in the Ready Relief Mine, Eng. Min. Jour., vol. 57, pp. 321-322, 1894.

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schistosity. He infers from this that when the second schistosity was imposed upon the schists, zigzag fissures were developed across the strata, the course being determined by the competence of the beds. Following this the fissure would continue in the cleavage for a short distance, and then again repeat the process. The siliceous waters circulating through this at first jagged fissure, gradually absorbed the roughness of the walls as the deposit of silica kept growing, thus leaving a greater deposit parallel to the slaty cleavage until there resulted the smooth rounded rolls.

In examining samples of the vein quartz under the microscope, the individual quartz grains exhibited strain shadows while the mass as a whole showed a cataclastic texture. The quartz grains have been elongated parallel to the schistosity. This proves without doubt that the folding of the vein has been post-mineral instead of pre-mineral as advocated by Fairbanks.

In most of the mines in the district the quartz veins occur in lenticular masses that have not suffered deformation such as is exhibited by the quartz lenses at the Golden Chariot Mine. In several of the mines the lenses of quartz are arranged en echelon. The size of the lenses varies from a few feet to several thousand feet in length.

The development of lenticular ore bodies by shearing subsequent to ore deposition has been discussed by Graton.[14] At the Golden Chariot mine

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[14]Graton, L. C., Gold and Tin Deposits of the Southern Appalachians, U. S. G. S. Bull. 293, pp. 35-37. 1906.

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post-ore metamorphism certainly has played a large part in causing an en echelon arrangement, but this can not be applied to some of the mines in the district because the laminations of the schist does not curve around the end of the lenses, but the quartz lenses die out in a series of parallel stringers.

Presumably the en echelon arrangement was determined by zones of less competent beds before a second schistosity was imposed to deform them. The vein-like extension would represent deposition in more competent beds according to Hanson.[15]

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[15]Hanson, G., Pyritic Deposits in Metamorphic Rocks, Econ. Geol., vol. 15, p. 606, 1920.

General Character:- The gold-quartz veins are either lenticular, folded, or continuous fissure fillings. As a rule the banded quartz, which usually carries the highest gold values, is confined to the lenticular masses. These have been formed in large part by post-mineral metamorphism.

At the Shamrock mine where the vein is fairly continuous, the banded quartz carries no gold. At the Golden Chariot mine the banded quartz (see plate I, fig. 1), which carries gold, is characterized by having a ribbon or sheeted structure. It occurs either in lenses or in a fairly continuous vein of as much as fifty feet in length. This type of structure has presumably been formed by repeated filling of small openings produced by intermineralization fault movements.[16]

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[16] Hulin, C. D., Structural Control of Ore Deposition, Econ. Geol., vol. 24, pp. 15-50, 1929.

Mineralogy

Ore Minerals

Native Gold: The gold in the quartz veins contains variable amounts of silver and is always of a lighter color if considerable silver is present. Coarse gold in the form of nuggets was taken out of the mines near the surface in the early days. Some of the gold occurs in thin sheets in the sheeted zones and as threads and microscopic particles distributed throughout the quartz veins. The gold in the oxidized portions of the veins was probably derived from auriferous arsenopyrite and pyrrhotite.

Arsenopyrite: This mineral occurs mainly in small stringers in the quartz veins, where it is found in massive, granular, or crystalline forms. In some of the mines, especially in the Golden Chariot, the gold is closely associated with it.

Pyrrhotite: Found as stringers or laminae near the margins of the quartz veins. Both the crystalline and massive forms occur. When subjected to weathering, the pyrrhotite becomes tarnished to the colors of red and blue so that it has the appearance of bornite. At the Ready Relief and Hubbard mines it is associated with gold.

Minerals	Washington Vein	High Peak Vein	Ready Relief Vein	Chariot Vein
Pyrite	X	X	X	X
Arsehopyrite	X	X		X
Pyrrhotite	X	X	X	X
Molybdenite			X	
Albite	X	X	X	X

Table Showing Distribution of Minerals

Fig. 3.

Pyrite: This mineral was found to be confined mainly to the margins of the quartz veins. Both the lamellar and granular forms are common. In no place did the writer observe pyrite associated with gold.

Molybdenite; Segregated masses in the quartz occur in the form of scales. It is associated with both pyrite and pyrrhotite at the Hubbard mine, the only locality known to the writer to contain molybdenite.

Gangue Minerals

Quartz: Color white to greyish-white with a coarse massive texture. The structure is hypidiomorphic and under the microscope the quartz shows in some specimens a cataclastic texture with strain shadows in the individual grains. "Sugar" quartz is found at the Golden Chariot mine. The formation of this type of quartz has been due to post-mineral faulting which has crushed the original coarsely crystalline quartz vein.

Albite: This is found associated in small amounts with quartz although in some localities albite predominates over the quartz, giving the vein a pegmatitic aspect.

Kaolinite: This mineral occurs as an alteration product of albite and probably sericite. It is found in the zone of oxidation.

Sericite: A common constituent of both the quartz vein and schist wall-rock. It is an alteration product of the wall-rock.

Graphitic material occurs on the wall-rock of the veins in both the Ready Relief and Golden Chariot mines. It is due presumably to faulting and squeezing of the schists as numerous slickensided surfaces are developed on it.

Paragenesis:- In studying the order of crystallization of the min-

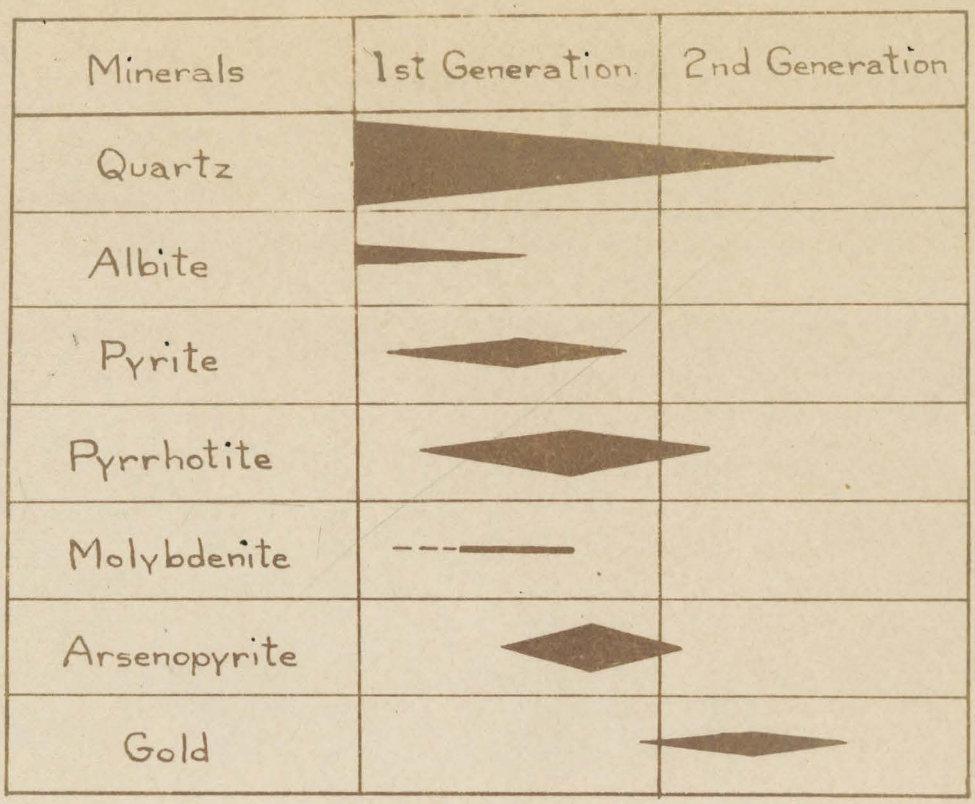


Fig. 4 Paragenesis

erals contained in the gold quartz veins, the writer was handicapped by the lack of a complete suite of sulphide samples, because many of the mines are still above the water level.

A study of the polished sections of the ore brings out certain pertinent facts present themselves. (see fig. 4.) The normal order of crystallization was found to conform with the paragenesis of mesothermal and hypothermal gold-quartz veins summarized by Buschendorf.[17] Where molybden-

[17] Buschendorf, F., Zeitsch. Prakt. Geol., 1926, pp. 1-11.

ite occurs in the crystallizing sequence of the sulphides, the writer could not exactly ascertain. From all indications it appeared to have crystallized out later than the pyrite or pyrrhotite, which is contrary to its usual order of deposition. According to Cissarz[18] it is a pneumat-

[18] Cissarz, A., Neuen Jahrbuch fur Mineralogi, Beilageband 56. Abt. A., 1927, p. 136.

olitic mineral which has crystallized out before or contemporaneous with the quartz and albite.

Genesis:- The deposition of the gold-quartz veins without much doubt followed the intrusion of the quartz diorite and is closely associated with it. The veins are presumably a transition between mesothermal and hypothermal gold-quartz veins,[19] because of the presence of molybdenite

[19] Lindgren, W., Mineral Deposits, p. 746, 1928.

and pyrrhotite which are usually rare minerals in mesothermal deposits. No high temperature minerals were found, such as apatite, tourmaline, magnetite, and garnet.

The writer was not able to trace the pegmatites dikes into quartz veins directly. At one locality, however, the Chariot vein, between two quartz vein outcrops, the writer observed a pegmatite dike made up of orthoclase, albite, and quartz separated by bands of pure quartz, which would probably indicate that the pegmatites might form a transition between the magma and the gold-quartz veins.

The gold, which is largely later than the arsenopyrite, is found also to have been deposited contemporaneously. It has been shown by Palmer and Bastin[20] that arsenopyrite is an extremely effective precipitant of gold. This would indicate that arsenopyrite, to a great extent, determined the ore shoots.

[20] Econ. Geol., vol. 7. pp. 140-170, 1913.

The localization of rich ore shoots especially above the water table would indicate that some enrichment may also have taken place by the removal of valueless material, as suggested by Rickard.[21] No porous, cellular ore containing much limonite or hematite was observed, so that it is difficult to determine the amount of pore-space left by the removal of sulphides by solutions.

[21] Rickard, T. A., The Formation of Bonanzas in the Upper Portions of Gold Veins, Am. Inst. Min. Eng., Trans., vol., 31, pp. 198-220, 1902.

Placers:- Although the quartz veins show free gold at the surface, placers are not common. Placers, however, have been worked in a small way at Coleman Creek and near Wynola. Colors can be obtained from either Banner or Chariot canyons, especially where Banner creek joins the Chariot Creek at Banner valley.

Conclusions and Practical Deductions

1. There are four main parallel gold quartz veins in the schist series which conform to the strike and dip of the schist.

2. The order of crystallization of minerals follows the usual order of deposition of pyrite, pyrrhotite, molybdenite, arsenopyrite, and gold.

3. Veins occur in three forms:

   a. "Rolls."

   b. Lenses which are in en echelon arrangement.

   c. Fissures.

4. "Rolls" have been formed by post-mineral metamorphism.

5. En echelon arrangement of the lenses have been due in part to pre-mineral compression parallel to the strike of the schists, causing elliptical openings in less competent beds and straight fissures in more competent beds.

6. After the formation of the elliptical openings and straight fissures, these were filled by mineralizing solutions.

7. Post-mineral compression normal to the strike of the schist has caused in part the formation of lenses of vein quartz.

8. The Julian veins are intermediate in character between the Mother Lode mesothermal gold veins and the Appalachian hypothermal gold veins.

9. There is some indication that the pegmatites may grade into quartz veins.

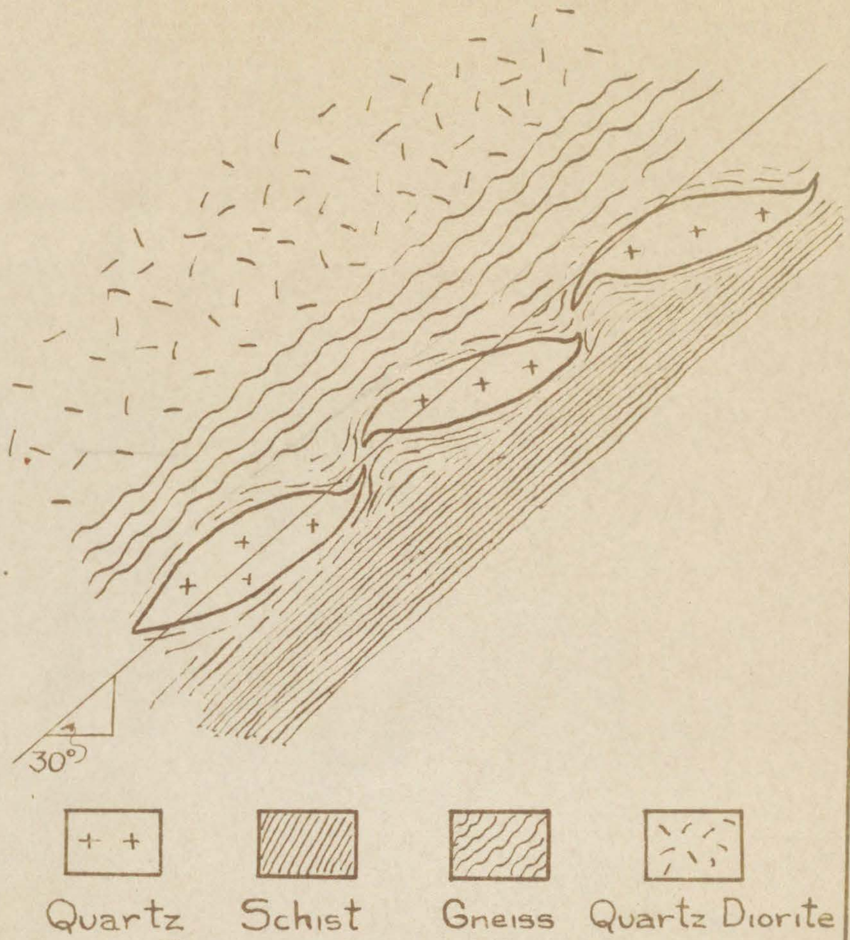
10. Previously deposited arsenopyrite and pyrrhotite probably deter-

ed the position of the ore shoots.

The study of this district has led the writer to make certain deductions which may have a practical bearing on future operations.

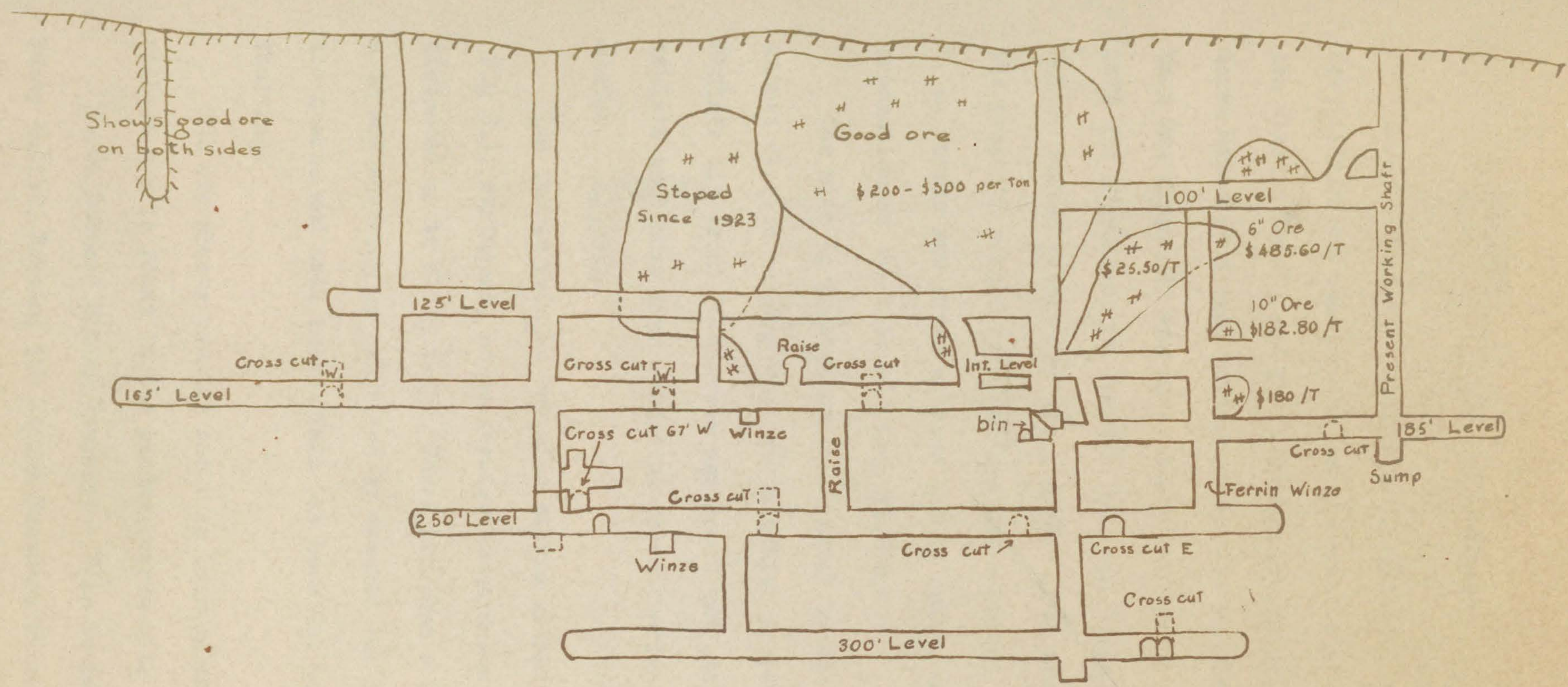
Some gold is found along the entire length of the quartz veins, but only certain portions of the veins are rich enough to mine. These richer portions are as a general rule confined to the narrower parts of the vein, which necessitates the removal of a large amount of waste rock in extracting the ore, thus bringing the tenor of the ore down so low that it makes it unprofitable to work at times.

A good grade of milling ore may be expected at depth because this type of vein usually persists with depth. The writer believes that only a small amount of enrichment has taken place in these veins above the water table. It is reasonable to assume that the ore shoots carry gold below the water table, but a decided change in the character of ore has taken place at water level. The change from oxidized vein material carrying free gold which is amenable to amalgamation, to gold associated with arsenopyrite, pyrrhotite, and pyrite, will necessitate a change in the metallurgy of the ore. The chief factor that caused some of the mines to close down when they had reached water level was the increased sulphide content of the ore. On a continuous vein running from Julian to Banner through a vertical range of 1500 feet, gold is found throughout its entire length. The vein is as rich in gold content at Banner as at Julian. This criterion substantiates the possibility of gold being found at depth.



Section of Quarz Lenses

Fig. 5



Longitudinal Section of Chariot Mine

Scale 1" = approx. 70'

Fig. 7

Mines

Golden Chariot:- This mine is owned by the Golden Chariot Mining Corporation and consists of two patented claims; the Golden Chariot and the Chariot North, and four unpatented claims. The property is located three miles southeast of Banner and was originally discovered in 1871 by a Mr. King. It was later taken over by Mr. James Mc Donald about 1873 who organized the Chariot Mill and Mining Company and obtained a United States patent for the ground. Upon the death of Mr. Mc Donald the property closed down and was not reopened until Nov. 1922, when Mr. C. A. Ferrin was given a lease and an option on the mine. The total production of the mine has been $1,800,000.

The mine is located on the Chariot or Contact vein between a quartz diorite hanging wall and a schist footwall. (see fig. 5, and 7) Schists dip about 70 degrees northeast and strike N. 10 degrees W. The schists that have been subjected to weathering have the appearance of slates.

The quartz vein in the mine occurs either as lenses (see Plate I fig 2.), stringers, or as straight continuous fissure fillings for distances up to fifty feet. There has been a large amount of compression and shearing as exhibited by crushed and brecciated character of the quartz and wall rock. This has been due to post-mineral overthrust faulting.

The ore shoots usually occur in lenticular masses of quartz and the richest ore is found in the banded quartz with a sheeted structure.

North Hubbard Mining Company:- This company owns the North Hubbard, Ready Relief, Redman, and Hidden Treasure Mines. The Ready Relief mine has produced $750,000 while the North Hubbard has produced about $250,000

SECTION OF FOLDED VEIN

Fig. 6

in gold.

The Ready Relief mine, which has been the big producer, was first located in 1871 by Mr. D. D. Bailey, who worked the property for a long time. In recent years the property has been worked by a number of lessees. The main workings can be reached either by an adit or by a shaft which is 200 feet deep. These workings are in a fine-grained fissile mica schist which has the appearance of being slate. The workings at the Hubbard mine are reached by an adit 248 feet long and are in the same type of rock as the that found in the Ready Relief mine.

The schists in both mines dip about 70 degrees northeast and strike varies from N. 15 degrees W. to N. 40 degrees W. An interesting feature about these mines is the folded vein Fig.6 with large amounts of pyrrhotite accompanied by a small amount of molybdenite and no arsenopyrite. A considerable amount of alum is found as an alteration product of the schist, which has been formed by the reaction between iron sulphate and the schist.

PLATE I.

Fig. 1. Banded gold-vein quartz from 300 foot level of the Golden Chariot mine.

Fig. 2. Specimen of a gold-quartz vein lense from 300 foot level of the Golden Chariot Mine.

Plate I

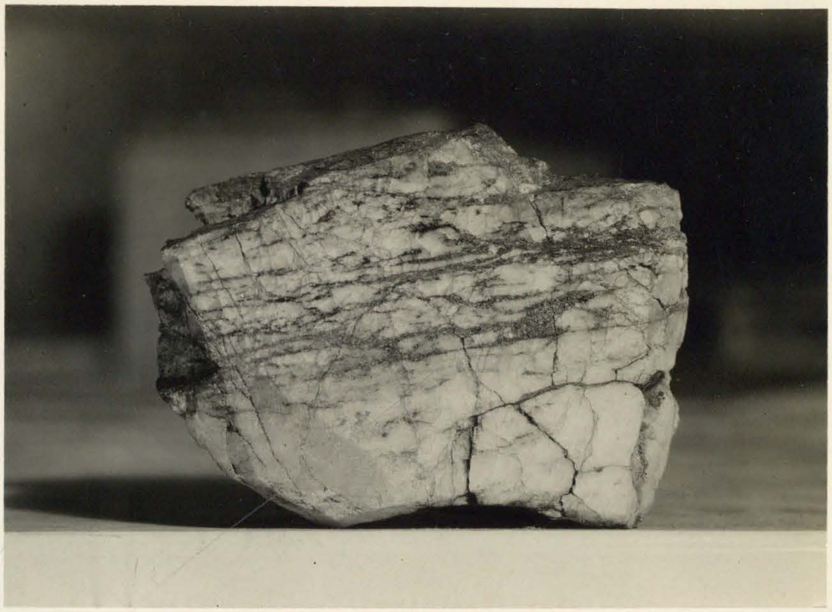


Fig. 1

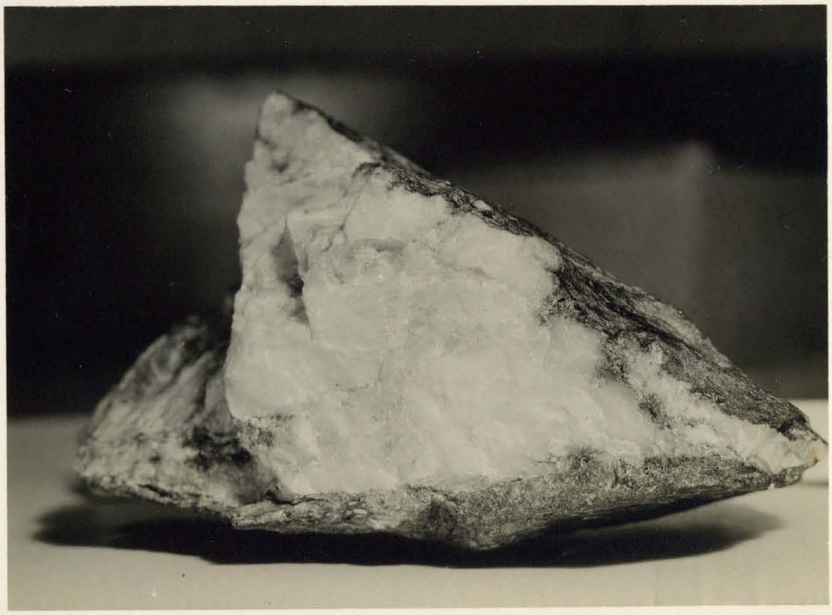


Fig. 2

PLATE II

Fig. 1. Polished section of ore from the Ready Relief mine, showing pyrite surrounded by pyrrhotite. x 200. py, Pyrite; pr, Pyrrhotite; q, Quartz.

Fig. 2. Polished section of ore from 165 foot level of the Golden Chariot mine, showing that the gold is contemporaneous with the arsenopyrite. x 200. as, Arsenopyrite; g, Gold.

Plate II

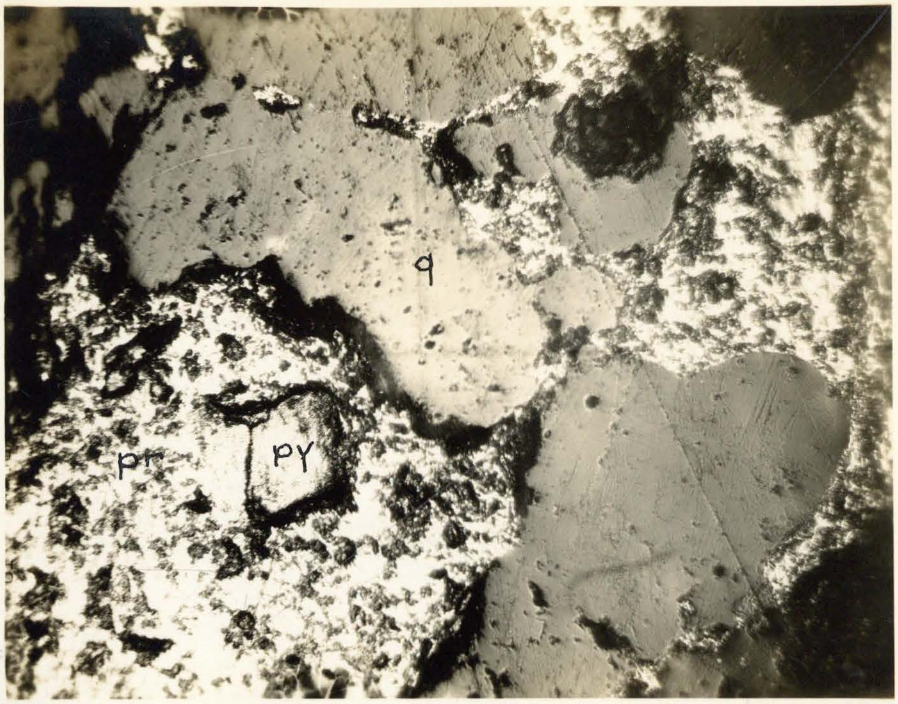


Fig. 1

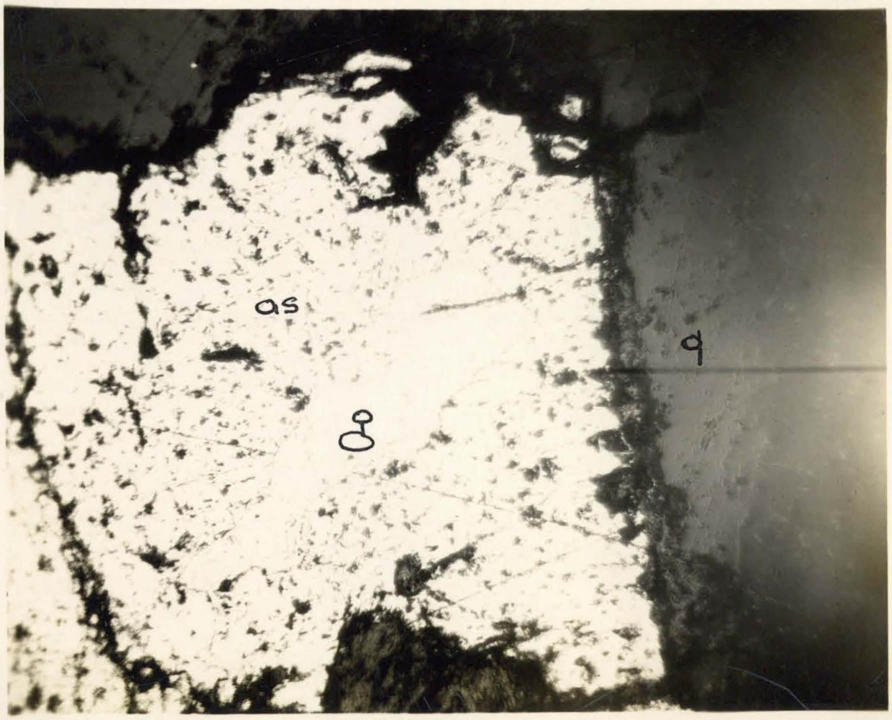


Fig. 2

PLATE III

Fig. 1. Polished section showing the gold veinlets cutting the arsenopyrite. x 200. as, Arsenopyrite; g, Gold; q, Quartz.

Fig. 2. Polished section showing gold cutting the quartz. x 200. g, Gold; q, Quartz.

Plate III

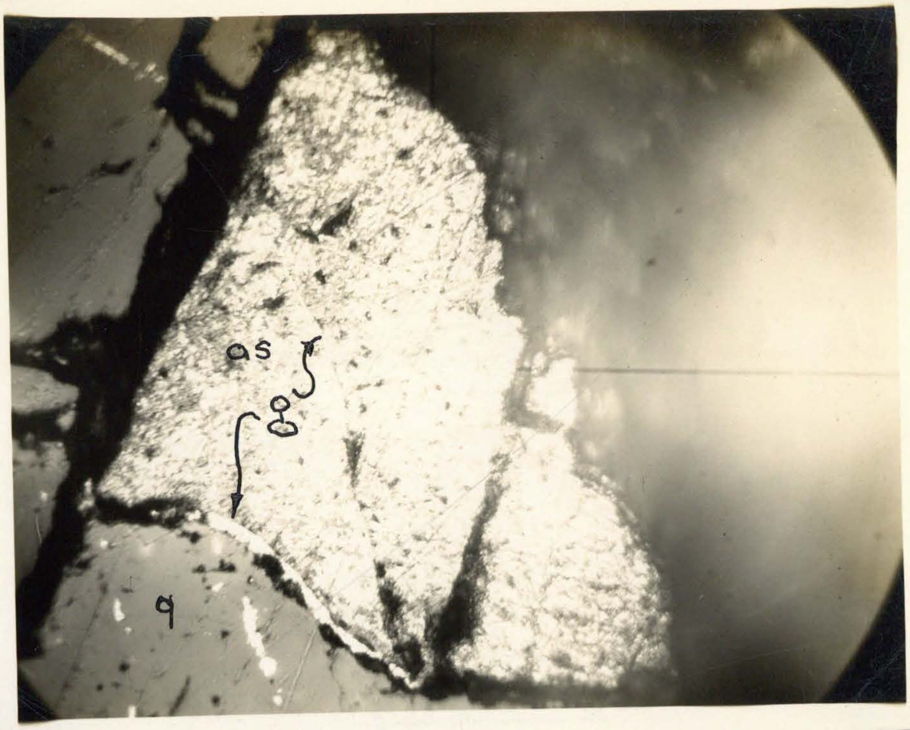


Fig. 1

Fig. 2

PLATE IV

Fig. 1. Looking northwest along Banner Fault.

Fig. 2. Looking due east at Banner valley in the foreground, at San Felipe valley and Granite mountain in the background. The stream running from Banner valley into San Felipe valley across the southern extension of Volcan mountain is presumably an antecedent stream.

Plate IV

Fig. 1

Fig. 2

PLATE V

Fig. 1. Looking due south at Golden Chariot mine. Line indicates "Contact" vein.

Fig. 2. Adit of the Ready Relief mine. Lines indicate position of gold-quartz vein.

Plate V

Fig. 1

Fig. 2

PLATE VI

Fig. 1. Photomicrograph of thin section showing brecciated character of the vein quartz at the Ready Relief mine.

Fig. 2. Photomicrograph of thin section showing brecciated character of the vein quartz at the Golden Chariot mine.

Plate VI

Fig. 1

Fig. 2

PLATE VII

Fig. 1. Mill at the Ready Relief mine which is situated near the mouth of Chariot canyon.

Fig. 2. Looking northwest along the veins and contact between schist and quartz diorite.

Plate VII

Fig. 1

Fig. 2