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Reconnaissance Geologic
Map of a PORTION OF the
OLD WOMAN MOUNTAINS
San Bernardino, California

ESSEX

TECTONIC ANALYSIS OF THE RANDSBURG QUADRANGLE, CALIFORNIA

By

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Summary

Influence of the Garlock Fault (or the stresses responsible for it) is widespread in the area. Many of the gold, silver and nearly all of the tungsten veins are nearly parallel to it, (N 70°-80° E), and usually show the same left lateral movement. Many of the other veins and fractures were generated by these horizontal stresses.

Most of the gold and silver veins of the area are areally closely related to the sub-radial pattern of rhyolite - latite and diabase - basalt dikes that radiate from the rhyolite - latite pipe in the center of the quadrangle.

The ore bodies of the Yellow Aster and Kelly Mines, the leading gold and silver producers, respectively, are localized in the footwall of strong, moderate to flat dipping faults or in fractures related to these faults.

Ore deposition occurred at shallow depths and at least in the case of silver perhaps even at the surface.

Structurally, the ground between the large rhyolite pipe and Red Mountain is a very favorable area for the formation of ore deposits. It is largely unexplored, being obscured by post-mineral cover.

Introduction

Purpose of this analysis is to try to deduce the possible mechanisms by which the ore bearing structures in the Randsburg Quadrangle may have originated and their influence on the localization of ore bodies.

Three types of valuable mineralization are known, tungsten (scheelite) veins in the Atolia area, silver veins in the area southeast of Randsburg, and gold veins which are more widespread. In the Stringer district gold and scheelite occur together.

Much of the data used in this report including the geologic map of the quadrangle are taken from Geology and Ore Deposits of the Randsburg Quadrangle of California by Hulin in 1925. Hulin only spent about 2 months mapping the quadrangle and examining many of the properties. As a result much of the geology is not as detailed as might be desired. However, several months were spent in the laboratory for petrologic and mineralogic determinations and this part of his work is much more complete.

Other sources of information are listed in the bibliography.

Location

Randsburg is about 37 miles N 53° E of the town of Mojave in South-central California. The Randsburg quadrangle, a 15 minute quadrangle is bounded by 35° 15' - 35° 45' north and by 117° 30' - 117° 45' east.

History and Production

Gold was discovered in the district in 1895 and over $12,000,000 has been produced from the Yellow Aster Mine alone. During the periods of World Wars I and II tungsten has been mined with production over

1 million units of WO_3 by 1953. In 1917 the California Rand Silver Mine or Kelly Mine was discovered. Silver production is reported to be $16,000,000[22], mostly from the Kelly Mine.

Stratigraphic Column

A brief summary of the rock types which occur in the Randsburg Quadrangle is given here. If a more complete description is desired the reader is referred to Hulin, 1925.

Johannesburg Gneiss (Archean?)

The oldest rock exposed is the Johannesburg Gneiss. It is composed of a variety of rock types, of which a hornblende - plagioclase gneiss is the most representative. Also present are hornblende gneiss, coarsely crystalline marble and some quartzite. Total exposed thickness is about 2500 feet.

Structurally the gneiss appears quite simple having a general east - west strike and dips north 40 - 60°. Locally the attitudes may vary markedly from this figure.

Rand Schist (Archean?)

The Rand Schist, about 2000 feet thick, comprises the bulk of the Rand Mountains. East of Government Peak the main rock type is a mica - albite schist, with quartz, feldspar, and biotite as the most abundant minerals. An amphibole schist is well developed west of Government Peak but also occurs interbedded with the mica - albite schist, and many graduations between the two types are found. Quartzites and limestones in beds 1 to 10 feet thick occur throughout the series interbedded with the schists.

Structurally the schists are usually flat lying but have been folded into broad open folds with dips on the flanks of up to 15°. Generally they show a low regional dip to the south or southeast. Near the quartz monzonite intrusion the schists may stand at any attitude.

How the Rand Schist is related to the Johannesburg Gneiss is uncertain but the best evidence available indicates that the formations are unconformable; the gneiss being older. Probably the gneiss has been thrust over the schist as indicated on section C - D. However, it is possible that this is a conformable contact with the gneiss being the younger rock.

Paleozoic Strata

Marine limestones, cherts, clay shales and sandstones are exposed in the northwest corner of the Randsburg quadrangle in the El Paso mountains and extended several miles to the west into the Saltdale quadrangle. Although undifferentiated by Hulin, Dibblee had divided these rocks into 21 members extending his work into the Randsburg quadrangle. For a complete description of these rocks the reader is referred to Dibblee, 1952. Total thickness of these rocks is 35,000'. 13,000' of the series are exposed in the Randsburg quadrangle.

Atolia Quartz Monzonite

Dated Jurassic by Hulin, this quartz monzonite outcrops in three separate areas in the quadrangle and probably underlies most of the quadrangle. In all three areas it is quite similar in appearance showing a medium grained granitic texture. It is composed of orthoclase, plagioclase and quartz in about equal proportions and about 5 - 10% each of biotite and hornblende. Some smaller masses in the northern part of the Lava Mountains, perhaps later intrusions, vary in composition from quartz diorites to granodiorites. Locally near contacts, fragments of the invaded rocks are often present in the quartz monzonite, especially in the area southeast of Randsburg.

Rosamond Formation (Eocene - Miocene)

Of continental origin, the Rosamond Formation consists of stratified deposits of felspathic sandstones, conglomerates, and clays, and contains volcanic material only in the upper part. Poorly consolidated sandstones are predominate and show fresh feldspar as evidence of rapid erosion in the source area. Boulders of granitic rocks and schists occur in the lower part, the schists pebbles being very similar to the Rand schists. In the upper portions along with the boulders of granitic rocks and schists are pebbles of light colored porphyritic rhyolite and dark colored diabase, notably absent in the lower portion. These fragments appear to be identical to the rhyolites and diabases known to intrude the basal part ofthe Rosamond series, and if so, brackets the time of intrusion of the rhyolite plugs and dikes and the diabase dikes and limits the depth below the surface at which the mineral deposits were formed, assuming these dikes and plugs were the source of the pebbles.

Dibblee in the Saltdale quadrangle found Eocene plant fossils in the base of the equivalent Goler formation. Other dates up into the the Miocene have been given for upper parts of the Goler and Rosamond formations.

Thickness of the Rosamond Formation varies from zero in the northern part of the quadrangle where the Red Mountain andesite lies directly on the quartz monzonite up to 6500' of Goler sediments to the west in the Saltdale quadrangle.

Rhyolite - Latite Intrusions

One pipe about 2000' in diameter and several smaller pipes and sills and many dikes are present in the central part of the quadrangle. These rocks are porphyritic with small feldspar and or quartz phenocrysts and in some biotite and hornblende phenocrysts. They have a fine-grained to glassy ground mass. Composition varies from rhyolites through trachytes and quartz latites into latites.

The dikes are commonly 2 - 10 feet wide but a few may be as much as 100 feet thick.

From the largest pipe about a mile east of Randsburg, the dikes show a rough radial pattern and close association. This indicates a doming up by the pipe caused the radial fractures which were then filled by the dikes.

It is also noteworthy that this series of intrusives is observed to cut the lower 200 feet of Rosamond sediments. Around the large rhyolite pipe the sediments have been highly silicified extending to the floor of the valley to the north and including all of the exposed Rosamond sediments to the west. This silicification is probably the result of hydrothermal activity associated with the intrusion. Some spotty gold and silver occurs in the silicified area.

Diabase - Basalt Dikes

Basic dikes having about the same areal distribution as the rhyolite - latite dikes are much more common than indicated on the map. These dikes vary from inches to 10' in thickness but up to 50' but form poor outcrops. They are later than the rhyolitic dikes, and two small dikes have been observed cutting the Rosamond series about 200' above its base where it contained subangular fragments of the rhyolitic intrusives. The Rosamond was silicified more or less and is cut by calcite stringers.

Red Mountain Andesite (Upper Miocene)

Unconformably overlying the Rosamond series is a thick series of basic andesite lava flows with some agglomerates and tuffs. These volcanics probably originated as fissure flows and feeder dikes are observed in the northern part of the Lava Mountains and are best developed on the east side of Red Mountain. These dikes cut the

Rosamond series and apparently passed into the flows. Largest observed thickness of these dikes was over 50 feet and ½ mile in length. The form of Red Mountain as well as the extensive flows developed around it suggest that at one time it may have been a central vent for the pyroclastic materials as well as some of the lavas. The maximum observed thickness of 1400' is at Red Mountain.

Black Mountain Basalt (Pleistocene?)

Intrusive plugs and small flows of Basalt occur in the vicinity of the Garlock fault. Rocks of this type are better developed in the Saltdale quadrangle to the west. It seems probable that they are related to the Garlock fault in the Randsburg quadrangle.

Alluvium

Alluvium is widespread in the quadrangle and probably reaches a considerable thickness on the northwest side of the Rand Mountains.

In the Atolia area a shallow cover of alluvium is present over much of the area, and is 50' deep east of Atolia. Some of this alluvium has been worked as placers for scheelite and gold. 5 to 10% of the total scheelite production is from placer deposits. Of the many known veins in the Atolia area only one actually outcropped, the others probably being found by tracing float to its source or by prospecting along the strike of known veins.

REGIONAL STRUCTURE

Garlock Fault

The most prominent structural feature of the quadrangle is the Garlock fault. It has an indicated left lateral movement of about 5 miles. Since deposition of the base of the Rosamond series approximately 650' of vertical movement has occurred with the north side or the El Paso Mountains being up lifted. About 7 miles to the southwest in the Saltdale quadrangle in the vicinity of Koehn Dry Lake, the U. S. Geological Survey using gravity methods found the "basement" to be 10,000 feet deep between two branches of the Garlock Fault as shown in figure 1. These two branches apparently come together and this displacement dies out to nothing in the Randsburg quadrangle.

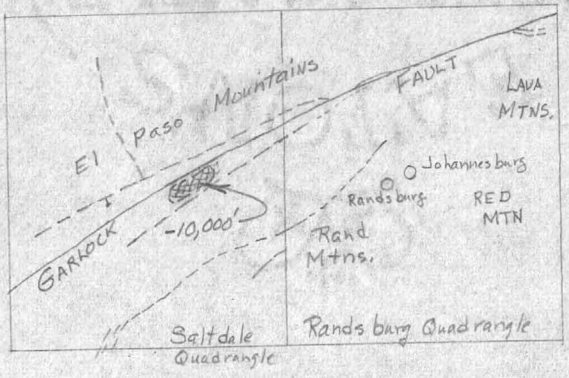


Figure 1
Partly after Hewitt, A Fault Map of the Mojave Desert Region
1" = 10 miles

Lava Mountains

An apparently anomalous condition occurs on the north end of the Lava mountains. Here a north facing scarp is present on the "normally" down dropped side of the Garlock Fault. This is explained by the presence of a flat thrust fault which is only exposed for a short distance in the northeast part of the map. It is older than the Garlock Fault and has thrust quartz monzonite over Rosamond sediments. My interpretation of Hulins description of this is shown on section EF. This thrust fault is responsible for the erosion of the Rosamond sediments prior to the deposition of the Red Mountain andesite in the northern part of the quadrangle.

Rand Mountains

Mentioned but not mapped by Hulin are several normal faults bordering or about parallel with the northeast trend of the Rand Mountains. The Jupiter Fault at the Yellow Aster Mine is one of these. Uplift along these faults is responsible for the steep northern slope of these mountains. This is opposed to the gentle southern slopes which may have resulted from slight tilting by these faults.

MINERAL DEPOSITS

Tungsten Deposits

The main tungsten production of the district has come from the area around Atolia. Here in a shear zone 500' wide trending N 80° E, about parallel to the Garlock Fault, tungsten mineralization occurs along north dipping faults which vary from N 75° E to N 75° W in strike and in dip from 45 to 90° being steeper in the east. This zone is about 2 miles long and is covered by alluvium on both ends. However, extensive prospecting along the strike has failed to find new ore bodies. Parallel veins with a small amount of scheelite are distributed northwest for a distance of about 2½ miles into the Stringer District where gold and scheelite occur together in narrow veins.

Ore bodies occur in shoots in the veins and are usually less than 100' in maximum dimension and range in thickness from 1" to 17' but are usually less than 1'. The largest known ore body which did not crop out, occurs on the south vein of the Union Mine. It is 1200' long by up to 17' wide and at last report had been mined for a vertical depth of 850' and a pitch length of 1080'. This was the deepest level of the mine and the ore although somewhat leaner on the lower levels continued downward. In recent years open cuts in the weathered quartz monzonite have mined ore apparently in stringer zones up to 200' wide and from 60' to 90' wide above some of the main veins. Prior to 1943 the average annual ore grade was over 4% being as much as 15% for some years. With open pit mining the average grade has dropped below 1%.

Mineralogy of the veins is simple, scheelite being the only ore mineral and sometimes the veins contain only nearly pure scheelite. Gangue consists of quartz, carbonates (calcite, ankerite, dolomite) with sporadic pyrite, stibnite and cinnabar.

Alteration of the quartz monzonite has taken place from a few inches to several feet from the vein walls and is most extensive at the Union Mine. The altered rock is impregnated with sericite, pyrite, kaolin (?), and chlorite giving the rock a greenish gray color.

Reasons for the localization of the ore bodies is uncertain but it has been suggested cross fractures may be important. However, only one or two cross fractures have been mineralized, and most of them show only a few feet offset and this is usually post mineral. The displacement on the veins is unknown but appears to be in the same direction as the Garlock Fault (i.e. left lateral).

Relationship of the scheelite veins to the rhyolite intrusions is unknown but the veins are cut by two persistent diabase dikes.

<u>Gold Deposits</u>

Most of the gold production has come from an area of about one mile radius from Randsburg. Other important production is from the Stringer District and from the St. Elmo Mine south of Atolia. Ore may occur in both quartz monzonite or the Rand schist. The gold veins cut and often follow dikes of both rhyolite - latite and diabase and appear to be areally associated with them. However, at the Yellow Aster Mine, the main gold producer in the quadrangle, no diabase dikes have been found.

Gold has been deposited along both simple and quite complex fractures which show a great variation in strike, dip, amount of displacement, and extent. Two general trends into which most of the veins would fit have been recognized. The strongest of these is about N 80° E or about parallel with the scheelite veins and the Garlock Fault. The other trend is about northwest-southeast. There are many exceptions to these trends. Without stating any evidence for it Hulin suggests that N 80° E fractures may be the earliest. This appears to be true at the Yellow Aster Mine but if this is true for the district as a whole is uncertain. Anyway both sets of fractures appear to have been developed before deposition of the gold, there being no evidence for a difference in age among the gold veins. Dip of the veins may be vertical as in the NW-SE veins at the Yellow Aster or as flat as 20°. Evidence of strong movements along some of the gold bearing fractures is shown by strong gouge zones and slickensides while others are fissures without much movement.

Three types of ore bodies are found in the district.

1. Deposits along faults in the crushed schist and granite.
2. Stockworks in granite.
3. Fissure with more or less quartz.

Fissure veins having two definite walls usually contain the most gangue minerals. They are usually narrow, less than 1' but may be up to 6' or 7' locally.

Many veins, especially those with low or moderate dips have only one definite wall, usually the hanging wall, Gangue minerals are usually sparse or non-existent in these veins but may be abundant locally. Here the ore is a layer of country rock below the faulting which has been impregnated with gold and to some extent by quartz and other minerals. Thickness may vary from a few inches to up to 16' as below the Jupiter Fault at the Yellow Aster Mine. Limits of the ore are determined by an assay wall.

Another series of ore bodies which possess no definite walls are found to spread out from fractures and to consist of mineralized country rock bordering the fractures. Examples of these are the East and West Sets and the Rand Vertical vein in the Yellow Aster Mine. (The East and West Sets are old large square set stopes) Little or no gangue minerals were deposited with this ore and at most all that is seen is a network of narrow quartz stringers cutting the mass. Widths up to 75' were mined in the East Sets of the Yellow Aster in the early days. The latest mining at the Yellow Aster has been of the very low grade stockworks in the quartz monzonite between the Jupiter, Hanging Wall, and Foot Wall Faults. This ore will average $1.00 to $1.25 / ton but is mined very cheaply by open pit methods.

Nature Of The Veins

Most of the veins have been oxidized and iron oxides are abundant. Some sparse sulfides mainly arsenopyrite, but some pyrite and rare galena were deposited with the ore and are now oxidized in the upper levels. Pyrite is more abundant in the altered wall rocks. Quartz is the only abundant vein forming mineral in these deposits. Scheelite occurs in some of the gold veins such as the Yellow Aster and especially in the Stringer District.

Ore Grade

Both oxidized and unoxidized ore grades range from a few cents up to $50.00 to $75.00 per ton. Apparently oxidation has had little affect on the grade. The size and grade of the ore bodies seem to decrease in depth as below the Jupiter Fault in Figures 2B and 3.

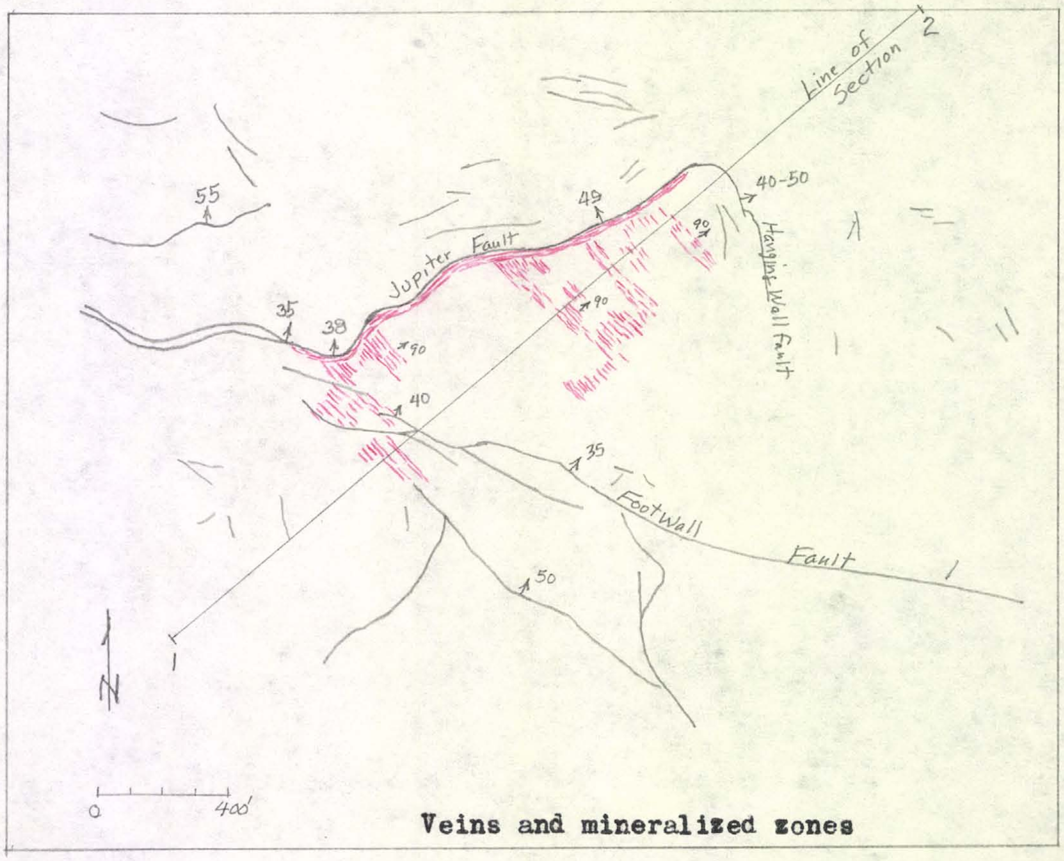
Alteration

At the Yellow Aster Mine gold has not been found where the quartz monzonite wall rock is not altered. Here the biotite has been bleached and the feldspars altered.

Structural Control of Gold Ore At The Yellow Aster Mine

At the Yellow Aster ore has been localized by the Jupiter and Hanging Wall Faults. The Jupiter Fault is very irregular and wavy both in strike and dip as shown on figure 2. To the northeast it apparently swings to the south where it is called the Hanging Wall Fault. It is possible that these are two faults. The crushed zone along the Jupiter Fault is from 2 to 80' thick and many slickensides and much shattering occur where it changes strike to form an inverted trough with the Hanging Wall Fault. Movements along this fault have been in different directions at different periods, and have been both pre - and post-mineral.

According to Hulin, the Jupiter Fault is one of the normal faults that generally parallel the trend of the Rand Mountains. Its irregular shape suggests that it might have originated under tensional stress. However, later movements along this very crooked surface have produced the crushed and gouge zone along the Jupiter and Hanging Wall Faults and fractured to a lesser extent the triangular block of ground between the Jupiter, Hanging Wall and Footwall Faults. (The Footwall Fault is post-mineral.) It seems quite probable that the Jupiter Fault has had a left lateral component of movement. This would almost have to be a necessity if the Jupiter and Hanging Wall Faults move as a unit down the top of the inverted trough as they would if they are one and the same. If the Jupiter Fault acted independently, the left lateral shearing stresses so prominent in the region as shown by the Garlock Fault certainly could have produced this effect. Either or both of these possibilities would have caused the northwest trending veins of the Yellow Aster Mine due to the hindered movements along the Jupiter Fault. (Figures 2A, 2B, 3).



Veins and mineralized zones

Fault system of the Yellow Aster Mine (after Hulin)

Figure 2A

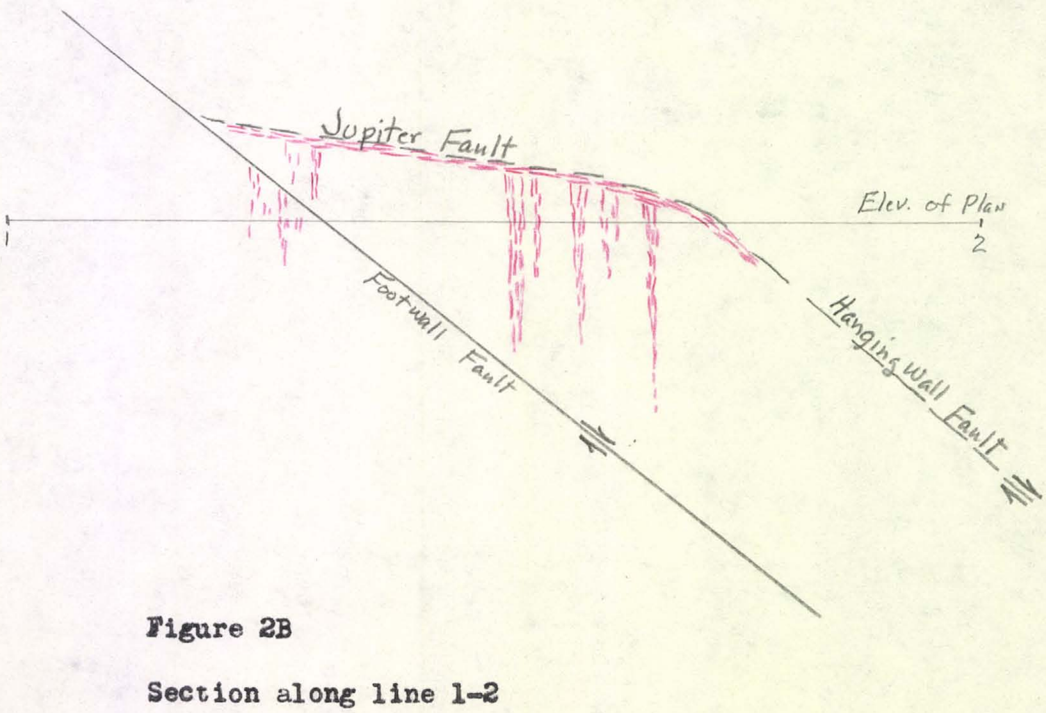


Figure 2B

Section along line 1-2

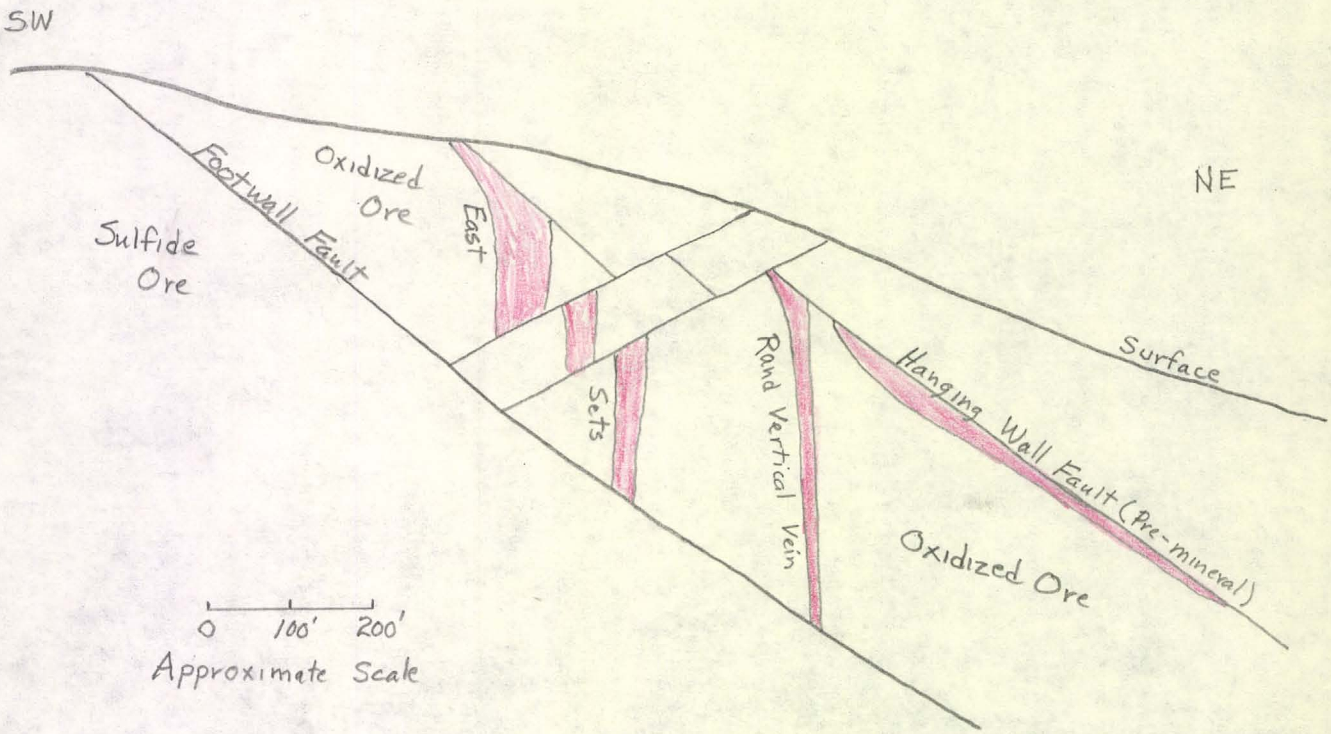


Figure 3. Hypothetical Cross -Section of the Ore Bodies of the Yellow Aster Mine (After Hulin)

Ore in the vertical NW veins and along the Jupiter Fault feathers out with depth.

Silver Deposits

Silver production has been restricted to an area of about 2 square miles south and southeast of the large rhyolite pipe in the center of the quadrangle. Economic mineralization has been found only in the Rand schist but occurs also in the lower Rosamond sediments and the quartz monzonite. In the silver area the schist is flat dipping usually about 20° SE. Diabase dikes in the area are small, irregular, altered near the veins and are cut by veinlets containing silver minerals. One of these dikes away from a vein shows silver assays of 0.8 oz. / ton.

Mineralogy

Mineralogically the silver veins are much more complex than the gold or tungsten veins. At least 18 minerals are known to occur in these. Quartz and chalcedony are the main gangue minerals, along with allophane and calcite which is late and not abundant. Miargyrite is the most abundant silver mineral, stylotypite is common. Pyargyrite and proustite are present only in small quantities. Cerargyrite is the main supergene silver mineral. Pyrite and arsenopyrite are common in the veins and are the most abundant metallic minerals in the veins. Stibnite is best developed in the leaner ore. All of the silver ores carry a little gold and some native gold has been found.

Ore Grade

Both hypogene and supergene ores have been high grade. Supergene ore containing values up to 13,000 oz. / ton, mostly cerargyrite and secondary sulfides, has been mined. However, most of the ore runs from about 10 to 300 oz. / ton. The average grade of all ore mined to 1925 was 50 oz. silver / ton, and $3.00 gold / ton (old price). The best grade of ore is in the north-south veins and is richest at the junction with northeast veins.

Wall Rock Alteration

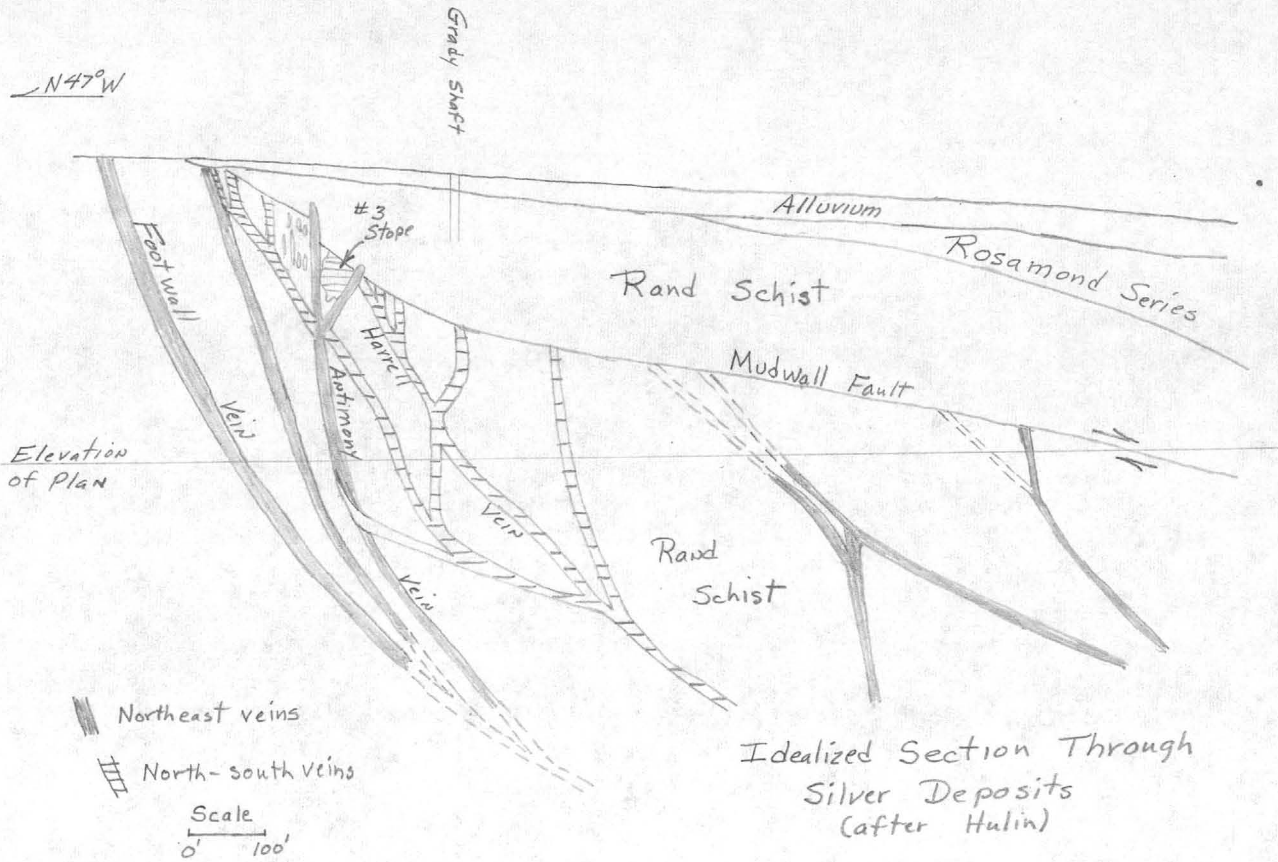
The schist is silicified and pyritized, the ferromagnesian minerals and feldspars are destroyed. Diabase is softened, bleached, pyritized and the ferromagnesians are destroyed.

Ore Textures

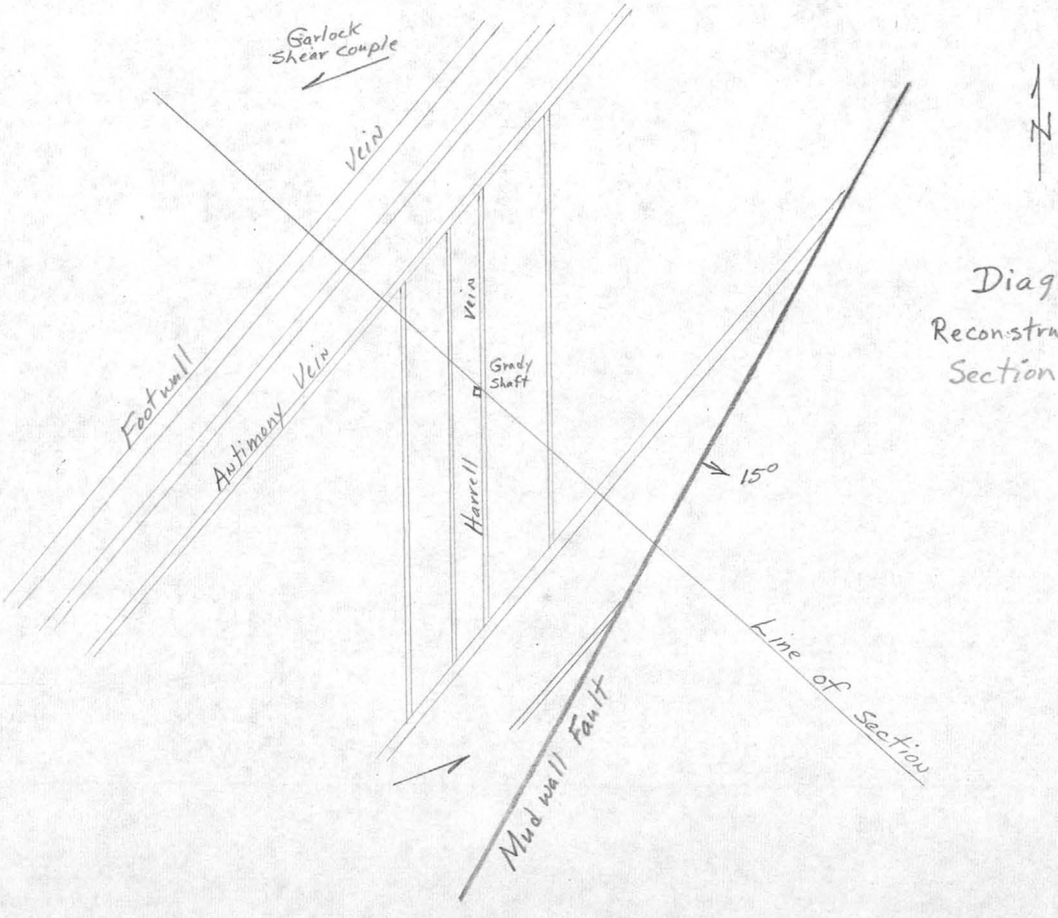
Fine grained to aphanitic gangue bluish gray to gray in color is characteristic. Angular breccia fragments of schist and white quartz similar to the gold quartz are common. The veins are brecciated and crushed and the fragments rounded, Often this brecciated vein material shows little recementation leaving the vein porous on a coarse scale. Large drusy cavities are also common. The silver minerals may be in the breccia fragments but more often occur surrounding them. The walls of the veins are seldom sharp and commonly pass somewhat indefinitely into the wall rock and veinlets carrying silver minerals pass out from the vein proper and form a network in the adjacent schist, so that it is sometimes ore.

Structure

Silver ore is found in definite but complicated veins. Two sets of veins are present. The earliest strike about N 40° E and are larger. The later veins strike N-S. Both flatten with depth and the N-S veins converge with depth. (Figure 4) The NE veins are larger and more persistent. The largest of these, the foot wall vein is 3500' long, 40-80' wide averaging 50'. The NS veins are short, usually 5-10' wide and up to 30' wide. They may merge with or intersect other NS veins either in strike or dip. In #3 stope of the Kelly Mine, the entire mass of rock is cut by numerous small



Idealized Section Through Silver Deposits (after Hulin)



Diagramatic Plan Reconstructed from Above Section

FIGURE 4

intersecting veinlets instead of a larger vein.

A flat pre-mineral fault terminates all of the veins except the few that outcrop and as far as is known no veins have been found above it. It strikes N 30° E, and dips 30°-10° SE. It is a crushed zone of schist showing intense movement. So intense is the crushing that the original character of the schist is lost and a thick fault gouge developed which is called the "mudwall". This is not a simple plane but a warped surface. Some of the veins have been observed to go into the mudwall for a short distance and the gouge is itself slightly mineralized with pyrite and stibnite.

Gardner says a contour map on the flat fault surface shows that the ore bodies occur under upward swells in the flat fault. This would result in a hindered fault movement if the faulting were normal.

Origin Of The Silver Veins

First to be developed in the formation of the silver veins was the flat Mudwall Fault. The nature of the original movement on this fault is not known. Several possibilities exist. (1) A thrust fault; (2) a normal fault due to sag into a possible volcanic crater area under Red Mountain. (3) It is the result of the footwall being forced up by the intrusion of the rhyolite pipe to the north and northwest. (4) It may possibly be a flatly rotated antithetic fault due to uplift to the east. Evidence for this is lacking.

Anyway, if this fault is not originally a normal fault, later normal movement occurred. This was possibly due to the doming by the rhyolite plug. As a result the N 40° E veins were formed as tension fractures or feather joints by the hindered movements along this warped fault plane. These veins merge with depth and flatten in dip showing that there has been some rotation of the veins beneath the Mudwall Fault. (Figure 4).

The NE veins were then filled with low grade or barren hard, dense fine-grained siliceous material.

Next, perhaps starting immediately after the NE fractures were opened, horizontal shearing forces acting in the same relation as along the Garlock Fault formed the N-S veins as torsional or tension fissures between the NE veins. (Figure 4) Apparently these N-S veins did not form until after the NE veins had been filled with the early vein material which then hindered the easy release of the forces along them and resulted in the "torsional" breaking which formed the N-S veins.

Long and repeated movement has occurred which has resulted in a complicated brecciation and fracturing of the veins. Where the veins have been reopened or broken by this action silver ore bodies were formed.

<u>Relation To Other Veins</u>

Evidence shows that the silver veins were quite likely the last stage of mineralization. They are observed to cut, and alter diabase dikes and to cut at least one gold vein. However, good gold values and lower silver values are reported to occur in the deepest workings. This might indicate that they are grading into gold veins at depth?

It has previously been noted that the gold veins are also later than the diabase dikes. Since some of the gold veins contain scheelite in varying amounts and the scheelite veins at Atolia are cut by the diabase dikes, the following relation is suggested as a sequence of mineralization: 1st tungsten, 2nd gold 3rd silver.

The changing composition of the dikes with time from rhyolite to latite to diabase may have resulted in a changing composition of the mineralizing solutions. However, many other factors may be important also.

Relation To The Surface At Time Of Mineralization

An attempt was made to determine the depth below the base of the Rosamond formation to the tops of the veins as they are now exposed. This work was hampered by the absence of any dips and strikes on the published map.

As has been pointed out previously, the rhyolite - latite and diabase dikes are known to cut the lower 200' of the Rosamond formation. Accordingly, if the base of the Rosamond formation can be projected to the veins an approximate depth of formation of the veins can be obtained. Difficulties arise from the variation in thickness of the Rosamond formation.which may average about 1000' in the quadrangle but ranges from 0' in the northern part to 6500' a few miles to the west in the Saltdale quadrangle.

No tangible results were obtained from efforts to construct a structure contour map on the base of the Rosamond. It did show, however, that it is quite possible that a sag basin or some type of structural low or possibly an old stream channel is developed between Red Mountain and the rhyolite plug. Here the Big 4 shaft was sunk 1300' in flat and irregularly inclined Rosamond sediments. The older formations were not reached.

However, projections on cross-sections A-B, C-D, and E-F do give some idea of the position of the base of the Rosamond. These projections were done mainly by connecting points on contacts and may be considerably in error if much faulting occurs between two projected points. The results of these projections are summarized below.

Section	Depth Below Base Of The Rosamond Formation		
	Tungsten Veins	Gold Veins at Yellow Aster	Silver Veins
A-B	----	1200'	0'
C-D	2,600'	----	300'
E-F	700'	----	-----

From this it is suggestive that the tungsten veins at the west end of the Atolia area were formed at greater depth than the portions of the gold and silver veins now observed. However, in the eastern part of the Atolia district scheelite veins have been found very close to the Rosamond contact. Also, veins in the Kelly Mine have been mined 1500' below the outcrop. At this level some gold ore is present.

This evidence shows that depth has had but little effect on the mineralization and that in all likelyhood the different types of mineralization are not the result of vertical zoning. Also the deposits must have been formed at shallow depths, perhaps some even coming to the surface. The textures of the deposits are also suggestive of shallow depth.

Future Possibilities

One unexplored area that seems to be structurally favorable for the formation of ore deposits in the area east of the large rhyolite plug. The big drawback to this area is the cover of sediments and volcanics younger than the ore.

However, several favorable structures are present here.

1. It is very likely that the subradial pattern of dikes which are developed around the rhyolite plug to the west, north and south is also present in this area, at least in some modified form. It seems almost certain that at least some dikes would occur with a N 80° E trend, roughly parallel to the Garlock Fault. Considering the apparent close association of the dikes with gold and silver ore this is important.

2. If this area is truly a sag basin and if Red Mountain is a source of volcanic material, there would have been ample opportunity for fractures to form which were favorable for the deposition of ore. It is possible that some of these may be post-mineral.

3. The Mudwall Fault which localized the silver veins projects into this area.

4. The main known gold and silver producing areas are peripheral to the rhyolite plug. About 30% of this peripheral area is on this east side and is covered.

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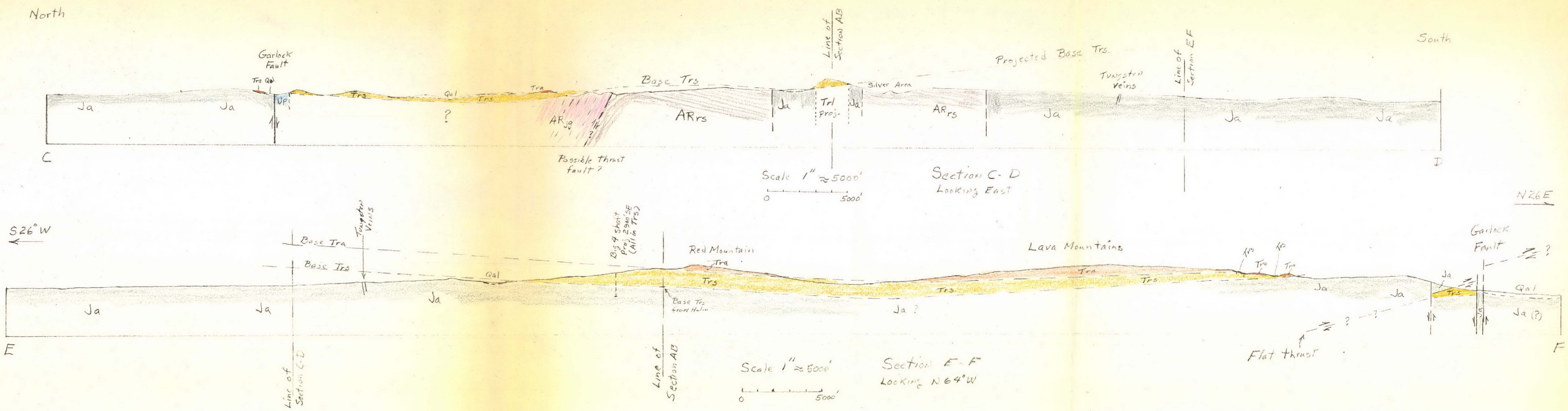

Cross Sections of the
RANDSBURG QUADRANGLE
D.Y. Mac Iver, May 1959

Submitted by Robert W. Turner

A REPORT ON THE ORE DEPOSITS OF THE RANDSBURG QUADRANGLE, CALIFORNIA

Mining 111 B

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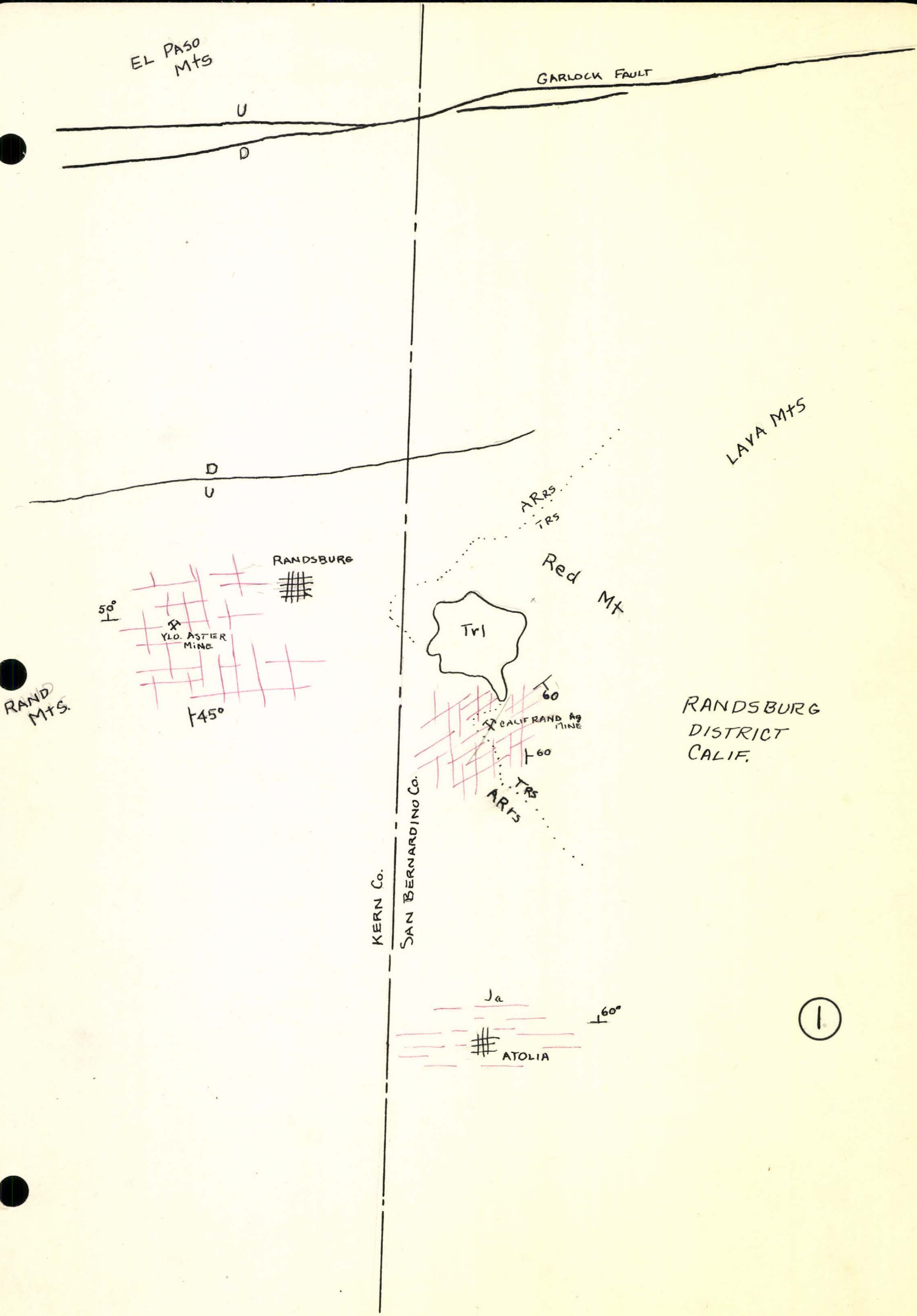
Location

The Randsburg Quadrangle lies in the northern part of the Mojave desert and is partly in Kern County and partly in San Bernardino County. The Garlock Fault zone runs through the northern part of the quadrangle.


EL PASO Mts
GARLOCK FAULT
U
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RANDSBURG
50°
YLO. ASTER MINE
RAND Mts.
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60
CALIF RAND Ag MINE
60
TRS
ARrs
KERN Co.
SAN BERNARDINO Co.
Ja
60°
ATOLIA
RANDSBURG DISTRICT CALIF.

Topographic Features

The main topographic features of the area are the Rand Mountains which trend north-east, south-west of Randsburg, and the Lava Mountains which lie on the same general line as the Rand Mountains in the eastern half of the area. Red Mt. , the highest point in the quadrangle is two miles east of the town of Randsburg. The valleys between the rather steep mountains are filled with detrital material from the surrounding mountains.

Lithology

The formations present are of a varied nature and range in age from Archean to Quaternary. The formations are listed oldest to youngest.

Johannesburg Gneiss	Archean	Hornblende-plagioclase gneiss, crystalline ls.hard 2500' thick
Rand Schist		Biotite albite schist, amphabole schist and qzt, minor ls. competent, major part of Rand Mts. A recrystallized intrusive rock with interbedded sediments. 1500-2000'.
Undifferentiated Paleozoic	Paleozoic	North of Garlock Fault.Marine ls., cherts, clay,shale & ss. 15000-16000'.
Atolia Qtz. Monzonite	Jurassic	Intruded into Rand Schist and undiff. Paleozoic at El Paso Mts. ¾ of quad. intruded by. (¼ of this outcrops) Compt.
Rosamond Series	Upper Miocene	Very incompetent bed of clays felspathic ss. and conglom. of continental origin. Outcrops around base of Red Mt. Contains much material of underlying formations. Much removed by erosion. 1000'

Rhyolite-Latite Intrusion	Upper Miocene	Intruded into base of Rosamond as pipes, dikes and sills. Intruded into the lowe 200'. Center of the intrusion was large neck 1 mi. east of Randsberg with the sills and dikes radiating outward from it.
Diabase-Basalt Intrusion	Upper Miocene	Dikes intruded into the lower 500' of the Rosamond Series. Distribution roughly the same as the rhyolite. Intrudes the Rand Schist, Q.M., Rhyolite series and the Rosamond.
Red Mtn Andesite	Upper Miocene to Pliocene	Makes up the Lava Mts. in the center of the area. Lies on the Rosamond with an angular unconformity between. Comp. of lava flows, agglomerates and tuffs. A competent bed. Was poured out on a flat surface of Rosamond. Evidence of explosive action. 1400'
Black Mtn. Basalt	Lower Pleistocene	Thin flows occuring in north part of the quadrangle, south of the Garlock Fault.
Alluvium	Quaternary	

Structure

1) Folding

Intense folding is found only in the extreme northern part of the quadrangle noth of the Garlock Fault. This folding is in the Paleozoic section. South of the Garlock the folding is gentle, the fold being open and never being overturned. The Johannesburg Gneiss and the Rand Schist both have low dips and broad open folds. The dips are generally to the south and south-west. The Rosamond is more intensely folded but only locally. Folding was in progress at the time of the deposition of the Rosamond. The Red Mtn. Andesite is slightly tilted but was not folded. The reason the sediments and volcanics north of the Garlock are folded whereas the formations south of the fault are not seems to be the result of the proximity of formations to a rigid basement. The Paleozoic formations north of the Garlock were far enough above the Archean basement to yield by folding. The rigid rocks exposed by continual uplift south of the Garlock Fault could only yield by faulting which is the major structure in the area.

2) Faulting

As noted above, faulting is widespread in the area. Faulting has occured in all of the formations and the ages vary greatly. Most of the faults mapped are of Upper Miocene and later ages. The most notable fault, of course, is the Garlock fault which trends N-E across the northern part of the quadrangle. From the formations outcropping in the area the earliest movements of the fault were vertical with recent horizontal movements. Hulin believes the horizontal displacement on the fault has been 5 miles.

The Rand Mts. appear to be a tilted fault block with the main normal fault striking north east on the north west side of the mountains and roughly paralleling the Garlock Fault. Within the Rand Mountains and south of the main fault fronting the mountains there are numerous parallel faults which strike roughly N 70 E. Another group strikes north-south. These faults will be discusses more fully in the discussion of the individual ore deposits.

Geologic History

1. Archean Sea depositing sediments which later were subjected to intense pressure and heat. Formed the Johan-

nesburg Gneiss.

2. Uplift and erosion.

3. Late Archean Sea depositing coarser deposits of sediments as the area was closer to the shore-line. Also igneous intrusions and volcanic activity occurred. Great metamorphism due to the pressure of overlying sediments.

4. Great erosion stripping off much of the Archean section. Small amount of folding.

5. Paleozoic deposited.

6. Uplift and erosion of all of the Paleozoic south of the Garlock.

7. Intrusion of the Quartz Monzonite in the Jurassic.

8. Erosion until the Middle Miocene. Much of the Quartz Monzonite was exposed.

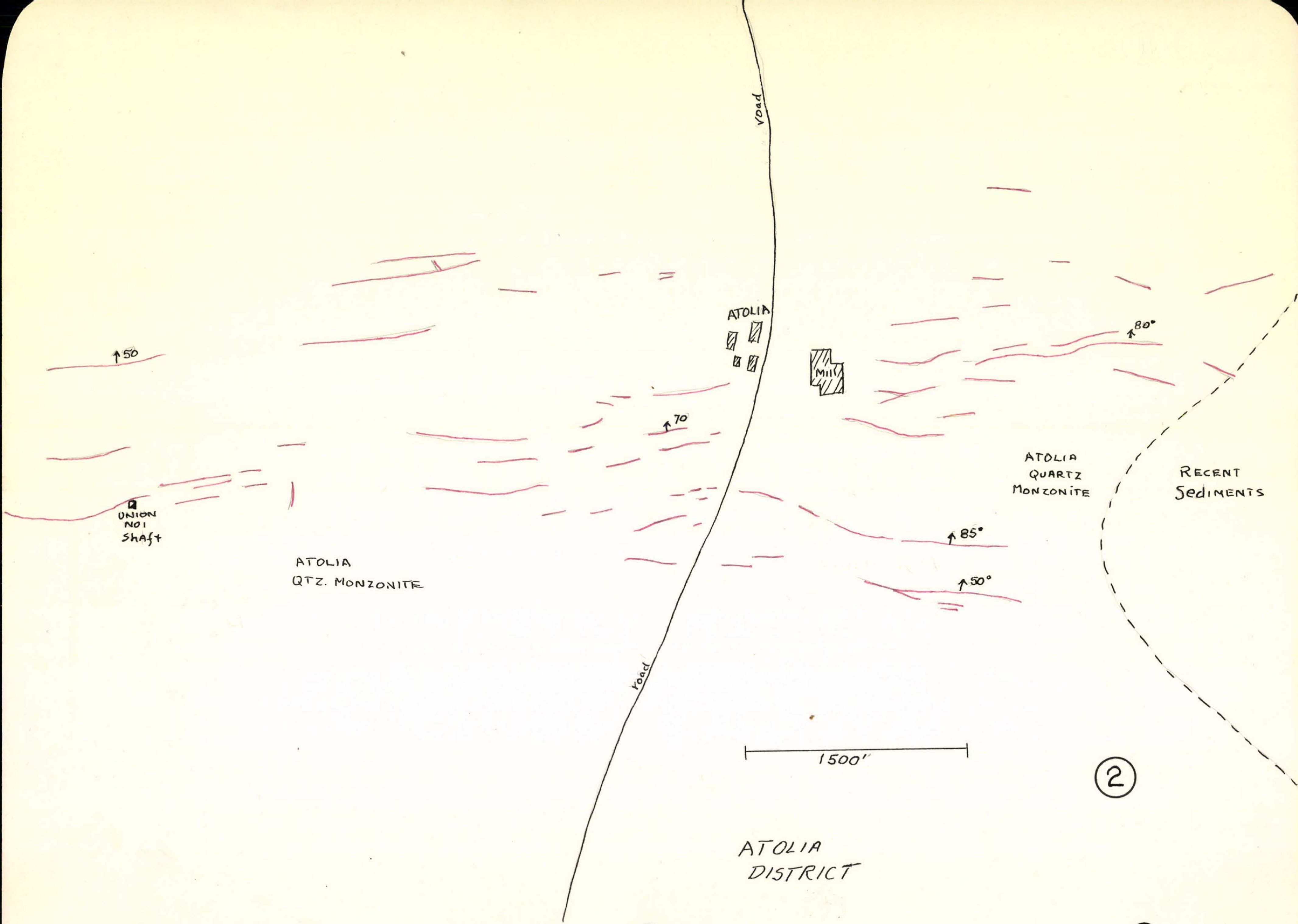
9. Large scale faulting in the Upper Miocene. This faulting produced large fresh water lakes in which the Rosamond was deposited. This faulting and folding were contemporaneous with the deposition of the Rosamond. This large scale faulting provided channels for the rhyolite and diabase intrusions which occurred at this time.

10. The Red Mtn. Andesites were erupted at this time. (Late Miocene)

11. During the Pliocene the Black mountain basalt was erupted.

12. Major horizontal movements on the Garlock Fault.

In the area there is large scale and repeated faulting, repeated uplift, hetrogeneity of the rocks and igneous intrusions. Thus, the area is theoretically favorable for



②

ATOLIA
DISTRICT

the locallization of ore deposits.

Ore Deposits

There are three main types of ore deposits in the quadrangle, each in a rather distinct environment and formed at a slightly different time than the other two. In order of age the deposits are: 1. Tungsten which is the oldest.

2. Gold

3. Silver

These surges of minerallization were not of distinctly separate ages but overlapped each other somewhat.

1. Tungsten Deposits (2)

The tungsten deposits occure in steep fissure veins which trend N 60-70 E and are in a zone one fourth mile wide. The veins are roughly parallel. The veins are mainly in quartz monzonite. The zone in which the ore occurrs is continuous for two and one-half miles along the strike. The veins are cut by many small cross faults. Some of these cross faults are mineralized while some are post-ore in age and merely offset the ore. As movement has occurred in many of these fissures they can also be classed as faults. The movement has not been great but enough has occured to brecciate the ore and to cause slickensiding.

Mineralogy The mineral assemblage is relatively simple and gives some guides for ore exploration.

Quartz a. Early quartz which is dense, fine grained and gray-white. Most of the ore is associated with this type of quartz.

b. Second quartz which is transparent and coarse. There is not a sharp break between the fine and coarse varieties of quartz but the content of ore becomes less as the coarsness of the quartz increases.

Scheelite $CaWO_4$ Pure white in color and occurs in well formed crystals in the fine grained early quartz. This is the only ore mineral.

Calcite White and coarse.

Stibnite Rare

Pyrite Small amounts

Dolomite Deep yellow-brown

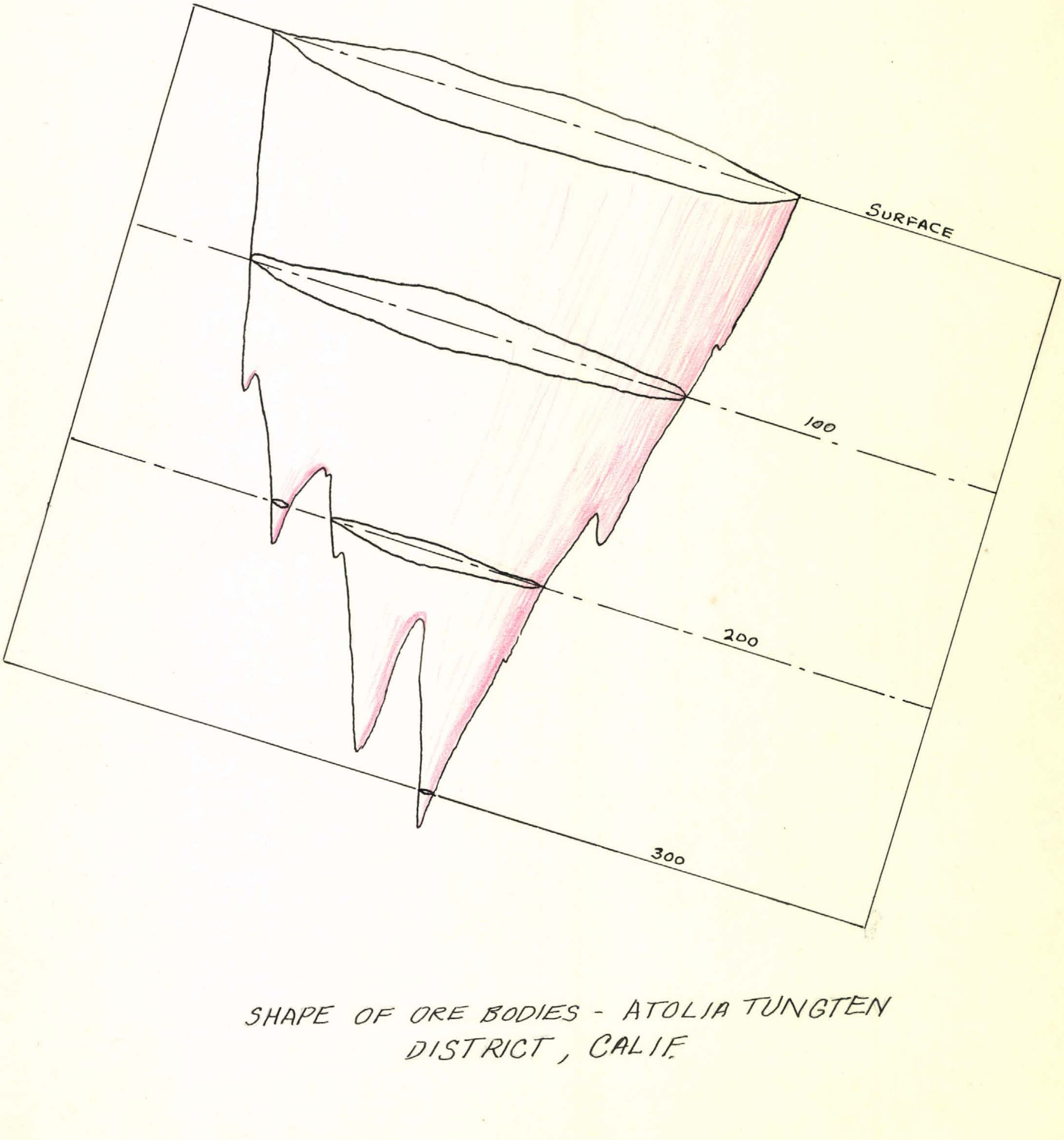
Ankerite

Gold Very small amounts. Rarely enough to mine alone.

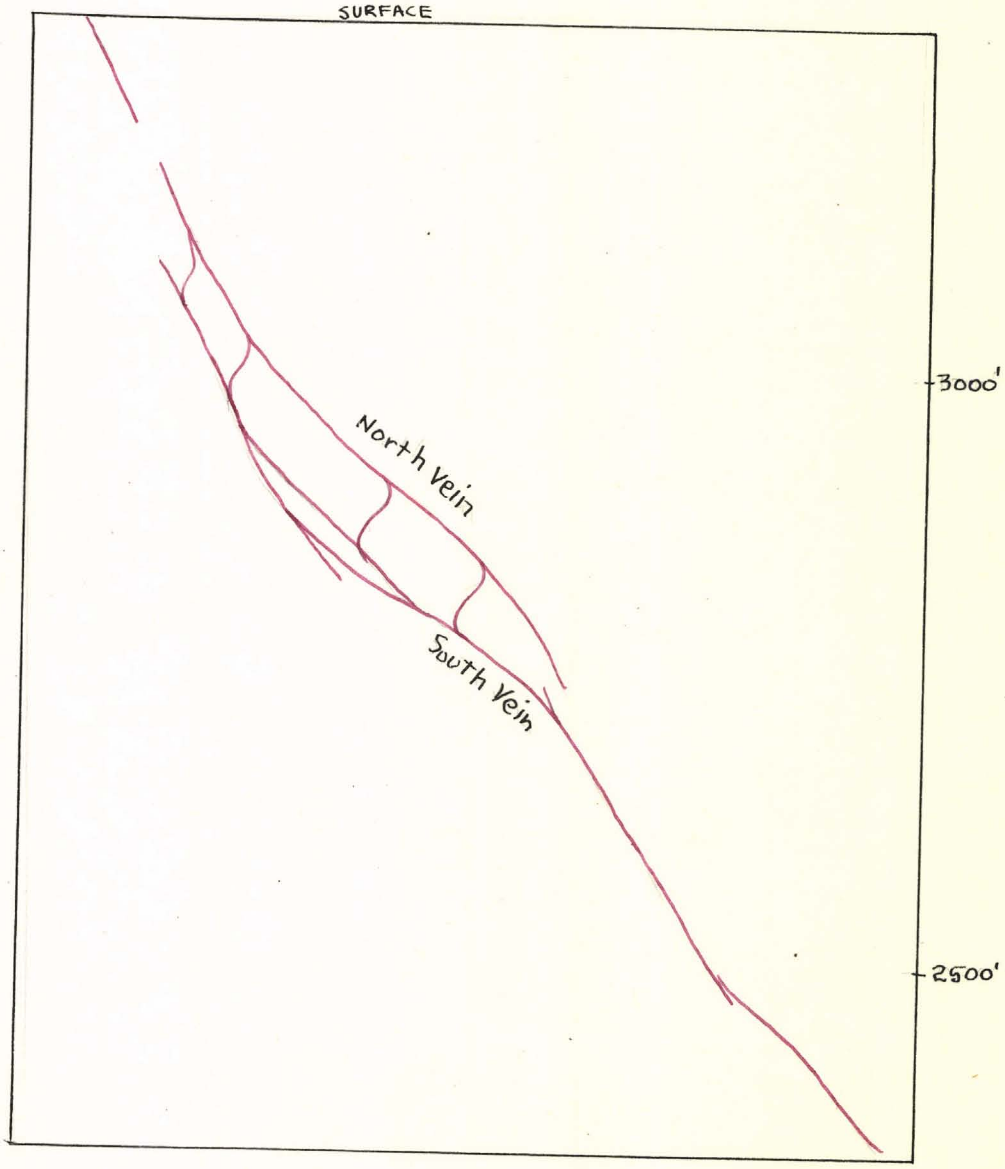
The order of the emplacement of the minerals was:

1. Fine grained quartz and scheelite.
2. Coarser quartz and a smaller amount of scheelite.
3. Barren quartz
4. Pyrite, Stibnite
5. Dolomite, Ankerite, calcite

Localization of the Ore- The ore occurs in rough pyramidal shapes with the base at the surface of the vein and the apex downward. The deposition was by fissure filling with very little replacement taking place. That faulting was going on during and after the emplacement of the ores is shown by the brecciation of the ores. One factor which tended to localize the ore was the intersection of cross faults with the main veins. These faults occured during and after the ore deposition. Another structure of the veins which tended to concentrate the ore is shown in the

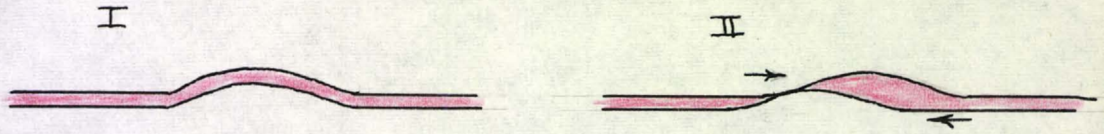


SHAPE OF ORE BODIES - ATOLIA TUNGTEN DISTRICT, CALIF.



UNION NO.1 SHAFT ATOLIA CALIF.

drawing.



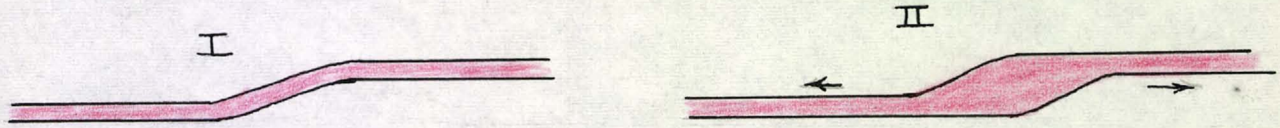


Plate (4) shows another localization for ore in the Union No. 1 Shaft west of Atolia. The ore was concentrated at the streches of the veins where they flatten out. The flattened areas may have caused the ore solutions to "stagnate" at this point and to drop their load. Movements as shown in the drawing above could also have provided an area of larger dimensions for the deposition.

The ore is shallow usually disappearing from 190 to 300 feet. The South Vein of the Union Mine, however, extended down to 1000' and did not run out of ore.

Age and Genesis-- The ore is believed to be of Early Upper Miocene age and associated with the rhyolite intrusions and large scale faulting which occurred at this time. The deposits have several typical epithermal characteristics:

1. Fine banding of vein material.
2. Little replacement, mostly fissure filling.
3. Numerous drusy cavities and well developed comb structure.
4. Fine grained pyrite and quartz.
5. Disappearance at a relatively shallow depth.
6. Much greater longitudinal extension of ores along the strike of the vein than down dip.

The Original Prospecting-- The original veins found were quartz veins which were easily found. The scheelite was defined by its good cleavage. As the veins run in a narrow belt and are roughly parallel most ores that outcropped were soon discovered. The veins ran in width from several feet down to knife edge veinletts.

Future Ores-- The veins that outcropped were all discovered in a short time. Other ore veins were found by crosscutting and other exploration methods at depth. As almost all of the ore veins have given out at a shallow depth it is unlikely that the veins can be extended any deeper with the hope of finding ore. Exploration should be carried out along the trend of known ore veins. Due to the erratic nature of the known veins the ore cannot be blocked out and reserves estimated. Diamond drilling from the surface as well as underground to intersect extention of veins combined with trenching in the shallow alluvium along trends may produce ore.

2. Gold Deposits

The major production of gold is restricted to an area surrounding the rhyolite pipe. No major production of gold has occurred over one mile from this pipe. As is shown on the illustration the major area is south west of the intrusion. The veins in which the gold occurs are almost entirely in the Rand Schist and the Quartz Monzonite. As the gold veins follow the trend of the rhyolite dikes and are restricted to the same areas a definite relation between the gold and the rhyolite is indicated.

Ore Texture-- The main vein material is quartz. Metallic minerals were introduced relatively late after the bulk of the quartz was deposited. The more important vein minerals were (in order of abundance):

1. Quartz
2. Arsenopyrite and pyrite
3. Galena
4. Gold which replaced the above minerals

The deposition of the metallic mineral did not begin until most of the quartz had been deposited as these minerals are well developed toward the center of the vein and in some cases make up a major part of the youngest veins. Almost all of the gold bearing veins are oxidized. Only where the conditions were such that the veins were protected by some structure are the primary sulfides found. Some gold enrichment at the surface occurred by downward migration of the gold. Galena was the mineral most frequently replaced by the gold.

Age and Genesis-- The age of the gold is placed as Upper Miocene and slightly younger than the scheelite deposits. A general parallel strike of the gold and scheelite veins suggests that the veins in which the gold was deposited were formed in the same manner and perhaps at the same time asthe scheelite veins. Most of the epithermal characteristics which were listed for the scheelite veins are present in the structure of the gold deposits.

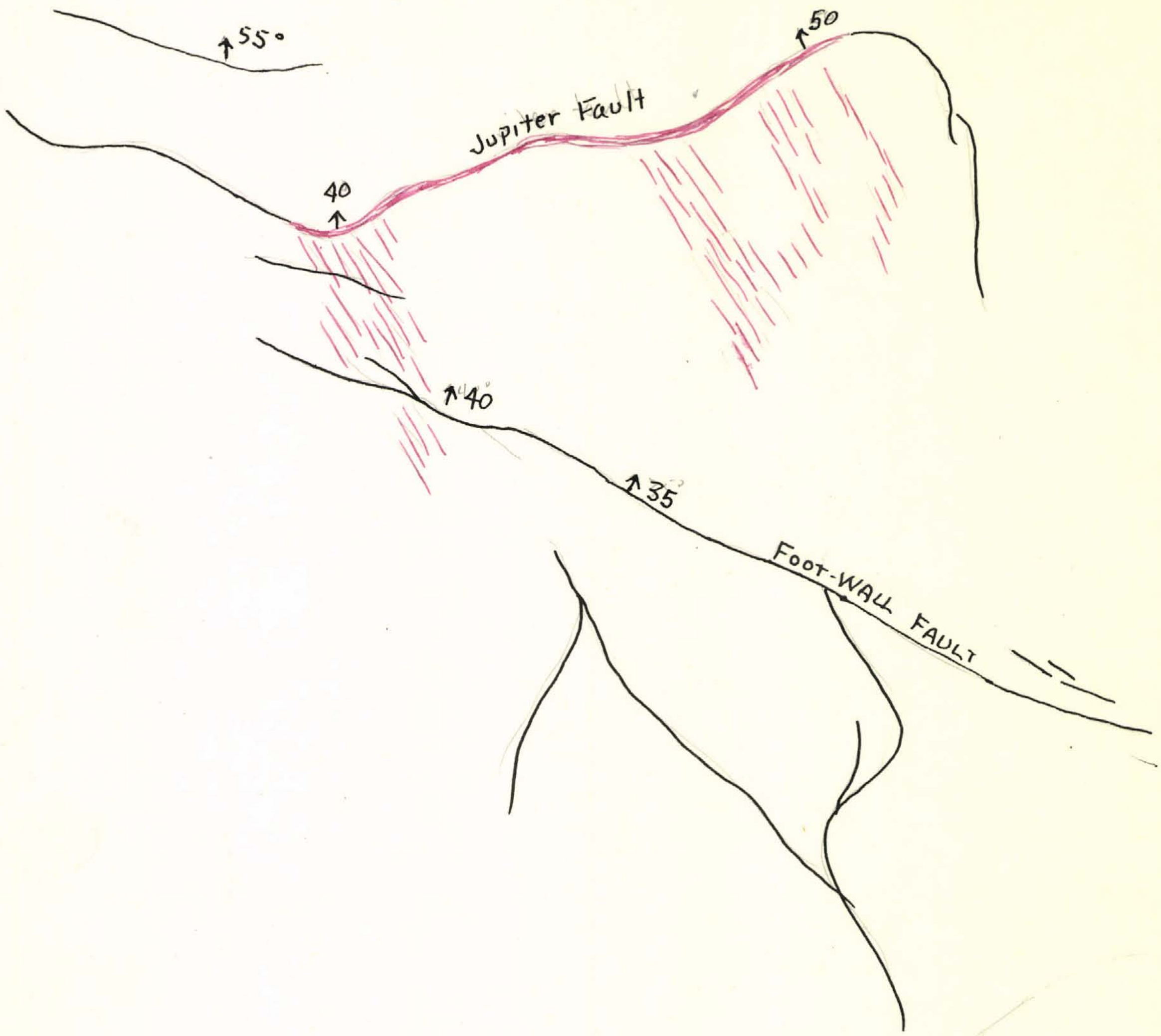
Structure-- The gold ore has been deposited in fissures, one set of which runs parallel to the scheelite veins N 80 E, and another group of veins which strike north-south. The two systems seem to be the same age as in some cases the north-south veins cut the north-east veins and in other cases the opposite is seen. Locally these veins vary greatly in strike and dip. The dips are north in the E-W veins and east in the N-S veins. The width of the veins is also erratic but the average is one foot. In high angle veins two well defined walls are seen whereas in low angle veins only the hanging wall is seen. Hulin believes that faults have the two well defined walls and fissures have only one well developed wall. In some veins the vein material grades into the wall rock in both walls with no border line seen.

The veins are very erratic in width and grade and die out suddenly along the strike or dip. Complex post-mineral faulting has increased the difficulty of mining the veins and has made exploration uncertain. Hulin expresses the belief that these veins were formed by compressive forces but the fissures indicate tension forces caused by uplift.

One structural control of the gold and also the silver veins is the rhyolite neck. The Rosamond, Quartz Monzonite, and the Rand Schist formations were silicified over a wide radius by the hot solutions from the rhyolite. In the silicified zone the formations were more brittle than the surrounding beds. In this zone the fractures and faults produced by diastrophic forces would tend to stay open longer and be more numerous. Ore solutions from the rhyolite itself or solutions rising along the faults produced would find this zone more favorable for deposition.

Another ore localliztion structure is shown in Plate (5) at the Yellow Aster Mine. The ore occurs in the vert-

FAULT SYSTEM IN THE YELLOW ASTER MINE



ical fractures and in the Jupiter fault. The distribution of the vertical fractures at the sharp bends of the Jupiter Fault suggests that these fractures are feather joints. The Jupiter Fault is a pre-mineral fault. The gold bearing solutions may have risen along the vertical fracture s and were concentrated at the fault because of the gouge in the Jupiter Fault or the solutions may have risen along the fault itself and passed out into the vertical fractures. As the Footwall fault cuts off many of these ore bearing fractures it seems to be post-ore.

Many of the gold bearing veins were faulted and did not outcrop at the surface. Thus many veins were found by underground exploration. No veins have persisted beyond a few hundred feet along the dip so new veins will have to be found on the same horizon as the known veins are now on. Future exploration will have to concentrate on known trends and on lateral exploration adjacent to present workings.

Silver Deposits-- Almost all of the silver production has been limited to the California Rand Silver Mine 1½ miles south east of Randsburg and about ¼ mi. south of the large rhyolite intrusion at the base of Red Mt. Although this mine was the only producer, it produced a large amount of high grade ore. The vein at the surface carried oxidized silver minerals and assayed $60 in gold and 436 oz of silver. Down to 50 feet this mine had no dump as all of the ore was shipped and produced $96,000. By 1923 $10,152,666 worth of ore had been mined. The mine was discovered in 1919 and by 1923 the mine was practically closed down.

The order of formation of the vein minerals was:

1. Silica
2. Pyrite
3. Arsenopyrite
4. Stylotypite
5. Chalcopyrite
6. Miargyrite
7. Pyrargyrite
8. Prousite

Secondary Minerals:

9. Secondary Sulfides
10. Cerargyrite
11. Melanterite

Ore Texture-- The ore mined was both secondary and primary. The richest ore ever mined was in the Treasure Box Vein where the ore assayed 13000 oz per ton of ore. Ore here consisted of cerargyrite and secondary sulfides. The average grade of all ore mined was from 10 to 300 oz silver per ton. Gold occurs in all of the ore but is erratic and low grade. The veins, epithermal in character, are finely banded, have fragments of the wall rock included in the vein material, contain many drusy ca vities and are badly brecciated. This brecciation is caused by post-mineral movement of the veins. As in the tungsten veins the first quartz was very fine in texture and became coarser in succeeding generations. As the silver is more recent than the scheelite the silver was introduced along with coarse quartz. Enrichment was confined to shallow depths and was by direct replacement of primary silver minerals by cerargyrite. The age is Upper Miocene and slightly later than the gold and scheelite.

Structure-- The silver occurs in two systems of parallel veins. The oldest system strikes N 40 E and the more rec-

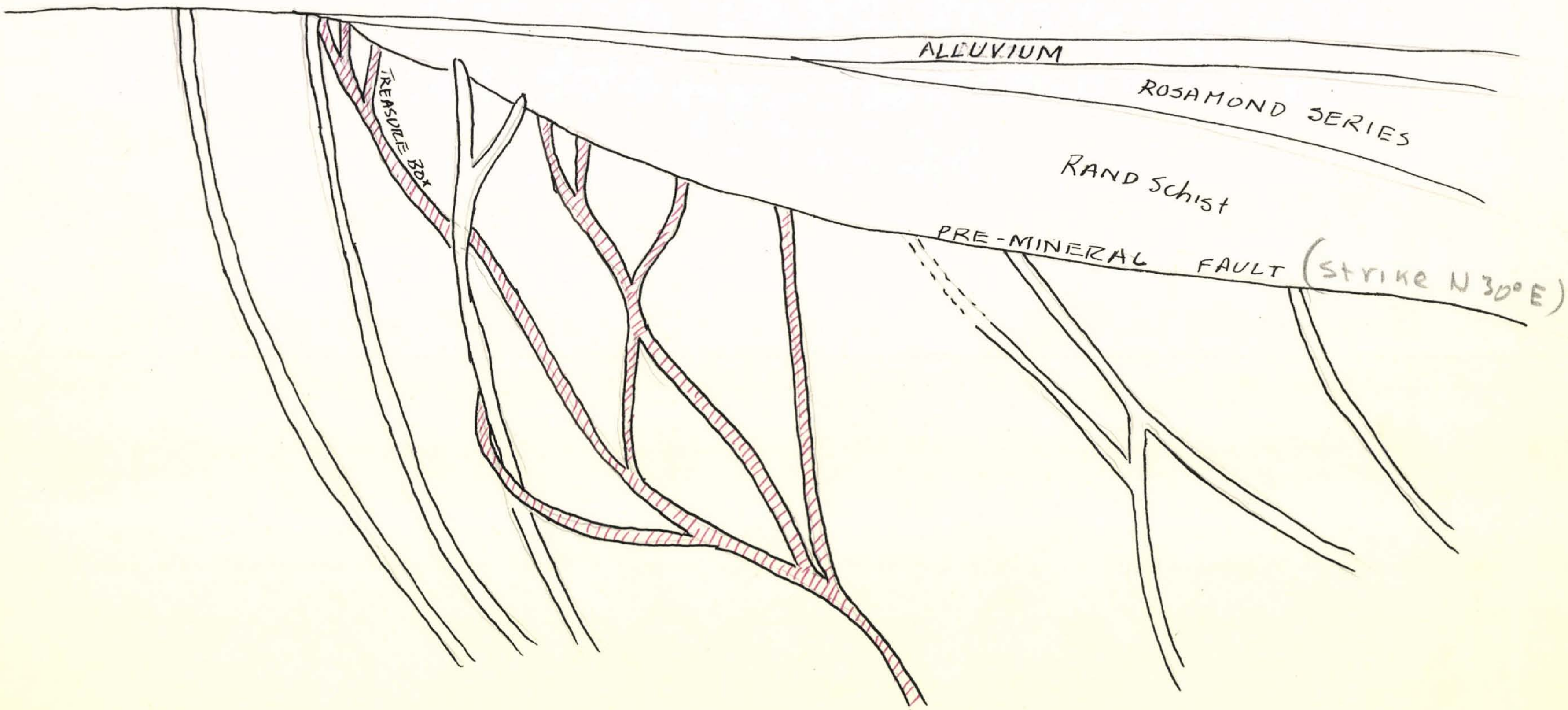
at the surface the ore is
oxidized silver minerals and
occurs in rather flat tabular
~~are~~ shapes — at depth the
~~sil~~ vein minerals were
silver sulfides in vein (new)
deposits.

ent set which strikes roughly due north. These veins have a general dip toward the east, steep at the surface and flatening at depth. The veins vary in width from 80' wide down to fractions of an inch. The veins of each individual system converge at depth which greatly limits the ore which can be expected at depthin a series of parallel veins. All of the veins except one or two are cut off before reaching the surface by a flat fault known as the "Mud Wall". This fault is made up of fine gouge of schist. This gouge is mineralized in the area of the veins and is thus classed as pre-mineral. The fault has apparently sealed off rising ore solutions which could not pass through the fine gouge and deposited the ore below the fault.

The ore in the north-south vein system seems to be localized between intersections of the north-east system of veins. The highest grade silver is at the intersection s of the two vein systems.

Due to the "Mud Wall Fault" most of the ore is primary. The epithermal characteristics of the ore are:

1. Fine banding.
2. Fissure filling predominates.
3. Drusy cavities.
4. Fine grained quartz and fragments of the wall rock. in the vein material.
5. Much greater extension of ore along the strike than along the dip .



IDEALIZED SECTION THROUGH SILVER DEPOSITS section strikes N47°W

// NORTHEAST VEINS

NORTH-SOUTH VEINS

The Original Prospecting-- The original discoveries were of ore exposed as horn silver in a prominent quartz vein striking N 40 E in the Rand Schist. The vein was very well defined and had very rich ore at the surface. Prospectors had been over the same ground where the original discovery was made, but they were looking for gold and passed up the silver showings. The discovery sight was 30 feet from a well traveled road and a trail passed over the vein where the ore was found. The find was purely by accident. Two gold prospectors were coming back to town at the end of the day and were resting along the trail. One prospector idly broke off a piece of the vein and sent it in for a gold assay. This sample returned 463 Oz silver and $60 gold.

Future Possibilities for ore.-- Due to the flat fault cutting off most of the veins before outcropping the prospect for finding new veins is rather good. Lateral exploration on the same horizon as known ore could be undertaken whereas exploration at depth looks useless as the veins merge and die out at depth. As the Rosamond Series and alluvium cover much of the surface around the mine shallow trenching or explor. by diamond drilling may also expose ore. A negative factor, however, is that even with intense exploration no other major mine has been found.

Mineralization in the Vicinity of Randsburg, California*

A Study of the Tungsten, Gold, and Silver Deposits of This Interesting Area

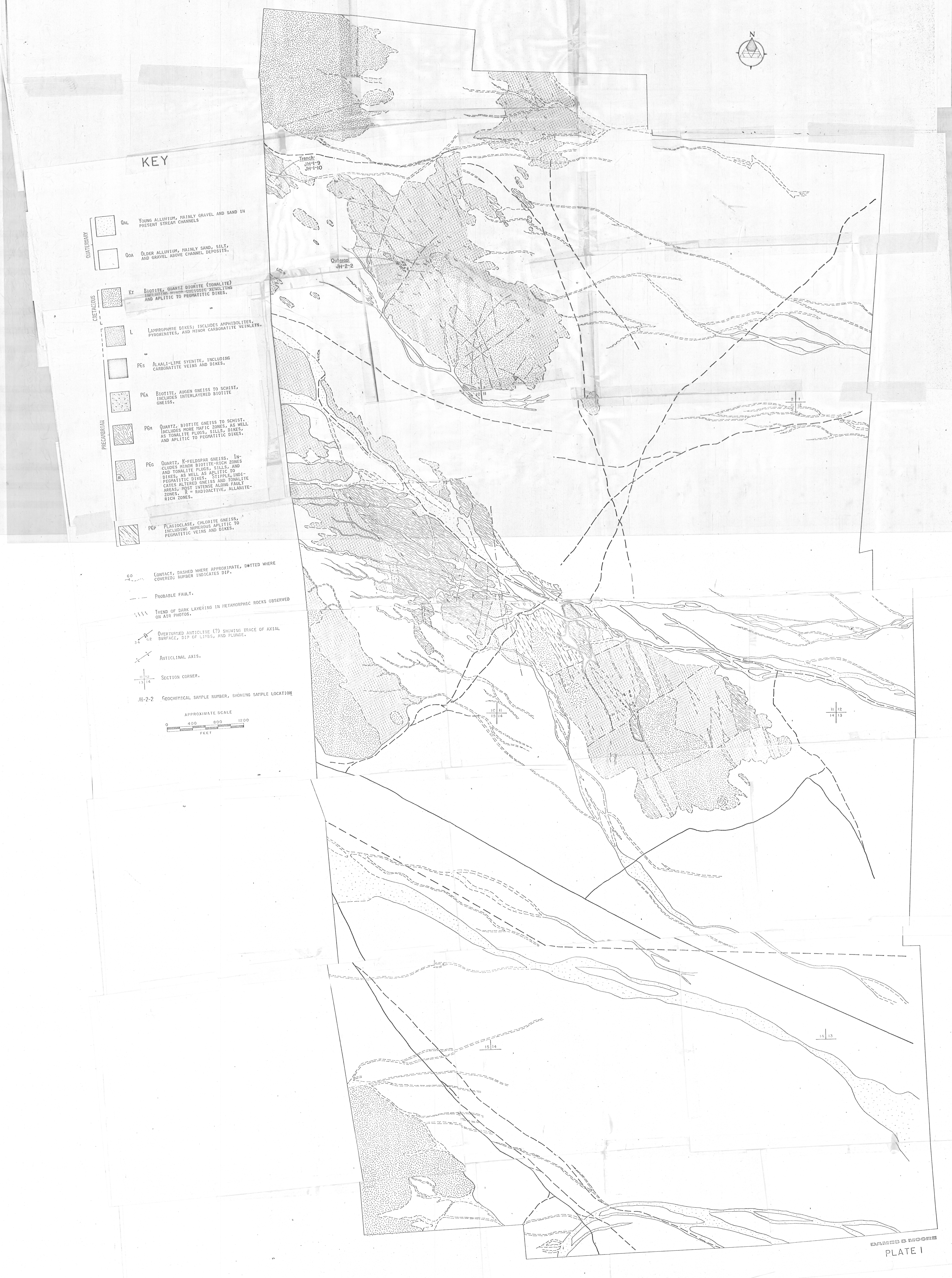
By Carlton D. Hulin
Consulting Geologist, Alameda, California

C

SECTION ALONG LINE A-B.

RECONNAISSANCE GEOLOGIC MAP OF A PORTION OF THE OLD WOMAN MOUNTAINS

SAN BERNARDINO COUNTY, CALIFORNIA



DAMES & MOORE

PLATE I