THE EARTH'S MINERALIZATION ENVIRONMENT OF THE GEOMINERAL COMPANY'S CLAIMS NEAR CALICO, CALIFORNIA

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A few of the ideas and the basic data are new; some are not, although a number of the relatively broad generalizations have only been reached recently.

The writers, of course, take responsibility for the manner in which the concepts are presented and supported in this paper, also any omissions and errors are solely the fault of the authors.

Harold S. Cook, Jr.

William F. Roberts

Los Angeles, California

June 6, 1967

ABSTRACT

Geology of the Geomineral Company's claims is basically a crossing situation of two sets of strike-slip and dip-slip fault systems brought about by Convection Currents and the mineralization is brought about by flows along the above mentioned fault systems with the oxidation and supergene enrichment being controlled by the lake that existed in the area during the Tertiary period.

The technical tools used to arrive at the above conclusions are outlined in this report.

The stratigraphic column in the Geomineral's claim area is Andesite, which is Pliocene, the Barstow formation, which is Upper Miocene, and the Pickhandle formation, which is Lower Miocene and Oligocene in age.

REPORT

GEO-MINERALS COMPANY PROPERTIES

CALICO-ODESSA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

The regional geology and tectonics of the Mojave Desert Region is well shown by U.S.G.S. Map I-512 (Plate #1, this report). The regional geology of the area has been masterfully summarized by T. W. Dibblee, Jr. and D. F. Hewett of the U.S.G.S. in Mineral and Water Resources of California, Part I. /1 The areas to the North and South whose tectonic activity has profoundly affected the Mojave Desert Region is excellently shown to the North by P. C. Bateman/2 and by P. C. Bateman and Clyde Wahrhaftig/3 and by J. H. Stewart and D. C. Ross/4.

The main points here are:

1. The collapse of the Owens Valley graben.
2. "The fact that the Sierra Nevada Batholith is a part of the more or less continuous belt of plutonic rocks that extend from Baja California northward through the Peninsular Ranges and the Mojave Desert, through the Sierra Nevadas at an acute angle to the long axis of the range, and into western Nevada; it may continue at depth beneath the volcanic rocks of the Snake River Plains and connect with the Idaho Batholith."/3
3. The Quaternary volcanic (less than a million years old) that extends along the base of the Sierra Nevada, Big Pine and Independence, and in the Coso Range.

In the South the geology and tectonics are equally well shown by by Hill and Dibblee/5, John C. Crowell/6, and T. W. Dibblee, Jr./7 as to the San Andreas Fault System and the Garlock Fault which are the bounding faults on the South and Southwest, and on the North of the Mojave Desert Block.

The geology and tectonics of the Salton Trough is brilliantly summarized by W. B. Hamilton/10 & 11 in Mineral and Water Resources of California, Part I, a portion of which is herewith quoted.

"The Salton Trough is the northern extension of the structural depression of the Gulf of California. Continental crust, lacking beneath the deep southern part of the Gulf, thickens gradually northward along the northern part; it is about 20 miles thick at the International border, and 25 miles thick at the north end of the Salton Trough (Biehler and others, 1964). The structure of the Salton Trough is dominated by the several right-lateral strike-slip faults of the San Andreas system -- San Jacinto, Imperial, San Andreas proper, etc. -- which trend obliquely into it from the northwest. The faults present an en echelon array, stepping to the right; individual faults strike more westerly than does the fault system as a whole, or than does the gulf depression into which the system trends. Right-lateral surface offsets within the Salton Trough occurred during earthquakes of 1857 (San Andreas fault; the offset sector was mostly northwest of the trough, but probably extended into it), 1934 (San Jacinto fault, in Mexico; Biehler and others, 1964)/8, and 1940 (Imperial fault). Deformation of the region is continuing at a very rapid rate, and the southwest margin of the trough moved several feet northwestward, relative to the northeast margin, within the short period 1941-1954, without further surface faulting (Whitten, 1956, fig. 3)/9 . Future severe earthquakes accompanying surface faulting are to be expected.

"Previous late Quaternary right-lateral offsets along the San Andreas fault in the trough are indicated by displaced drainage lines and by the tight, locally isoclinal folds with steeply plunging axes of Pleistocene and alluvial sediments adjacent to the fault. Total Cenozoic displacement has been enormous: distinctive middle Eocene strata are displaced 180 miles along it, from the Orocopia Mountains at the northeast edge of the Salton Trough to the Tejon region (Crowell, 1962)/6; displacement of mid-Cretaceous granitic rocks has been 300 miles (c.f. Hill and Dibblee, 1953)/5. The Gulf of California apparently opened as the Peninsula of Baja California pulled obliquely away from the mainland during Cenozoic time, and the Salton Trough probably formed by tensional thinning of the continental crust accompanying this motion (Hamilton, 1961)/11.

"The folding and minor faulting, like the major strike-slip faulting, demonstrate clockwise torsion within the trough throughout late Cenozoic time (Dibblee, 1954, p. 28)/7. The primary right-lateral faults trend northwestward. Minor left-lateral faults trend northeastward, and probably represent adjustments between blocks dragged by the major faults. Folds in the Cenozoic sediments trend mostly eastward and are en echelon, along or near both the major and minor fault zones."

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GEOLOGY OF THE MOJAVE DESERT REGION

(By T. W. Dibblee, Jr., and D. F. Hewett, U.S. Geological Survey, Menlo Park, Calif.)

The Mojave Desert is an area of low mountain ranges that separate many undrained alluviated basins or valleys. In the western part these have no definite pattern, but in the central and eastern parts many of them trend northwest and north. Relief increases eastward as altitudes of the alluviated valleys decrease from 4,000 feet at the western margins of the desert to near sea level at the Colorado River.

The rocks of the Mojave Desert province are separable into two major divisions, (a) pre-Cenozoic rocks, and (b) Cenozoic sedimentary and volcanic rocks. The pre-Cenozoic rocks are composed of (1) metamorphic and old sedimentary rocks, and (2) igneous rocks.

The metamorphic rocks are gneisses and schists of known and probable Precambrian age. They were recrystallized at great depth from rocks that were mostly sedimentary and which formed enormously thick sections. The gneisses are coarsely crystalline banded rocks composed mostly of quartz, feldspar, and biotite mica. They are exposed east and south of Baker, near Barstow and Randsburg, and near the southwestern border of the Mojave Desert. In a few places the gneisses contain deposits of rare-earth and radioactive minerals. The schists are foliated micaceous rocks. They are exposed only near Randsburg and in the Orocopia and Chocolate Mountains in the southern part of the desert.

Old sedimentary rocks, mapped as the Pahrump Series of Late Precambrian age, are found in only two areas in the extreme northeastern part of the Mojave Desert; one in the Silurian Hills north of Baker and the other farther east in the Kingston Mountains. This unit rests unconformably on gneiss, is many thousands of feet thick, and consists mostly of quartzite, shale or hornfels, and dolomite.

The Precambrian rocks are overlain unconformably by a great thickness of old marine sedimentary strata of Paleozoic age, divided into formations as shown on the columnar section (fig. 3). They are most extensive in the northeastern Mojave Desert near the Nevada state line, notably in the Kingston, Ivanpah, and Providence Mountains. The lower half of this stratigraphic section is of Cambrian age; in the Kingston and Ivanpah Mountains this section is mostly quartzite and shale (the basal unit, the Noonday Dolomite, has recently been assigned to the Precambrian). In the Providence Mountains the basal part of the Cambrian section is quartzite, the remainder is mostly limestone and dolomite. The rest of the Paleozoic (Devonian to Permian) section in these areas is mostly limestone and dolomite. Remnants of similar rocks of known and probable Paleozoic age engulfed in granitic intrusive rocks occur in many other parts of the desert, notably in the mountains southwest of Needles, in areas southeast of Twentynine Palms, in areas near Victorville, and in the Tehachapi Mountains west of Mojave.

Two nonmarine sedimentary formations of Triassic and Jurassic ages have been mapped in several places near the Nevada state line. Marine formations of these ages were recognized at one place near Baker, and possibly at another near Barstow. The thick section of slate (pre-Cenozoic rocks of unknown age) in the southeastern Mojave Desert near Blythe may be of this age.

The pre-Cenozoic igneous rocks are of two types, metavolcanic and plutonic. The metavolcanic (and hypabyssal) rocks are mostly andesitic porphyry of Mesozoic age that form a complex of extrusive and shallow intrusive masses and dike swarms in the central Mojave Desert. (emphasis ours)

The plutonic igneous rocks are coarsely crystalline and were emplaced at great depth. Most are granitic, are widespread, and make up the major part of the pre-Cenozoic rocks of the Mojave Desert. The oldest of these are granitic rocks (quartz Monzonite) exposed in the northeastern part (Hewett, 1956), and anorthosite and syenite in the Orocopia Mountains east of Salton Sea (Crowell and Walker, 1962). All are of Precambrian age and intrude gneiss. Gray granitic rock (quartz monzonite) of Jurassic (?) age is widespread in the east-central Mojave Desert. Gray to black diorites and gabbros of Mesozoic age crop out locally in many parts of the desert. All these Mesozoic plutonic rocks are intrusive into the metamorphic and old sedimentary rocks. Nearly all the above-mentioned pre-Cenozoic rocks are intruded by gray-white granitic rock (quartz monzonite to granite) of Cretaceous age that is very extensive in almost all parts of this province, especially in the western and central parts.

Metallic mineral deposits containing sulfides of iron, copper, lead, zinc, and silver, and commonly containing disseminated gold and silver, form veins in pre-Cenozoic rocks in many parts of the desert region. Most are found in metamorphic and old sedimentary rocks near intrusive contacts with granitic rocks; many occur in the granitic rocks. Tungsten ores occur under similar conditions. Other deposits containing these minerals except tungsten are found in fault or shear zones in these rocks. Deposits of iron ores are found in old sedimentary rocks along or near contacts with the intrusive granitic rocks of Jurassic (?) age. In the southwestern Mojave Desert, limestone is being quarried extensively for industrial uses, mainly for cement manufacture.

The Cenozoic sedimentary and volcanic rocks lie unconformably upon the pre-Cenozoic rocks which were deeply eroded during Cretaceous time. Those of early Tertiary age are sedimentary and are known in only one area strictly within the province, namely in the Orocopia Mountains east of Salton Sea where about 2,500 feet of marine sandstone (Maniobra Formation of Crowell and Susuki, 1959) of Eocene age are exposed.

Elsewhere on the Mojave Desert the Tertiary volcanic and sedimentary rocks are nonmarine, of middle and late Tertiary age, and are widespread. The most extensive Tertiary unit is an assemblage as thick as 10,000 feet, of volcanic lava flows, breccias, tuffs, and some sedimentary rocks, of probable Oligocene to early Miocene age. It is exposed in many areas in all but the southwestern part of the province. The volcanic rocks, which range from rhyolite through andesite to basalt, were erupted from groups of vents and

fissures, later filled with volcanic plugs, in many areas within these parts. Near Mojave in the western Mojave Desert, this assemblage was named the Gem Hill Formation of the Tropico Group; in areas north of Barstow, as the Pickhandle Formation (emphasis ours). Elsewhere it is not named. Ores of gold and silver, some very rich, were mined from veins in the volcanic plugs associated with this unit, notably near Mojave, Randsburg, Barstow, and Ludlow. These plugs contain veins of barite near Barstow and Ludlow and manganese ore near Ludlow. The volcanic rocks also contain perlite, pumicite, and tuff, of commercial grades.

The above-described volcanic and sedimentary unit is overlain, in places unconformably, by a predominantly sedimentary unit as thick as 5,000 feet of middle Miocene to early Pliocene age. In the western Mojave Desert it is known as the Barstow Formation near Barstow; (emphasis ours) Punchbowl Formation at Cajon Pass; and Fiss Fanglomerate near Rosamond. At the west end of the Mojave Desert this unit grades westward into marine beds. Commercial minerals in this unit include the world's largest deposit of borate minerals that are being mined from lake-bed shale near the base of this unit at Boron. Similar lake-bed shales of this unit contain deposits of borate and strontium minerals and of absorptive tuff or bentonite, near Barstow, Yermo, and Ludlow.

Stratigraphic sections of middle and late Pliocene age are exposed in the northern part of the province, notably west of Mojave and east of Randsburg. In the Randsburg area the section includes andesite flows and tuffs associated with andesitic intrusions. In other parts of the province much of the dissected alluvial sediments may be of this age.

Deposits of Quaternary age that fill the desert valleys are mainly alluvial sediments, some lake-bed clays, and dune sand. In a few places they include local basalt flows and cinder cones. The cinder cones are composed of basaltic pumice which is quarried for industrial uses. The clays of Bristol Lake near Amboy in the central Mojave Desert contain enormous deposits of salt with calcium chloride which are being quarried for industrial uses.

The pre-Cenozoic metamorphic and old sedimentary rocks of the Mojave Desert province are complexly folded, faulted, and intruded by plutonic igneous rocks. These igneous rocks, mostly granitic, which extend southeastward from the Sierra Nevada province, assimilated most of the pre-existing rocks. All this happened during the Mesozoic Era.

The Tertiary stratified rocks which rest on the deeply eroded surface of the pre-Cenozoic rocks are themselves tilted, faulted, and deformed into folds with axes that trend mostly west to northwest. They were deformed during late Tertiary and early Quaternary time. In many places Quaternary alluvial sediments and basalt flows are slightly deformed in the same manner.

The Mojave Desert Region is in large part bounded geologically on the southwest by the San Andreas fault and on the northwest by the Garlock fault, or physiographically by mountain ranges uplifted along these master faults.

Both are vertical, active faults along which movement was mainly horizontal; the area southwest of the San Andreas fault has moved northwest, and that northwest of the Garlock fault has moved southwest, relative to the wedge-shaped block that forms the major part of the Mojave Desert province. The southwest half of the Mojave block itself is broken by a number of vertical faults parallel to the San Andreas fault. Along many of these faults the terrain has slipped horizontally as on the San Andreas. South of the Garlock fault, and north of Salton Sea, the Mojave block is broken by some vertical faults that trend east, along which the terrain has slipped in part horizontally as on the Garlock fault. All or most of these faults within the Mojave block involve Quarternary formations and therefore active. (emphasis ours) The Garlock fault becomes a southwest-dipping thrust fault at its east end as it curves southeastward around the Avawatz Mountains.

The structural pattern of the eastern part of the Mojave Desert province differs from that of the western and central parts and is more like that of the Basin and Range province to the north. In this part the old sedimentary rocks are compressed into folds with axes that trend mostly north; some are broken by low-dipping thrust faults that are themselves folded. Most of this deformation occurred before or during the invasion of the Mesozoic granitic rocks, but some of the thrust faults involve lower Pliocene formations. Some of these show no topographic expression and therefore have long been inactive.

(Above from Mineral and Water Resources of California - Part I - Mineral Resources Report of the United States Geological Survey, pages 62 - 66)

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GEOLOGY OF THE GEO MINERALS CO. CLAIMS NEAR CALICO, CALIFORNIA

The geology as shown in Plates II, III and IV is based upon a careful study of the area mapped in Plate II, as well as a thorough study of the geological mapping made by others over a period of many years.

(It is interesting to note that 80 years ago this year, Waldemar Lindgren published his first American paper on Mining Geology which was on the Calico area[1].)

A complete list of the published geological maps of the area is included in the list of references attached hereto. [2-6]

The cross sections shown on Plate III and IV, I believe are self-explanatory except that they only show the dip slip component of the faults and not the strike slip component. The strike slip component on the Calico frontal faults I believe is approximately 300-500 feet right lateral and approximately 50 feet on the left lateral Doran fault. On the main Calico fault the motion will vary at different places along it, but on Section A-A' I believe it is approximately 1/4 of a mile right lateral. The dip slip components of the Calico frontal faults is believed to be at least 300 feet and possibly considerably more. The dip slip component on the Doran fault is believed to be 150 feet +. On the main Calico fault the dip slip component is at least 500 feet with possibilities of considerably more motion. All of these faults I believe are active and have had many recurrent flows of lava and mineralizing fluids on them.

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1. Lindgren, Waldemar, 1887, The Silver Mines of Calico, California: Transactions of the American Institute of Mining Engineers, vol. 15, p. 717-734. (Includes generalized geologic map; the first description of a mining district - though based on a very brief visit - by the future, renowned geologist.)

2. De Leen, J. L., 1950, Geology of the Calico mining district: University of California, unpublished master's thesis.

3. Dibblee, T. W., 1963, Geology of the Willow Springs and Rosamond quadrangles, California: U. S. Geological Survey Bull. 1089-C, p. 253. (Plate 11 shows the broad geology of the Mojave Desert, including the Calico region.)

4. Erwin, H. D. and Gardner, D. L., 1940, Notes on the geology of a portion of the Calico Mountains, San Bernardino County, California: California Division of Mines Report 36, p. 293-305. (Includes generalized geologic map.)

5. McCulloh, T. H., 1965, Geologic map of the Nebo and Yermo quadrangles, San Bernardino County, California: U. S. Geological Survey, Open-File Map. (The authoritative geology for the region, done 1952-54; copies for reproduction are at the Los Angeles office of the U. S. Geological Survey.)

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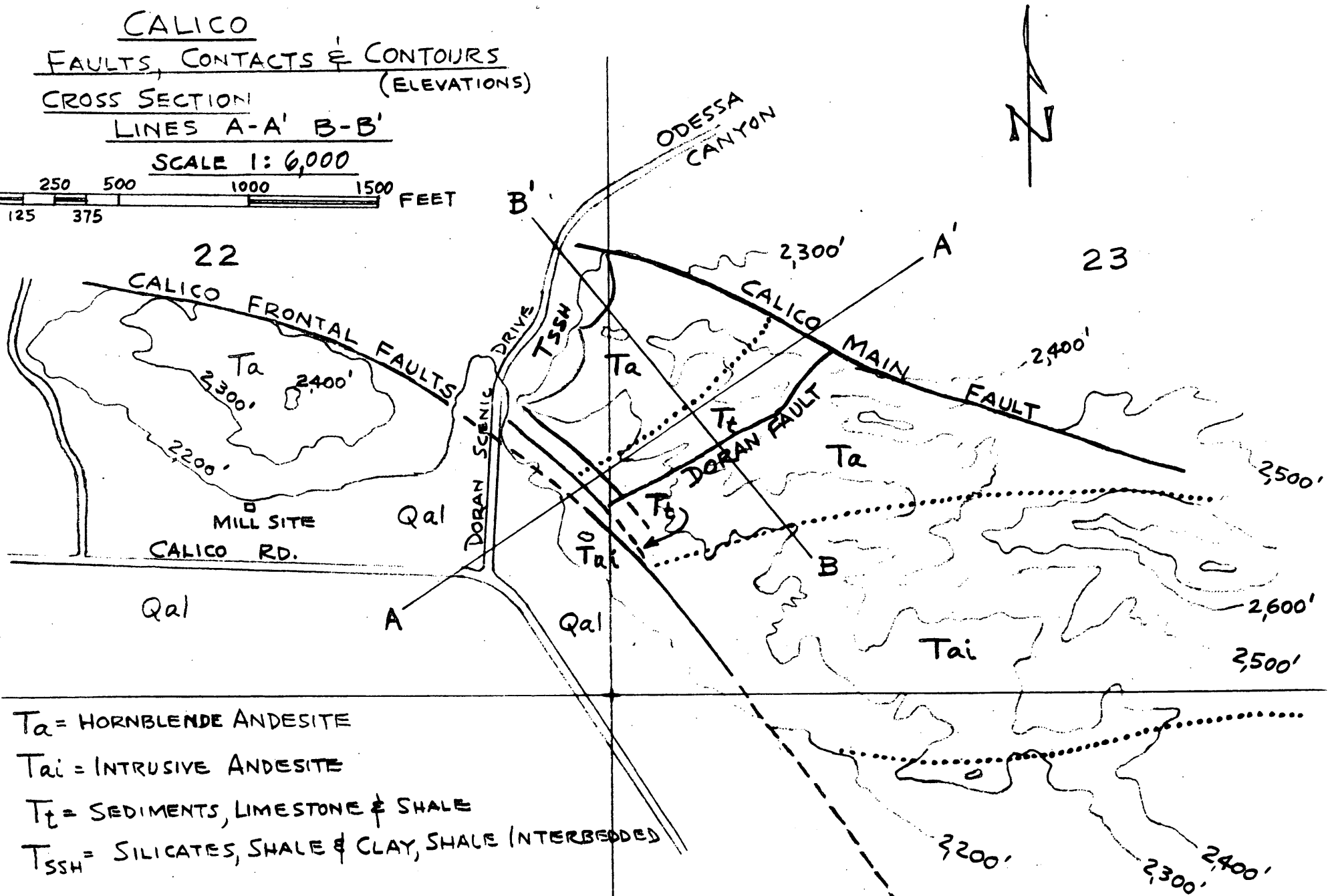
PLATE II

CALICO
FAULTS, CONTACTS & CONTOURS (ELEVATIONS)
CROSS SECTION
LINES A-A' B-B'
SCALE 1: 6,000

0 250 500 1000 1500 FEET
125 375



Ta = HORNBLENDE ANDESITE

Tai = INTRUSIVE ANDESITE

Tt = SEDIMENTS, LIMESTONE & SHALE

Tssh = SILICATES, SHALE & CLAY, SHALE (INTERBEDDED)

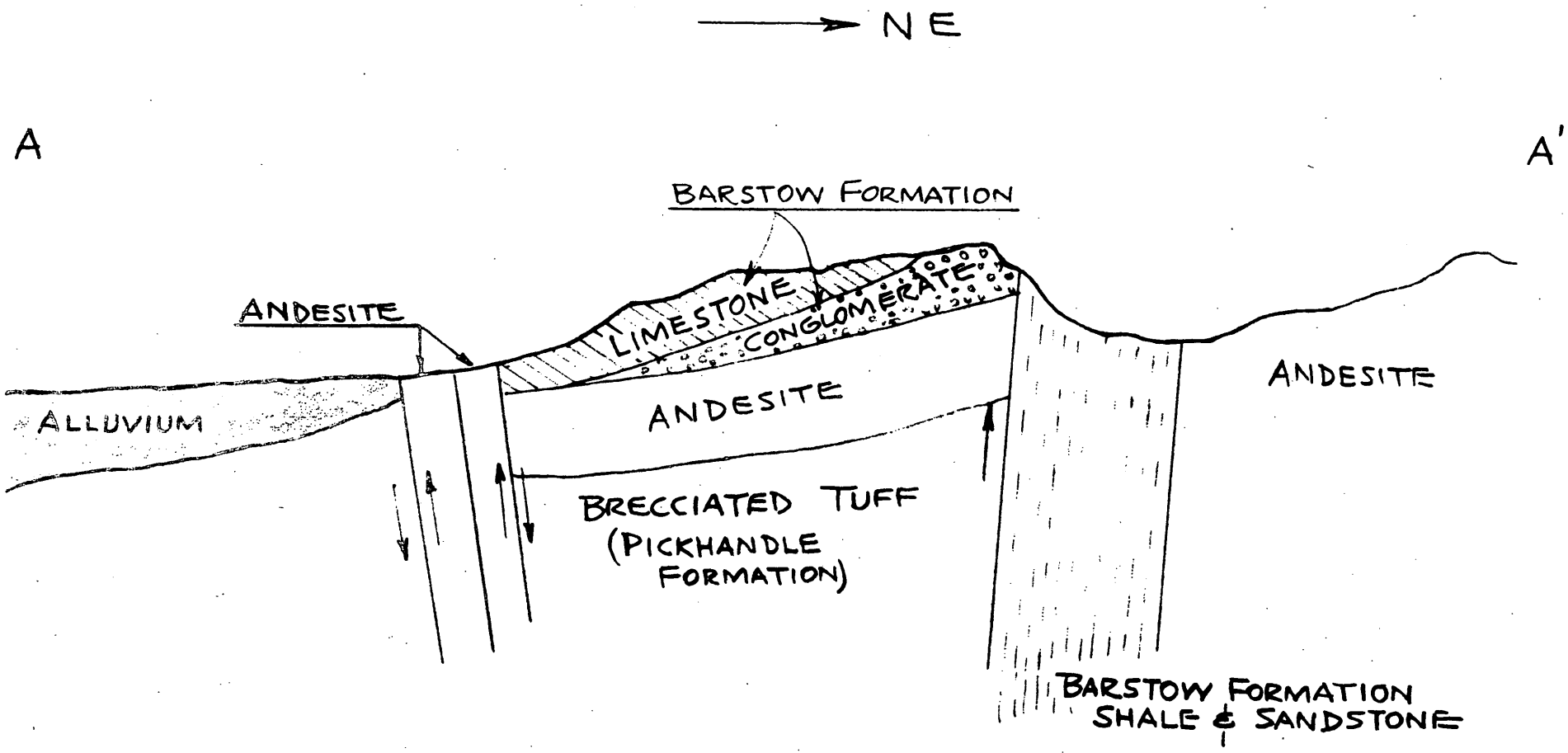
Tt & Tssh BARSTOW FORMATION

— = FAULT

- - - = FAULT (UNCERTAIN)

..... = CONTACT

JAN. '67 WFR



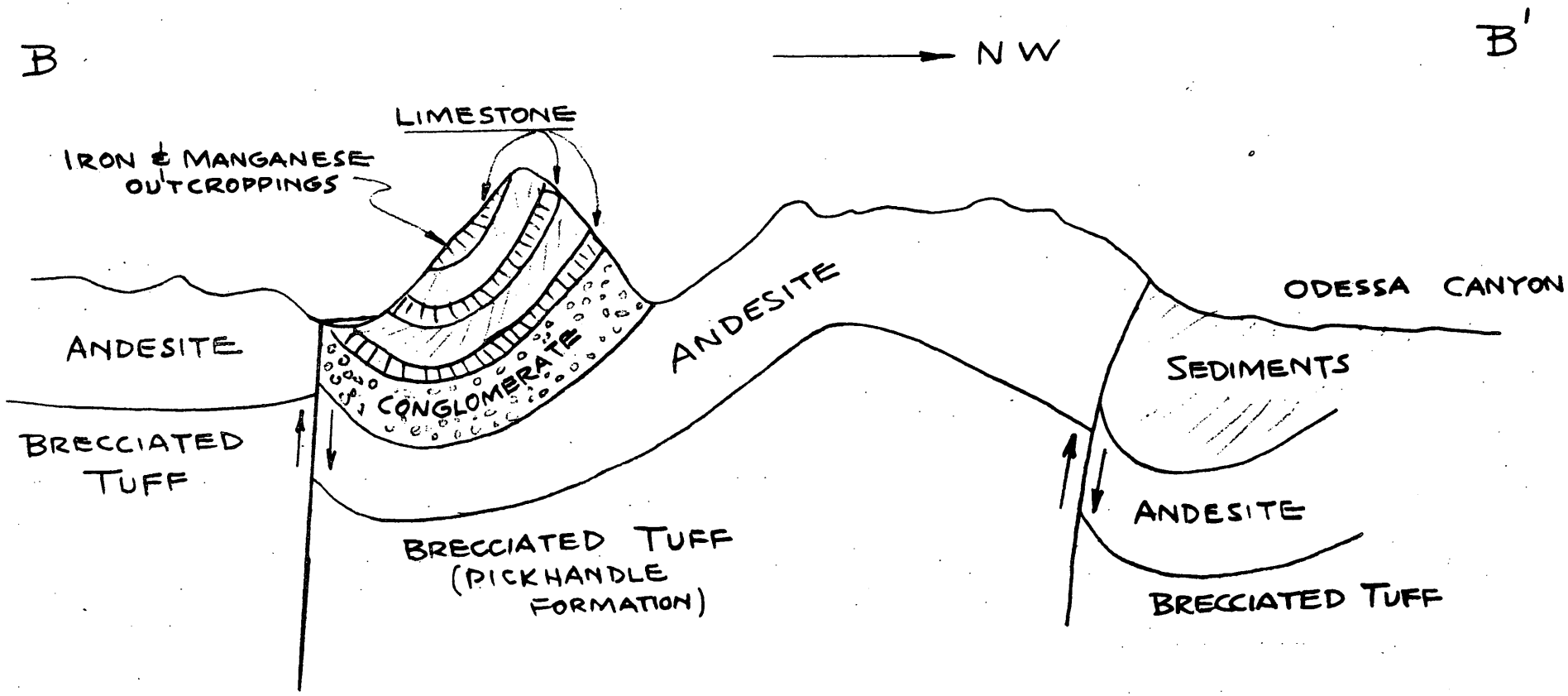
0 1/4 MILE

APPRX. SCALE

CROSS SECTION A-A'

SEE PLATE II

WFR



0 1/4 MILE

APPRX. SCALE

CROSS SECTION B-B'
SEE PLATE II

WFR

HYPOTHETICAL SECTIONS

Plates V, VI and VII that are shown herewith are completely hypothetical but are included because it shows the full picture of the geology as I see it, except of course it only shows the major faulting. One should realize there is undoubtedly a number of minor faults as well as a tremendous amount of fracturing and fissuring in the area.

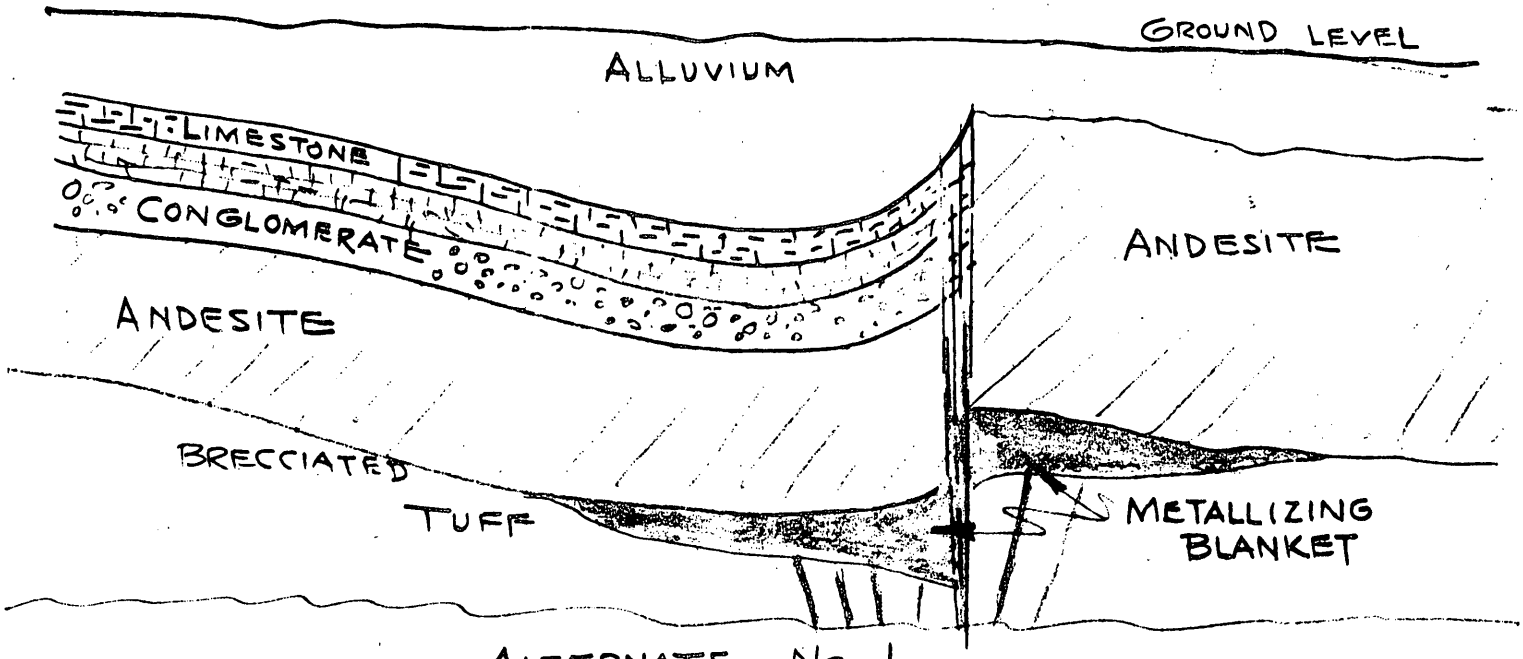
The second reason is that it shows the outline of the lake which will be discussed in the Section labeled "Hydrology" herein and also the effects of said lake will be shown in the Section entitled "Oxidation and Supergene Enrichment".

The third reason for showing these hypothetical sections is due to the fact the Geopulse instrument (see Geopulse Section) indicates a possible fault near the north line of the Cook and Roberts claims, as shown on the plates included.

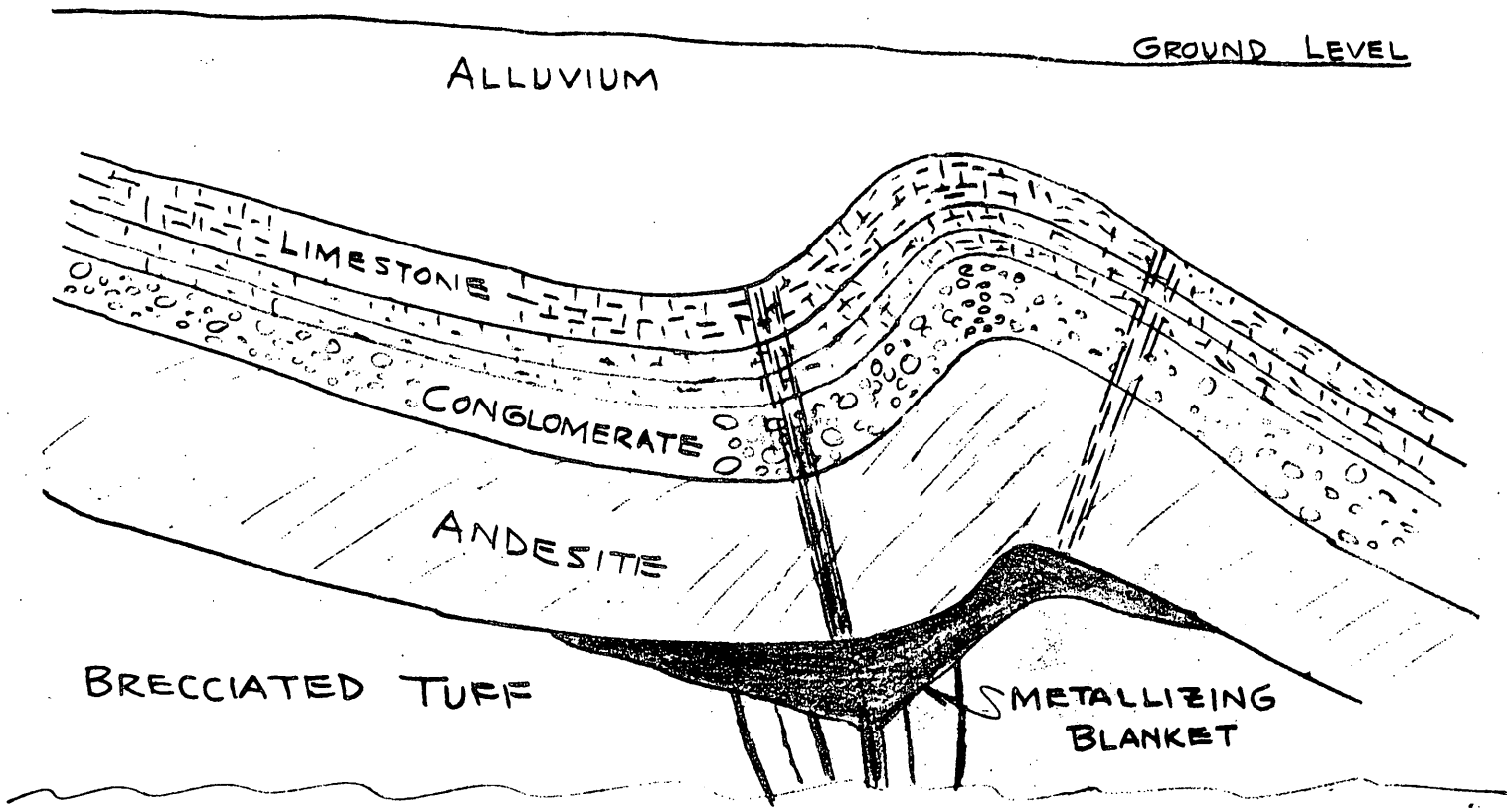
IN FRONT (WEST) of the FRONTAL FAULT

PLATE V

HYPOTHETICAL CROSS SECTIONS



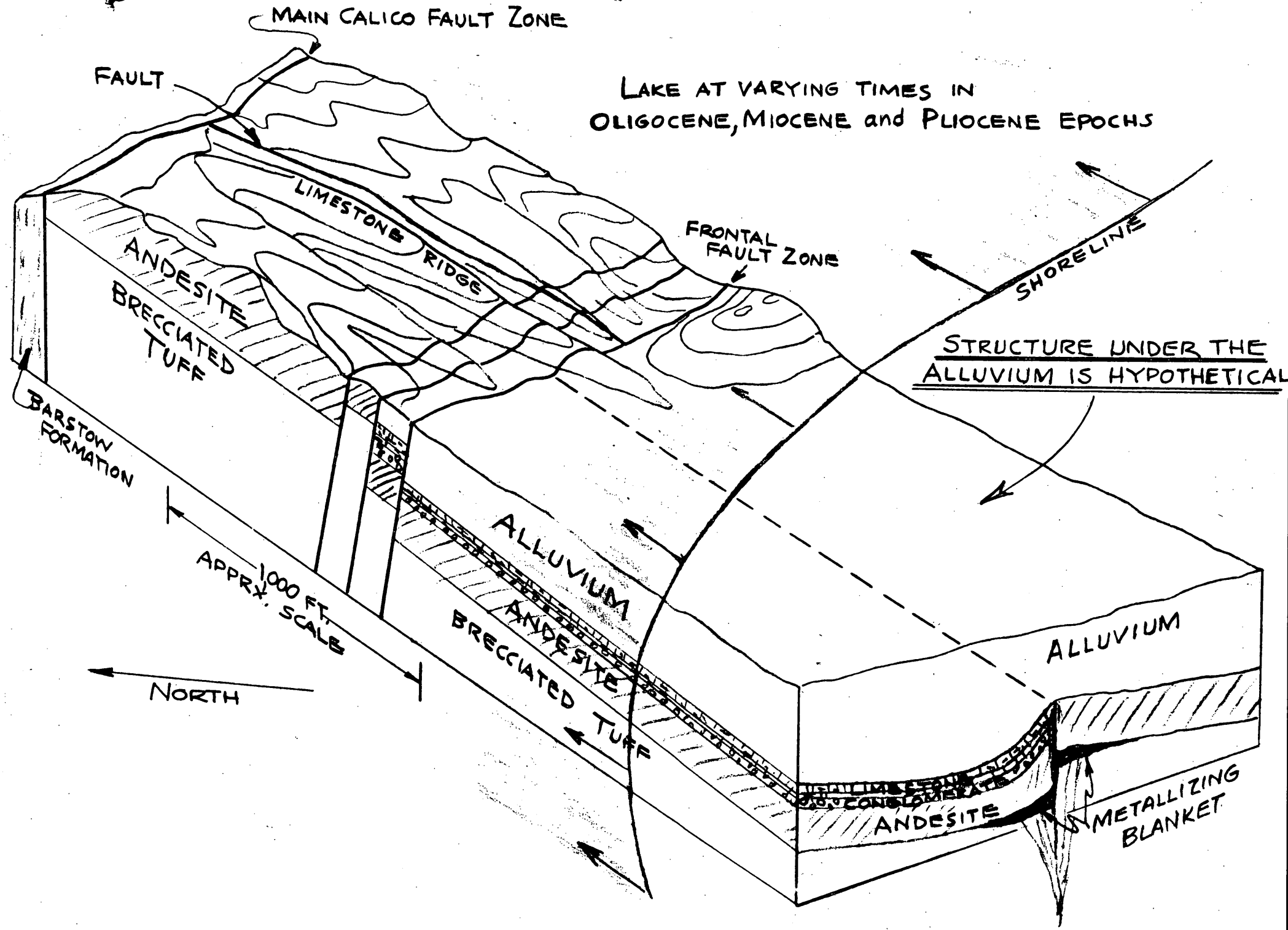
ALTERNATE No. 1



ALTERNATE No. 2

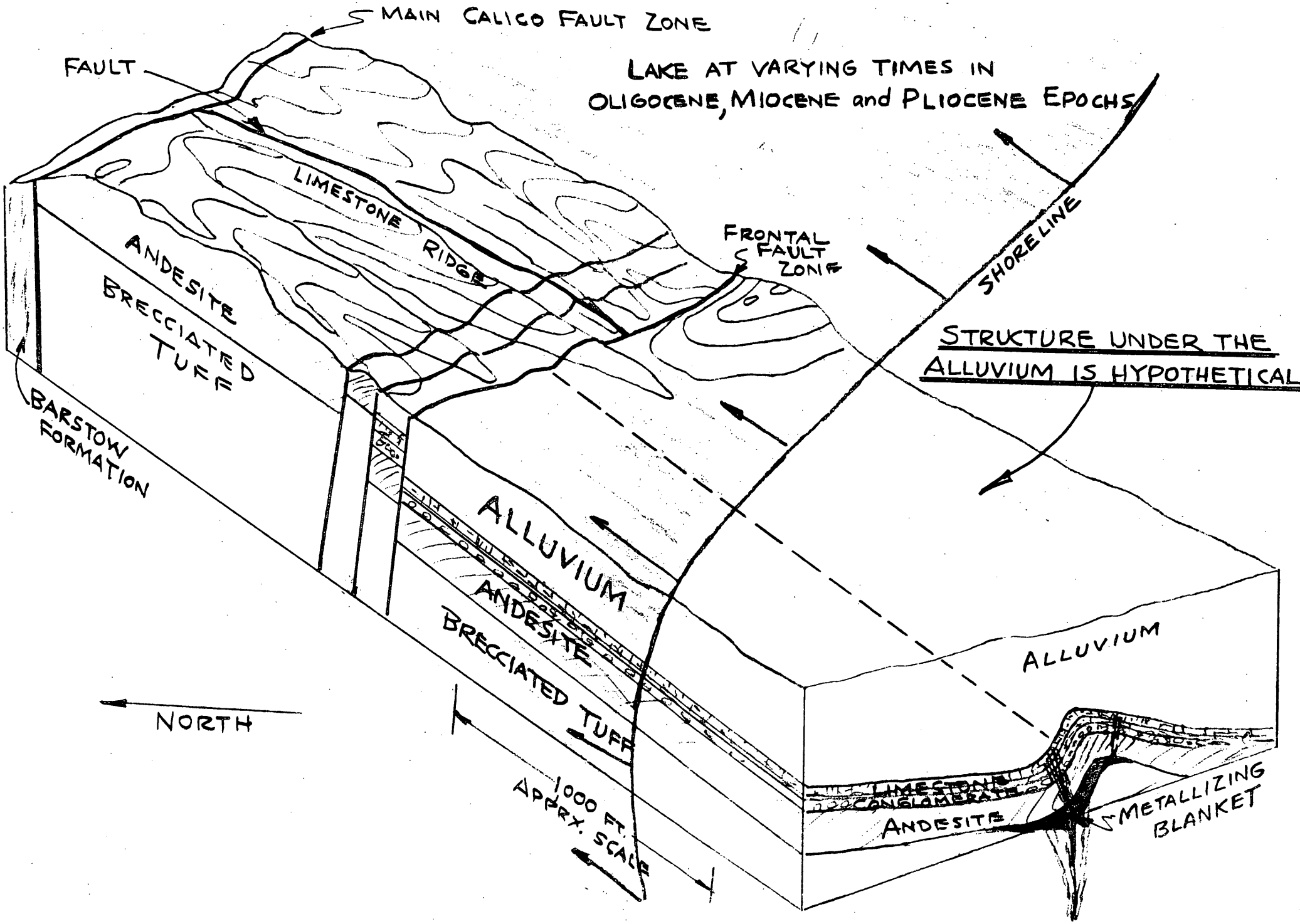
ALTERNATE No. 1

PLATE VI



ALTERNATE No. 2

PLATE VII



HYDROLOGY

The present hydrology of the Calico area has been covered by David G. Thompson[1]. He shows that the precipitation is approximately 4¼ inches annually in the Geo-Minerals Company's claims area. The only two water wells close to these claims are No. 2 in the Southwest one-quarter Section 28, Township 10 North, Range 1 East, with a depth of 65.4 feet and No. 3 in the Northeast one-quarter Section 28, Township 10 North, Range 1 East, with a small jack pump at depth 65.6 feet, the temperature of the water was approximately 70°F. at Daggett. The numbers 2 and 3 herein stand for the wells on Thompson's plate No. 24.

The claims are crossed by the Odessa Canyon Creek and by a small creek coming down Doran Canyon just South of the North boundary of the Cook claim and intersecting Odessa Creek. There is a small fan built up by Doran Creek and a large fan built up by Odessa Creek, both of these creeks have flow only intermittently, but occasionally there will be desert flash flood situations in them.

The most important hydrological fact in the area is the lake as shown by John H. Feth[2] which was taken from the works of A. R. Palmer[3]. Feth's abstract of Palmer's paper is herewith quoted in full:

"The Calico Mountains contain outcrops of the Barstow Formation (Miocene) especially in area East of Odessa Canyon. The Barstow includes about 2,000 feet of lucustrine and fluviatile sediments, beds - locally - having gypsum and associated borate minerals and petroliferous limestone nodules. Nodules carry remarkably preserved arthropod fauna and occur in thin beds of brown shale underlying a prominent 5 foot ledge of white gypsum in lake-bed sequence. The aquatic species of the fauna are strikingly similar to living assemblages found in Soap Lake in Central Washington and, with the lithology, imply deposition in a Miocene lake that may have been highly alkaline."

Feth on his Plate III from Bulletin 1080 showed that this lake existed at various times in the Oligocene, Miocene and Pliocene times of Tertiary Age. The southern boundary of this lake is herewith shown on our plate No. VIII. The alkaline waters of this lake were from time to time exceedingly high in sodium carbonate and more particularly sodium sulphate which was one of the main causes of the Oxidation and supergene enrichment of the mineralization of the Calico area. This will be more clearly shown in the section entitled "Oxidation and Supergene Enrichment".

The movement of the ore-forming solutions through the rocks are well shown by W. Lindgren[4], who is quoted herewith: "At considerable depths, the ore forming solutions move in a path prescribed by fissuring

and brecciation; they rarely penetrate great masses of rocks. Near the surface, especially in the great volcanic piles, different conditions prevail. Here are thick beds of tuffs and agglomerates with great porosity, and the stresses may irregularly shatter large volumes of rock. The solutions and gases - of meteoric or telluric origin - move far more freely and alteration is effected on the largest scale. Here, too, we find most emphasized the peculiar effects of the mingling of ascending and descending solutions."

"After the epoch of fumaroles and hot acid waters has passed and the rocks have cooled somewhat, the epoch of metallization proper begins; and the ore deposits are formed by rising hot solutions which contain carbon dioxide, silica, and hydrogen sulphide and are of alkaline rather than acid reaction."

The volume of water that evolved from the volcanic activity and the strike slip faults was very great as is so clearly shown by Fred M. Bullard[5]. This is also clearly shown by the fact of the small dry lake now existing approximately 1½ miles south of the Calico area and more importantly by the large lake outlined by Feth[2] in Cenozic Age.

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2. Feth, John H. F., Review and Annotated Bibliography of Ancient Lake Deposits (Precambrian to Pleistocene) in the Western States, U.S.G.S. Bulletin 1080, dated 1964.

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4. Lindgren, Waldemar, 1933, "Mineral Deposits", Fourth edition, p. 455,456 - first quote; p. 457 - second quote.

5. Bullard, Fred M., 1962, "Volcanoes in History, in Theory, in Eruption", p. 41-43, Chap. 11. (It is highly recommended that the entire volume be read.)

PLATE VIII

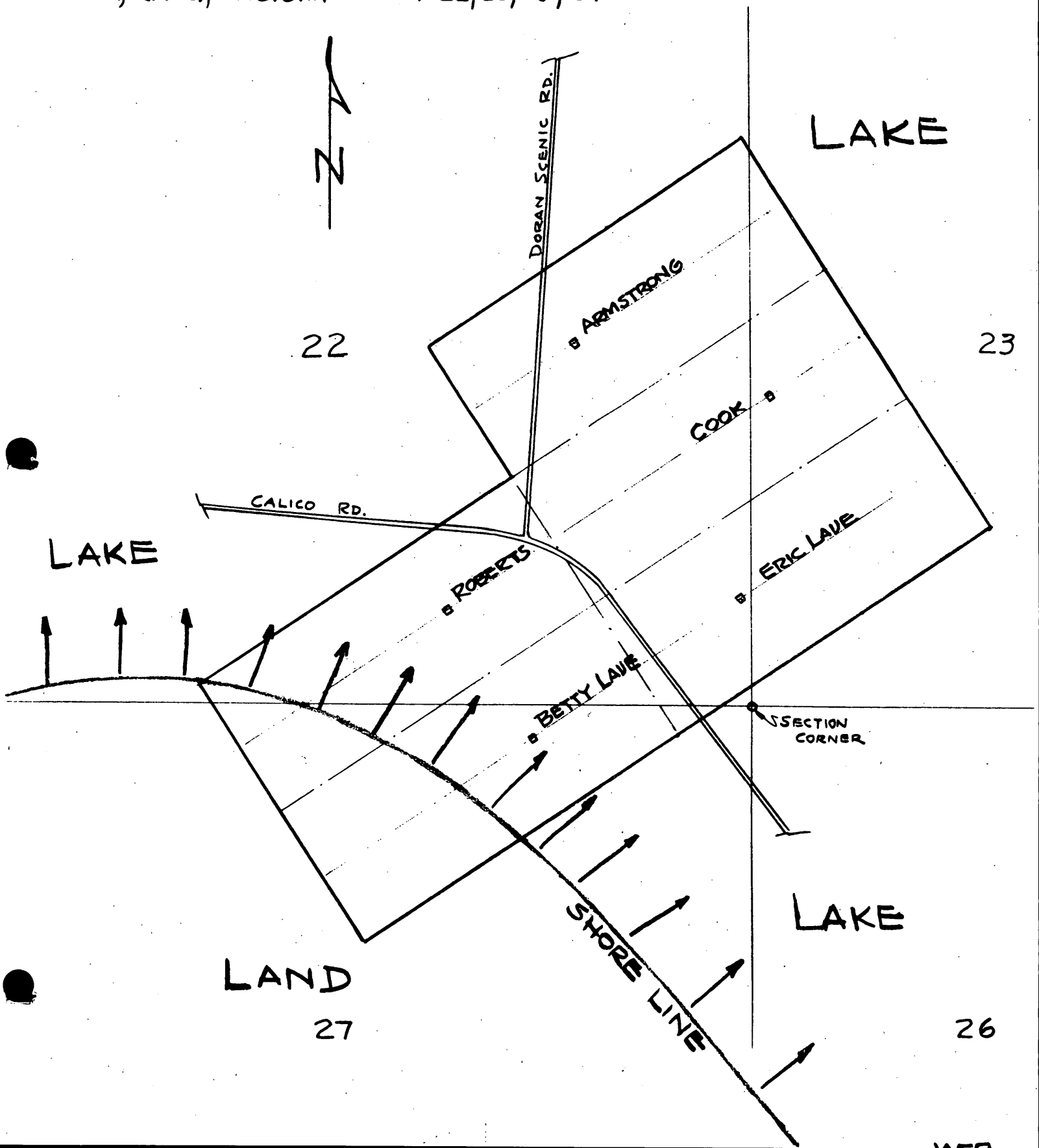
SALINE LAKE AT VARYING TIMES IN OLIGOCENE, MIOCENE AND PLIOCENE TIMES IN RELATION TO GEOMINERALS CO'S CLAIMS

SCALE ~ 1" = 500 FEET

0 250 500 1000 1500 2000

SHORE LINE LOCATION FROM JOHN H.F. FETH

T.10 N., R.1 E., S.B.B.M. SEC. 22, 23, 26 & 27



CONVECTION CURRENTS

I believe that all of the foregoing geology of our report is caused by convection currents of the type proposed by K. L. Cook[1]. His abstract is herewith quoted in full from the G.S.A. 1966 Annual Meeting:

"The northward landward extension of the East Pacific Rise under western North America (Heezen, 1960; Menard, 1960) is indicated by (1) the absence of the crest of the Rise in the oceanic area between the Mendocino and Murray fracture zones; (2) the crestlike features of the Basin and Range province (seismicity, rift systems, thin crust, low upper-mantle seismic velocity, high heat flow, absence of long-wavelength magnetic anomalies); and (3) the existence of the Colorado Plateau and the block-faulted Sierra Madre Occidental and Mexico Plateau.

"A postulated mantle convection current (associated with the formation of the Rise) rose beneath the eastern part of the Basin and Range province and flowed westward (Cook, 1962). The crustal drag caused a large continental-type block to move westward into the Pacific Ocean about 50-100 km in the California region between the Mendocino and Murray fracture zones, which were probably major lines of weakness existing before the formation of the East Pacific Rise. On the northern and southern margins of the block, the movement occurred along transcurrent faults in (1) the Cape Mendocino area and (2) the Garlock fault, Big Pine fault, Channel Islands, and transverse ranges areas. The westward movement of the block probably caused (1) the folding of the Coast Ranges and (2) the bending of the San Andreas fault in two areas. The right-lateral movement of the San Andreas fault is explained by a postulated second, northwestward-trending mantle convection current with a velocity gradient increasing southwestward. The Great Valley of California was possibly formed by the down-bending of the westward-moving convection current as it met the northwestward-moving convection current."

That such a hypothesis is possible is shown in the following quotation from Geophysical Abstracts for May of 1966 by R. W. Girdler[2]:

"The Red Sea and Gulf of California may be regions where new oceanic crust is forming, related to uprising mantle convection currents. The seismically active oceanic rifts with which they are in continuity, with similar seismic velocities of about 7 kmps, are also inferred to be regions where new oceanic crust is evolving; they are near the centers of oceans. Tensional rift zones which are regions of shallow seismicity help locate regions of rising mantle currents, and deep and intermediate earthquake regions help locate descending currents; maps of earthquake distributions reveal a possible large-scale pattern of mantle convection. A possible mechanism for the evolution of new oceanic crust is given, based on the isostatic equilibrium of oceans and continents."

And from the basis that compression of zones occur over downturning convection currents and dilational currents over up-welling convection currents, I believe that the currents shown by Cook are highly probable. That convection currents do exist has just been proven by the Lamont Geophysical group of Columbia University as shown in Naval Research Reviews for February, 1967, a copy of which is herewith included as Exhibit "A".

REFERENCES

1. Cook, Kenneth L., "Evidence for the East Pacific Rise and Mantle Convention Currents under Western North America", Abstract from Geological Society of America "Program 1966 Annual Meetings", p. 43, dated 1966.

2. Girdler, R. W., "The formation of new oceanic crust, in A symposium on continental drift: Royal Soc. (London) Philos. Trans., ser. A" Geophysical Abstracts Number 232, May 1966, p. 422.

Research Notes

Magnetic Studies of the Ocean Floor

New studies of the varying magnetic properties in oceanic crustal rocks and oceanic sediments have recently been reported by scientists of Lamont Geological Observatory, Columbia University. The research, carried out under the direction of Dr. James R. Heirtzler, senior research associate at Lamont, has been supported by the Office of Naval Research and the National Science Foundation.

The studies have revealed a "striking and remarkably perfect" symmetry in the linear magnetic anomalies on either side of mid-ocean ridges. In addition, the presence of polarity reversals in the remanent magnetism of deep-sea sediments has been shown.

Two controversial theories are strongly supported by these new findings.

One says the magnetic field of the earth has "flipped" many times in past ages, reversing the polarity of the North and South poles periodically. A reversal takes a few thousand years—just a fingersnap in geological time. Scientists say the latest reversal took place 700,000 years ago. During a general period of 1.7 million years before that, they say, the field was reversed and compass needles presumably would have pointed to the South Pole.

Support for this "magnetic flip" theory is found in paleomagnetic studies of deep-sea sediment cores based on a technique perfected recently at Lamont. A research team, led by Neil D. Opdyke, senior research associate, has charted the last five million years in the history of the earth's magnetic field. It has been found that sediments retain the same magnetic orientation as the earth's magnetic field at the time the sediments were deposited. The scientists measured and identified distinct alternating periods of normal and reversed magnetic orientation, working downward from the youngest layers of sediments at the top to the oldest (five million years) at the bottom of the cores. These findings agree with paleomagnetic work done previously on terrestrial lavas by the U.S. Geological Survey at Menlo Park, California.

The other theory says that the mid-ocean ridges have been formed by a continuing process in which hot rock constantly moves upward from the earth's interior over the geologic ages, cools as it nears the ocean bottom and spreads out laterally along the ocean floor on either side of the raised ridge. The theory, presented by F. J. Vine and D. H. Matthews of Cambridge, states that when this material cools below a certain temperature (570 degrees centigrade), it becomes magnetized in the direction of the earth's magnetic field at that time. The cooling takes place at the ridge. Each geomagnetic polarity epoch in the past, therefore, is "frozen" into alternating normal and reversed magnetized bands of rock parallel to the ridge axis which are constantly moving away from the axis.

This theory is substantially supported in the new Columbia studies by the almost perfect symmetry found in the pattern of these magnetic reversals on either side of some mid-ocean ridges. The sequence of parallel thick and thin bands with their varying intensities of normal and reversed magnetism on one side of the ridge has been found to be the exact mirror image of the sequence on the other side. The theory is further strengthened by the work of the Opdyke team, for when its vertical chart of dated magnetic periods in sediments is turned sideways and placed against the horizontal magnetic profile of the ocean floor, the patterns match.

Scientists note the age of a particular band of ocean floor by its magnetic "tag" and then measure its distance from the ridge axis where it had become magnetized many hundreds of thousands or millions of years earlier. With these figures the scientists can compute the rate at which the ocean floor is spreading.

The most striking new data has emerged in Columbia's studies of the Pacific-Antarctic Ridge, which lies between New Zealand and the tip of South America. There, magnetic profiles of the ocean floor were made over a span of more than 300 miles from each side of the ridge, a distance representing 10 million years in each direction. Nearly perfect mirror-image symmetry was found in the two halves of the 600-mile profile and further symmetry was indicated beyond that. Analysis of these data indicates that spreading rates of nearly two inches per year have persisted in this area for many tens of millions of years.

Similar evidence supporting the theory of upward convection movement of material within the earth was found in magnetic profiles across the Reykjanes Ridge, which lies in the far North Atlantic Ocean near Iceland, between Greenland and the British Isles. Other magnetic profiles over the Indian Antarctic Ridge south and southwest of Australia and over the mid-Atlantic Ridge in the South Atlantic Ocean indicate that these areas may yield further support for the theory of ocean floor spreading.

There is a body of scientific knowledge, however, which has not been reconciled with the ocean floor movement theory. Scientists have not found ocean sediments disturbed as they presumably should be by such ocean floor movements.

"Most geophysicists," said Dr. Heirtzler, "have thought the earth's crust incapable of such global motion without severe earthquakes or cataclysmic upheavals in the ocean floor. That the earth's crust is in smooth but large scale flow requires a rewriting of many geophysics and geology texts. Now that it is known how to study this motion, the patterns of motion can be studied in great detail."

REPRINT from NAVAL RESEARCH REVIEWS
FEBRUARY, 1967

EXHIBIT "A"

OXIDATION AND SUPERGENE ENRICHMENT

Oxidation is primarily brought about by water with dissolved oxygen and carbon dioxide. The following is quoted from Bateman, Alan M.[1]: "Locally chlorides, iodides and bromides play a part. The substances react with certain minerals to yield strong solvents, such as ferric sulphate and sulphuric acid. Sulphuric acid, in turn, reacting with sodium chloride yields hydrochloric acid, which with iron yields the strong oxidizing ferric chloride."

"There are two main chemical changes involved within the zone of oxidation: (1) the oxidation, solution, and removal of the valuable minerals; and (2) the transformation in situ of metallic minerals into oxidized compounds.

"The general tendency of the chemical changes in the zone of oxidation is to break down complex minerals and form simple ones. In general, among the metallic minerals, those lacking in oxygen (sulphides, etc.) are most susceptible to oxidation, and the most metallic oxides are little affected. Native metals may be attacked; quartz is resistant, but silica set free during oxidation is generally dissolved. Carbonates decompose readily; and most of the silicates are altered to a few stable minerals."

"Some constituents, like gold, generally resist solution and persist in the oxidized zone; others, like galena, are changed so slowly that they hang back in the oxidized zone while their more soluble companion minerals are removed; still others, like the minerals of copper, zinc, or silver, are readily soluble and so are generally removed. The oxides of iron are highly resistant to solution.

"The simple sulphides are only slightly soluble in cold water and their order of solubility as determined by Weigel is shown on page 249. In dilute sulphuric acid, pyrrhotite, chalcopyrite, bornite, sphalerite, and galena are attacked; but arsenopyrite, pyrite, and silver compounds are attacked only slightly. Such minerals as covellite, chalcocite, and molybdenite are not attacked. Ferric sulphate, however, readily dissolves most of them.

"Gottschalk and Buehler found that the little electric currents generated in mixed sulphides accelerate and retard oxidation and solution of certain minerals. Currents flowing from minerals of high potential to those of low potential accelerate solution of the latter and retard that of the former; e.g., sphalerite dissolves much more readily in the presence of pyrite. The sulphides can be arranged according to their differences in potential, which vary, however, according to the kind of solution. The potentials of marcasite and pyrite are high, and of

COMMON SULPHATES	COMMON CARBONATES	COMMON SULPHIDES (precipitated)
1. $MnSO_4$	1. K_2CO_3	1. MnS
2. $ZnSO_4$	2. Na_2CO_3	2. ZnS
3. $MgSO_4$	3. $CuCO_3$	3. FeS
4. $Al_2(SO_4)_3$	4. $MnCO_3$	4. CoS
5. $FeSO_4$	5. $FeCO_3$	5. NiS
6. $CuSO_4$	6. $MgCO_3$	6. CdS
7. Na_2SO_4	7. $ZnCO_3$	7. Sb_2S_3
8. K_2SO_4	8. $BaCO_3$	8. PbS
9. Ag_2SO_4	9. $CaCO_3$	9. CuS
10. $CaSO_4$		10. As_2S_3
11. $PbSO_4$		11. Ag_2S
		12. Bi_2S_3
		13. HgS

chalcocite and sphalerite low; therefore, the solution of the last two is accelerated in the presence of universal pyrite.

"The carbonates are low in solubility and the sulphates are high, lead and barium sulphates being exceptions. The order of solubility in cold water of the common sulphates and carbonates, as determined by Kohlrausch, and common sulphides as determined by Weigel (No. 1 being the most soluble), is shown in the lists above.

"The oxidation behavior of the common metallic compounds of hypogene ore deposits is summarized in Table 8; their precipitation is considered later."

In addition the waters at Calico contained sodium sulphide. The following quotes are from Ransome, F. L.[2]:

"In his early study of the quicksilver deposits of the Pacific Coast, Becker[3] availed himself of the facilities of the chemical laboratory of the U.S. Geological Survey and, in collaboration with Melville, showed that mercuric sulphide is soluble in solutions of sodium sulphide and in warm solutions of sodium sulphhydrate. Other metallic sulphides were found to be soluble in the same reagents and it followed that natural spring waters containing sodium carbonate and hydrogen sulphide are capable of carrying in solution not only the sulphide of mercury but also metallic gold, pyrite, sphalerite, cupric sulphide, and probably other metallic sulphides."

The supergene mineralization is primarily brought about by the deposition and solution of manganese oxides which are usually mixed with iron oxide and this solution, and the solutions therefrom, produce nascent chlorine.

(1) This has been clearly shown by W. H. Emmons[4] in his classic bulletin on the subject "The Enrichment of Ore Deposits".

(2) D. F. Hewett[5] has shown that many of the veins of manganese oxide in the Western States are of hypogene origin. He concludes that these veins formed near the surface where hot waters from great depth, containing manganese in the manganous state, met the zone of ground water that carried free oxygen. His data also indicate a genetic relation among several of the epithermal deposits in which manganese oxide veins nearest the surface will be succeeded in depth: (1) by veins with abundant barite; (2) by those with abundant fluorite; (3) by veins of the epithermal gold-silver type; and finally (4) by veins of the epithermal base-metal type. If the above hypothesis is correct, Hewett notes that holes drilled to reach 500 to 1,000 feet below existing workings on manganese oxide veins may strike veins of manganese carbonate and silicate with barite, fluorite, and sulfide minerals that carry silver and gold to warrant exploitation.

In addition the works of J. D. Hem[6] should be consulted in considering supergene enrichment.

All of the foregoing can be further modified by bacterial action as shown by Mulder[7] and Postgate, J. R.[8].

The flows of both the supergene and hypogene waters can also be greatly effected by the CO_2 content of said water, as is so well shown by Donald E. White[9] in his outstanding paper "Saline Waters of Sedimentary Rocks".

The importance of the chemical effects outlined above can not be overstressed in the southwestern portion of the Calico range, where you clearly had both large scale hypogene flows and tremendous supergene flows. The complexity of the resulting interactions of these flows will have led to the ore deposition and very possibly to a Bonanza situation.

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8. Postgate, J. R., 1951b. The Reduction of Sulfur Compounds by Desulfovibrio desulfuricanus. J. Gen. Microbiol., 5: 725-738.

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METALLOGENETIC EPOCHS

Waldemar Lindgren[1] has indicated that the mineralizing epochs in the Calico area were late Mesozoic epoch, early Tertiary epoch, the late Tertiary epoch and a past Pliocene epoch. He felt that at such times the higher isotherms rose towards the surface and that the time, geologically speaking, was short for this phenomena.

Later work by D. E. White[2] has indicated that the base metal silver deposit brine, of high salinity, rarely ever reaches the surface in undiluted form because of its density. It is my belief that possibly these highly saline brines have quite frequently flowed out of their channel ways at some depth along the channel way where said channel way has crossed a porous formation or bed. That this might be so is seemingly indicated by G. I. Smith[3] in his remarks on sodium sulfate as shown on page 390 of the Mineral Resources, Part I.

It is possible that many of our so-called Bonanza deposits are formed by these recurrent mineralizing flows as outlined above.

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THE HISTORY AND MINERALIZATION OF THE CALICO REGION

Mr. Harold Weber's exceptional report entitled:

"1. Silver Mining in Old Calico; and
2. Silver Deposits of the Calico District (Two Parts)"

are included in full in this report, as unquestionably this is the most outstanding paper on the area that has ever been published.

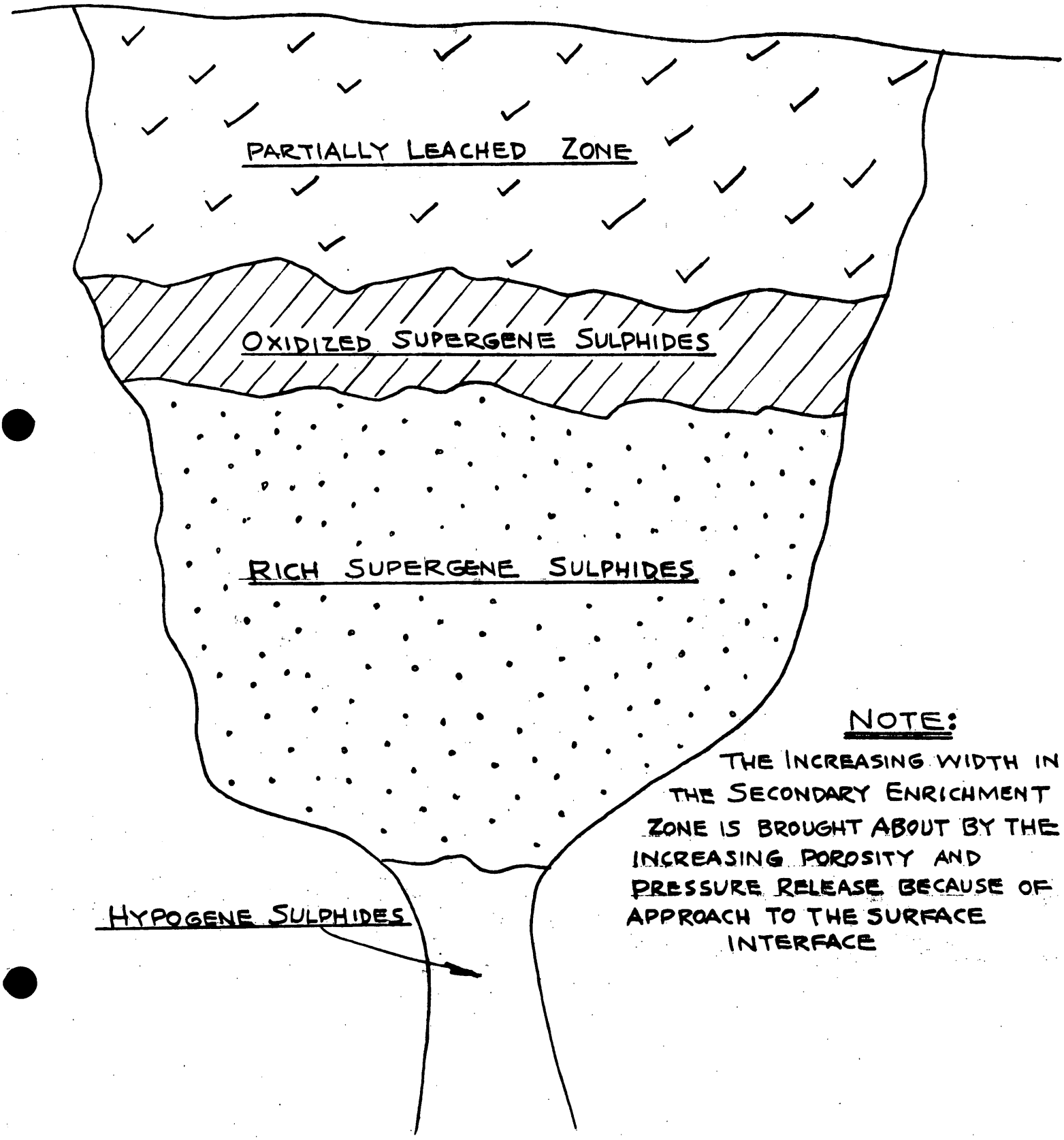
There is little that can be added to Weber's history. However, in the mineralization we are adding our Plate No. IX giving our views of what has happened to the faulting on Geo-Minerals Company's claims. We believe that the lateral motion on the Calico and Calico frontal faults dilated the Doran fault and its offset on the west side of the Calico frontal fault and thus the Doran fault and its offset fault have been the prime channel ways for the flows of mineralizing solutions as shown on Plate IX. (See also Plates V, VI, VII and VIII).

PLATE IX

OXIDATION AND SUPERGENE ENRICHMENT

HYPOTHETICAL PRESENTATION

SCALE 1" = 100' APPRX.



NOTE:

THE INCREASING WIDTH IN THE SECONDARY ENRICHMENT ZONE IS BROUGHT ABOUT BY THE INCREASING POROSITY AND PRESSURE RELEASE BECAUSE OF APPROACH TO THE SURFACE INTERFACE

MINERAL INFORMATION SERVICE

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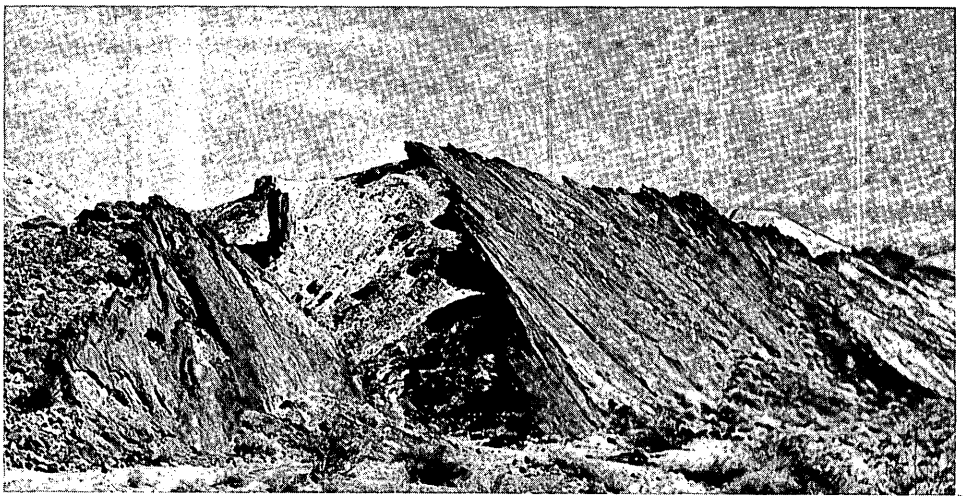

Calico Mountains

STATE OF CALIFORNIA ▪ THE RESOURCES AGENCY ▪ DEPARTMENT OF CONSERVATION ▪ DIVISION OF MINES AND GEOLOGY

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MINERAL INFORMATION SERVICE is designed to report on the progress of earth science in California, and to inform the public of discoveries in geology and allied earth sciences of interest and concern to their lives and livelihood. It also serves as a news release on mineral discoveries, mining operations, statistics of the minerals industry, and new publications. It is issued monthly by the California Division of Mines and Geology. Subscription price, January through December, is $1.00.

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MARY R. HILL, *Editor*

THE HISTORY TRAIL

From Mr. Braeme E. Gigas comes good news concerning the name Mount Mary Austin. Writes he, "Happily, we need no longer put that phrase in quotes, because I have just received a letter from the Board of Geographic Names that the name has been approved." An enclosed letter from the Board adds, "This decision will be published in Decision List 6601 and the entry will read as follows:

> Mary Austin, Mount: mountain, elevation over 13,040 ft., 1 mi. NE of Black Mountain and 8.5 mi. W of Independence; named for Mrs. Mary Austin, a prominent writer, natural historian, and long-time resident of the area; Inyo Co., Calif.; 36° 48′ 57″ N., 118° 21′ 43″ W."

THE HISTORY BOOKSHELF

Mines of the High Desert, by Ronald Dean Miller. 63 pages, 20 photos, maps, index, references. Price $1.95.

History of the Dale mining district, in and about Joshua Tree-Twentynine Palms National Monument, is recounted by Mr. Miller, who was for years a naturalist at the Monument. The two dozen mines of the area—among them the Virginia Dale, Old Dale, New Dale, Supply, OK, Zulu Queen, Gold Coin, Snowcloud, Lost Horse, Hexie, Anaconda, and Desert Queen—were "small, almost do-it-yourself" turn-of-the-century ventures, but their story contributes an interesting and picturesque page to desert lore.

Mines of the High Desert is the fifth booklet in Walt Wheelock's La Siesta Press desert series . . . its predecessors *Freeman's*, *A Stage Stop on the Mojave*, by E. I. Edwards (price $1.95); *Exploring Joshua Tree*, by Roger Mitchell (price $1.00); *Baja California Overland*, by L. Burr Belden (price $1.95); and *Desert Peaks Guide, Part I*, by Walt Wheelock (price $1.00). They may be obtained from La Siesta Press, Box 406, Glendale, California, 91209.

Dedicated to keeping the gold mining industry from becoming an irrevocable page from history is the monthly paper *American Gold News*, the official publication of the American Gold Association and the Mineral Association of Northern California. Those who wish to keep a finger on the pulse of the ailing industry can do so with a subscription, price $3.00 per year (foreign $4.00 per year) or $5.00 for two years. Address P.O. Box 427, San Andreas, CA 95249.

The Rock Paintings of the Chumash, by Campbell Grant. 163 pp., 120 figs., 30 colored plates and frontis. University of California Press, Berkeley and Los Angeles. 1965. Price $10.00.

Our thanks to reader "C.S.", Librarian at Santa Barbara Museum of Natural History, for his complaint that we had not reviewed *Rock Paintings of the Chumash*. We are much in his debt for calling to attention this unusually beautiful volume, typified by a clear, understandable text and some of the most finely reproduced Indian paintings it has been our pleasure to view. Campbell Grant, author and artist, has copied many of the original paintings, on the spot; his copies are printed in color, along with a few color photos of the originals for comparison.

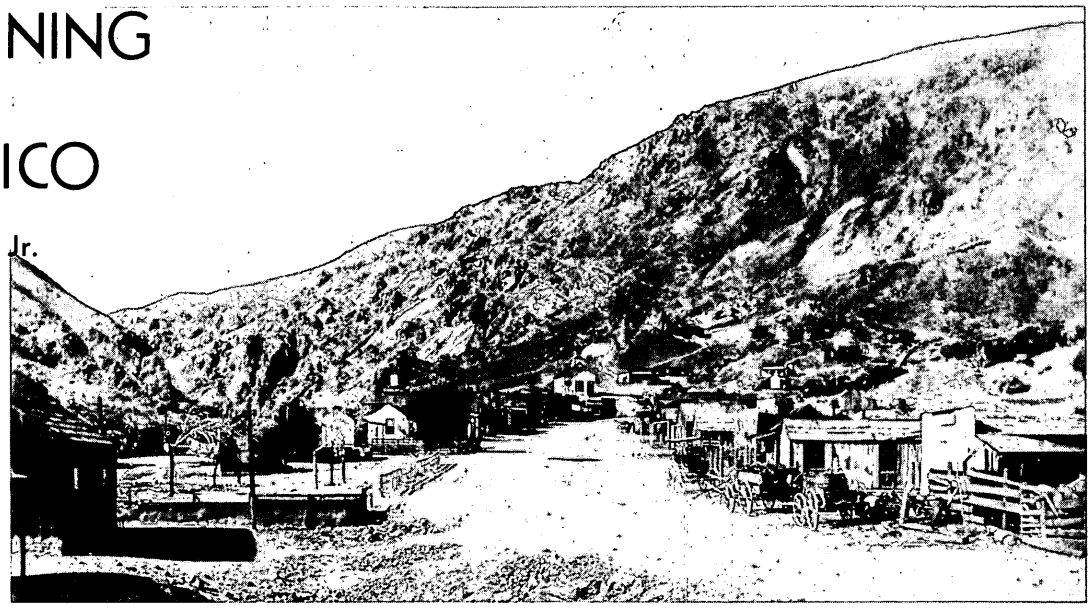
The book explores the territory of the Chumash, their history, and their culture, and the text is supplemented by numerous black and white illustrations. The material presented is authentic, yet its rendition is not hampered—for the layman—by the language barrier common to many scientific works.

Mr. Grant has included a short section entitled "Erosion and Vandalism" in which he concludes that "Damage through vandalism is a far greater threat to the existence of these pictographs than erosion". Fortunately their locations are not too well known, nor are they too accessible (what a sad comment to have to make!); but even so, many of them have been seriously damaged by vandals.

Rock Paintings may be ordered from University of California Press, Berkeley, California 94720. It is not distributed by the Division of Mines and Geology.

SILVER MINING IN OLD CALICO

By F. Harold Weber, Jr.



Early Calico, view north; in background are mine workings of Wall Street Canyon area to left and King Mountain area to right. Mine dumps on King Mountain are principally from Silver King and Oriental mines. Date of photograph not determined, perhaps about 1890. *Collection of The Huntington Library, San Marino.*

> Seven miles north of Daggett is the much talked of city of Calico. One narrow and serpentine street is the only thoroughfare. The place is built on a narrow ridge; the back end of lots on each side of the street end on or over a bluff. Small, hastily-built houses are the order of buildings, only a few two-story houses gracing the camp. Saloons are more than numerous. Business generally is overdone, and the number of black-legs and tin-horn gamblers that infest the place is remarked by a newcomer. The only water supply is that hauled two miles from Evans' well, and costs from 3 to 5 cents per gallon. Wood is $10 per cord. Board, $7 to $8 a week. The Occidental and Whitfield House are the only hotels, and they are pushed to their utmost capacity to accommodate the travel that is arriving daily. The camp is a good one, but at present is overestimated and overcrowded by men out of money and work. Capital, development and a chance is all this camp needs to be a second edition to the Comstock at no great distant date.

These words, written by a correspondent of the *Mining and Scientific Press,* were published in the issue of March 14, 1885. The "bonanza" Calico district then was in its fourth year of productivity, and near its zenith; within a few years it would begin to wane, becoming a near "ghost" by the very early 1900's. During this period of roughly 20 years, the 50-odd mines of the Calico district and surrounding region—the Silver King, Oriental, Waterloo, Bismarck, Garfield, Odessa, Occidental, Waterman, and others—yielded an estimated $13 to $20 million in silver. This production is small in comparison with $225 million taken from the great Comstock Lode at Virginia City, Nevada, but very significant in terms of metal mining in southern California. Since 1900, silver mining operations in the Calico district have been mostly small and intermittent; but great interest shown in the district by the mining industry since 1963 suggests that once again it may become the site of important silver mining operations.

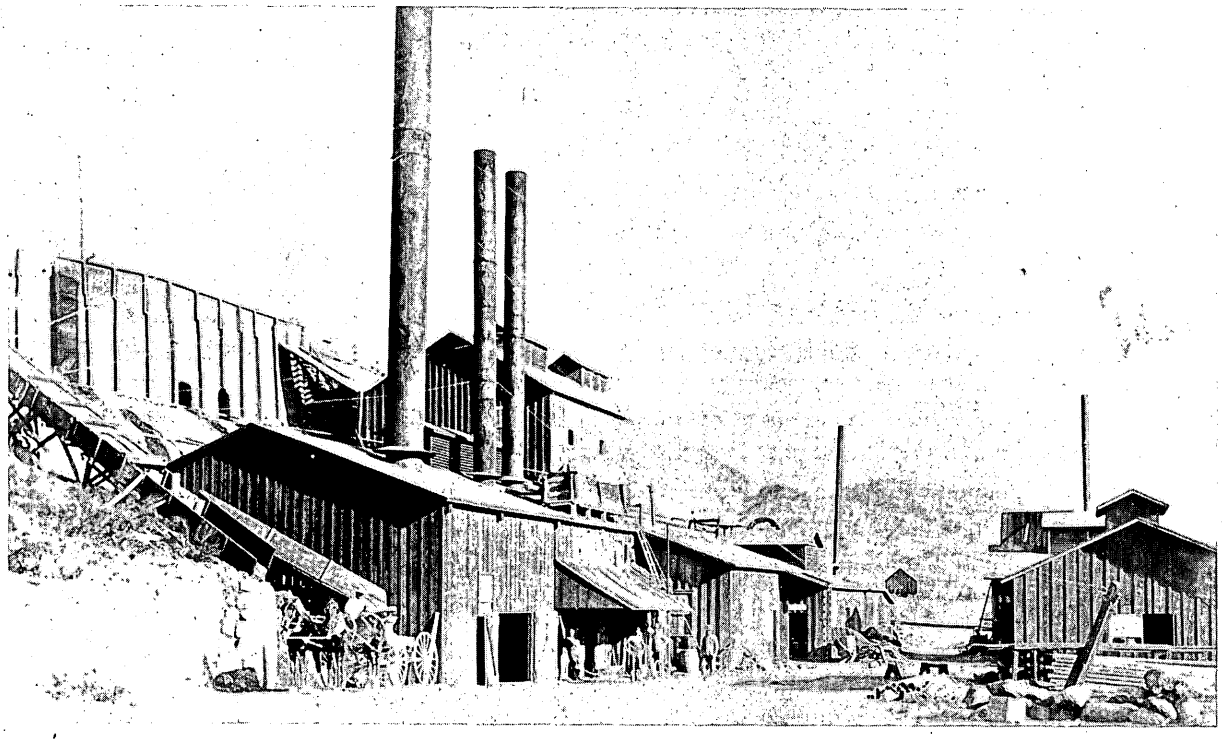
The little "ghost" town of Calico lies at the southern edge of the Calico Mountains, about 10 miles northeast of Barstow in the central part of the Mojave Desert of southern California, and about 100 miles northeast of Los Angeles. It is commercialized now, and hardly a ghost: parking lots often are filled with modern automobiles, whose brash, shiny colors seem out of place in an old mining camp. Genteel tourists poke curiously along the town street, perusing relics of former mining days, and wander among the dusty graves of the cemetery. Loudspeakers blare inducements to concessions, and the whistle from a sightseeing train echos hauntingly back into the mountains, to the north, where lie the old mine workings of the district. These workings consist both of extensive, professionally engineered adits and shafts, and of widespread, crude gopher-like surface diggings. Altogether, the mine workings have yielded perhaps 15 to 20 million ounces of silver, plus small amounts of barite, gold, lead, and copper. In addition, the region has yielded $9 million worth of borax minerals, mined from 1884 to 1907.

Prospecting for silver in the Calico Mountains and surrounding region apparently was begun seriously during 1880–81, although the first discoveries may

have been made earlier, perhaps in 1875. Some prospectors must have searched the Mojave Desert soon after development began of the gold mines in the Mother Lode region, but because the desert region was desolate, poorly accessible, and largely unexplored, mineral discoveries were few. The real spark to prospecting in the eastern mountain and desert region of California, and in Nevada, probably was ignited by discovery of the Comstock Lode at Virginia City in 1859, about 300 miles north-northwest of Calico, and its spectacular development during the 1860's. From this focal point, prospectors spread out widely over the west, and began to discover other great districts, including Eureka, Tintic, and Pioche. Prospecting also was sparked by completion of the transcontinental railroads, beginning with the Central Pacific in 1869, which enabled more men to come west to seek their wealth. In eastern California, during the 1860's and 1870's, Blind Spring Hill, Cerro Gordo, Panamint City, and Darwin were discovered; then Calico; following it, during the late 1890's and early 1900's, were developed the gold districts of Mojave and Randsburg, which eventually also yielded large amounts of silver.

The demand for silver that was the basis for prospecting was natural, as long through history silver had been considered a precious metal, and had been used in coins and as a backing for wealth. The United States had adopted the silver dollar as its unit of monetary value in 1776; and ultimately adopted bimetallism for monetary purposes, whereby the dollar eventually became (in 1837) worth 23.22 grains of gold or 371.24 grains of silver (hence the expression "16 to 1"). But until the Comstock Lode was discovered, the country imported nearly all of its silver. Since that discovery, the U.S. has been a major producer of silver, and during most years from 1871 to 1915 was the world's leading producer. In 1964 the United States ranked third in world output, following Mexico and Peru, and ahead of Canada and USSR. In that year, the United States produced about 36 million ounces of silver, worth about $47 million, principally as a by-product of base-metal mining operations, but partly from ore mined for gold or primarily for silver itself. About 52 million ounces of silver was imported during 1964.

One very important event that was gradually to blight the nation's young but growing silver mining industry occurred in 1873, when the United States went off bimetallism and onto the gold standard (though without basic change to the monetary policy). Soon afterward, the price of silver began to fall

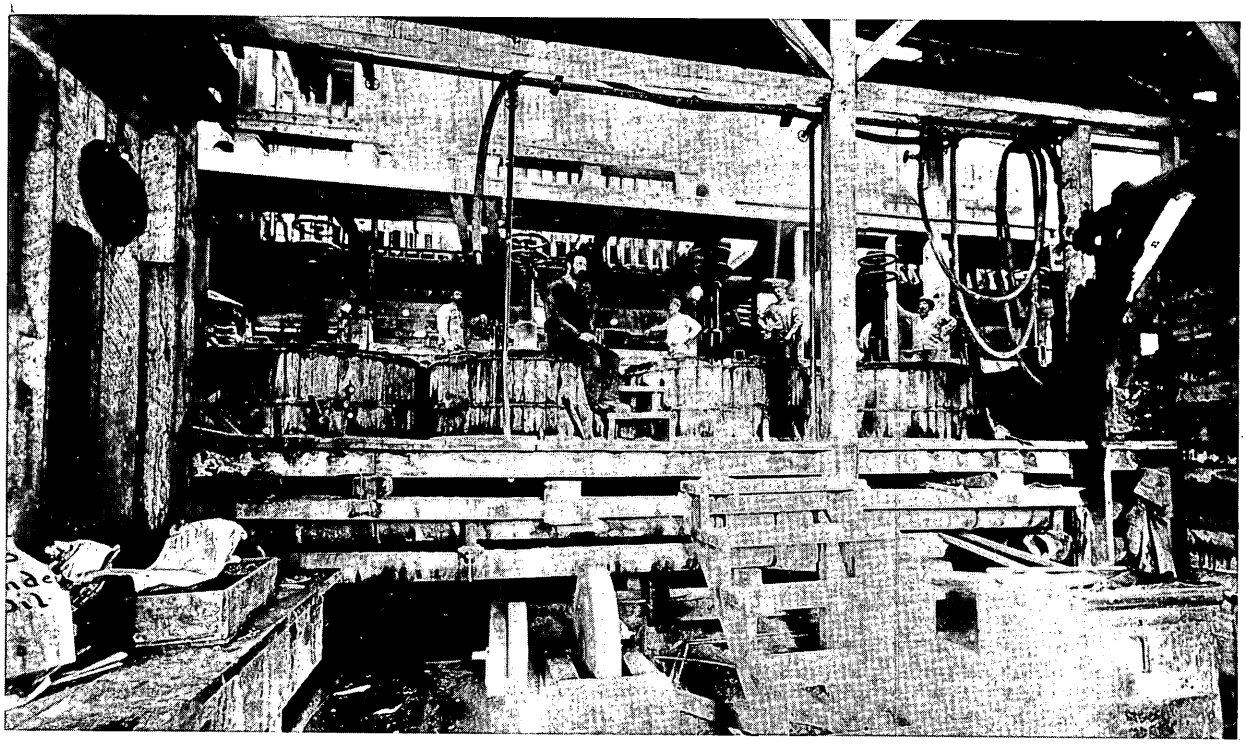


Mill of the Silver King Mining Company (also called Garfield mill). Photo taken perhaps about 1890. At that time ore from Occidental (including Garfield mine), Odessa, and Oriental groups was being processed here. Site of mill is on south side of hill between mouths of Wall Street and Odessa Canyons. *Collection of The Huntington Library, San Marino.*

irregularly from an average high during 1865–73 of about $1.33 per troy ounce to roughly $1.13 in 1881, when Calico was discovered, and to about 64¢ by 1894, when most of the larger operations in the Calico district had ceased or nearly ceased. The price continued to fall, though with fluctuations, to 51 cents in 1915, and to its ultimate low, about 25 cents, in 1932; even during this last period, however, developers and promoters were actively attempting to reopen and redevelop the mines of Calico.

In some respects it is ironic that the Calico district should lie so close to the new freeway of Interstate Highway 15, which links Los Angeles and Las Vegas, Nevada. For Los Angeles epitomizes the unbridled growth in population of the nation, which is reflected in the growth of the Nevada gambling industry that has evolved from the early days of silver mining. This growth in population has led basically, if indirectly, to the renewed demand for silver, and to the increase in its price from about 91 cents in 1961 to $1.29 by 1963. This relatively high present price has stimulated hope in the mining industry for an even higher price, which, in effect, evokes a rebirth in interest in all inactive silver-bearing deposits and districts. Especially of interest are "bonanza" districts such as Calico, which have yielded relatively large amounts of silver from near-surface workings in rich, shallow deposits, mined almost wholly for precious metals, because many such deposits in California commonly have not been thoroughly explored or studied either at depth or on the surface.

Development of the Calico district might be said to have begun earnestly on April 6, 1881 when S. C. Warden, Hues Thomas and John C. King and others located claims which they began to develop as the Silver King mine. Calico did not then grow with a great "rush", but by the spring of 1882 about 100 people were reported to be living in the town, and mining was underway. Activity was slowed during the summer, partly because of illness in the camp, and perhaps also because of the intense desert heat. But in the fall of 1882 mining in the region seemed to gather momentum: consolidation of smaller properties into larger ones led to more efficient development and mining, and more professional miners had arrived. In July, for example, the Silver King mine had been sold for $300,000 to San Francisco interests. In addition, the Atlantic and Pacific Railroad was being constructed eastward from Mojave. By October 22, 1883 track had reached Waterman's, near present-day Barstow, and by the end of the year it had reached Ludlow, 130



Inside mill of Silver King Mining Company. Tanks shown were part of system of Boss (multiple pan) process which utilized chlorination and amalgamation to recover silver. *Collection of The Huntington Library, San Marino.*

miles to the east beyond Calico. The railroad, obviously, became a vital link for the district, essential to growth.

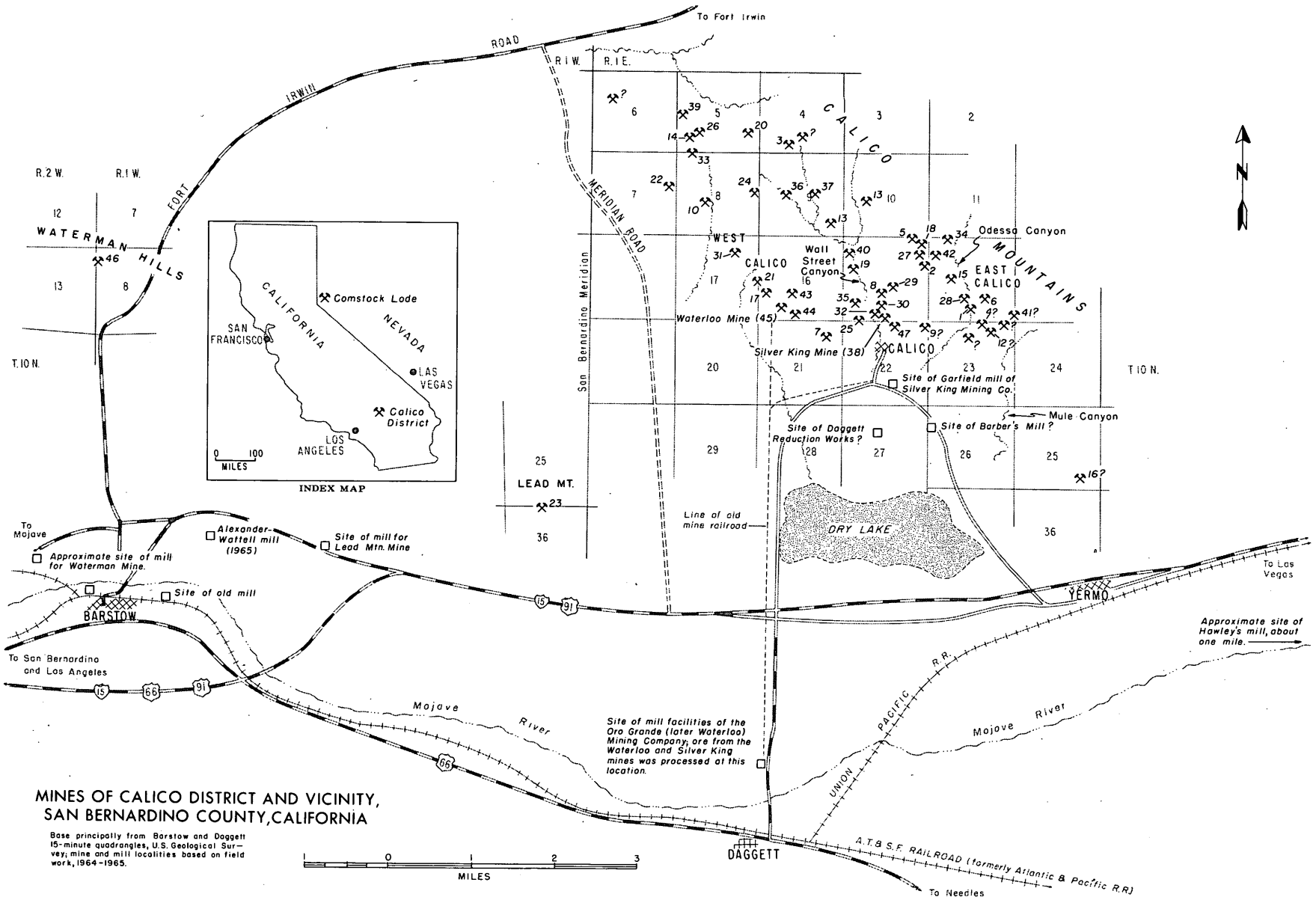
By the end of 1882, the district had taken shape geographically: immediately north of Calico camp, on the steep sides of Wall Street Canyon and on King Mountain were the Silver King, Oriental, Burning Moscow, Red Cloud, and other mines. To the northeast, in the vicinity of presentday-named Odessa Canyon, were the mines of "East Calico", including the Garfield (opened December 1882), Odessa, Bismarck, Blackfoot, and others; and to the west and northwest lay "West Calico," with ultimate development of the Waterloo, Langtry, and other mines. About 5 miles west of Calico, in low hills beyond a broad valley, was developed the Lead Mountain mine; and about 10 miles to the west the Waterman mine had been developed (perhaps even before the first mines at Calico).

Along with development of the mines, mills for processing the ore and recovering the silver were constructed near Calico and along the Mojave River, several miles to the south, where water was plentiful. The ore was hauled to the mills in horsedrawn wagons, and the earliest ore from the Silver King mine was hauled 40 miles to a mill along the Mojave River at Oro Grande. The general silver recovery process used in the region was the so-called "continuous pan" (or Boss) process, in which ore pulverized in stamp mills flowed as pulp through a series of pans in which it first was chlorinated, then amalgamated for recovery of the silver. Such a process apparently handled the free-milling oxide ores of the Calico mines relatively efficiently, for it recovered as much as 95 percent of the silver from the purest chloride ores, and about 75 to 80 percent of the silver from deeper, sulfide-bearing ores. Salt for the chlorination came from south of Danby (100 miles east of Calico) and coal for fuel came from New Mexico.

The Silver King was the most prominent mine in the district, according to a report of the Director of the Mint for 1882; by the end of the year it had been developed to a depth of 250 feet, with about 500 feet of drifts and crosscuts. These developments were reported to have exposed "a ledge 20 feet wide, between well-developed walls, with rich streaks of from 2 to 3 feet on each wall. . . . Many car loads of partially selected ore from the mine have been sold in San Francisco, averaging $300 per ton. . . ." The next in importance was the Oriental mine, under management of Judge James Walsh, a veteran miner, who said that Calico was "another Comstock". The 1882 mint report went on to say that "the Burning Moscow, Red Jacket, and Sue and Fay, and several others have been sufficiently developed to be called mines. In all these mines the ore contains scarcely anything but silver in spar, and in the shape of chloride, bromide, verda plate (green silver), and horn silver." The report also stated that "The Cuba mine is another valuable location in East Calico, and is being developed with promising results. On looking over the Cuba location, almost the entire surface of the claim appears covered with a conglomerated mass of calcareous tufa and porphyry carrying chlorides and horn silver. Wherever the surface has been broken, ore is visible to the eye. . . . All the first class ore from the mine will work $300 per ton, and the owners make it a point not to sack any that will not assay that much." (Silver was then worth about $1.14 per ounce). No minable gold had been found.

MINES OF THE CALICO DISTRICT

1. Alabama
2. Argentum
3. Backdoor No. 1 prospect
4. Baltic
5. Bismarck
6. Blackfoot
7. Burcham (Total Wreck) (Gold-lead)
8. Burning Moscow
9. Carbonate group
10. Cisco
11. Cuba (location undetermined)
12. Dietzman
13. Gale Group
14. Galena King
15. Garfield
16. Grandview
17. Grant
18. Humbug
19. Falls
20. Le Montain (Sliver-lead-barite)
21. Lamar
22. Langtry
23. Lead Mt. (Silver-barite)
24. Leviathan
25. Lone Star group
26. Mulcahy group
27. Occidental
28. Odessa
29. Old Oriental
30. Oriental
31. Possibility group
32. Red Cloud
33. Revier
34. Runover
35. St. Louis Consolidated
36. Silver Bow (Silver-lead-barite)
37. Silver Tip (Silver-lead-barite)
38. Silver King
39. Silverado
40. Sioux
41. Snowbird
42. Thunderer
43. Union (Gold)
44. Voca (Washington)
45. Waterloo
46. Waterman
47. Zenda



MINES OF CALICO DISTRICT AND VICINITY, SAN BERNARDINO COUNTY, CALIFORNIA

Base principally from Barstow and Daggett 15-minute quadrangles, U.S. Geological Survey; mine and mill localities based on field work, 1964-1965.

By the light of a candle and metal reflector, a Calico miner fills an ore car from a chute. Unidentified mine and date. O. A. *Russell Collection.*

As an example of how mining developed, the Garfield mine is reported to have been worked from December 1882 until April 1883 by only 2 men, who shipped 11 tons of selected, high grade ore which yielded $5,885 in silver; but from November 1883 to January 1, 1885, 2,400 tons of ore was shipped from the mine, which yielded $290,400 in silver (and a "large amount" of "unassorted" ore was worked locally at Barber's mill). By January 1883, the Waterman mine had yielded 9,000 tons of ore which yielded $39.30 per ton, with the resultant tailings yielding about $10 per ton (making a total of about $440,000); and during 1883, the Silver King mine was reported to have yielded about $426,000 in silver.

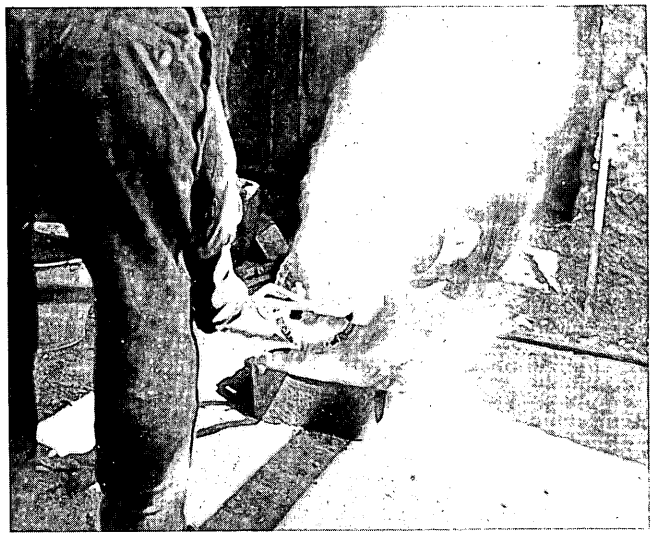
Smaller properties often were worked by so-called "chloriding" methods, whereby lessees operated mines individually or in small groups, paying one-quarter to one-fifth of the mill proceeds to the owners. This procedure was very inefficient, and hindered or prevented maximum possible development of the mines. For most such lessees cared only to mine expediently the richest possible ore, which was commonly composed of thin stringers and veinlets of silver chloride and associated minerals. Compounding the problem were the expensive charges to miners for hauling and milling: the charge for hauling from Calico mines to mills along the Mojave River was $2.50 per ton; and the charge for custom-milling was $11 to $14 per ton, even though the actual milling cost was only $3 to $5.

Productivity in the district reached its peak during 1884–1885, when perhaps as many as 2,500 people lived in the district. By this time, the Silver King mine had been purchased by the Oro Grande Mining Company, owned principally by C. M. Sanger of Milwaukee. (Ultimately the Oro Grande Mining Company also was to gain control of the Waterloo mine, after settlement of a law suit.)

At the beginning of 1884 the Silver King mine had been worked to a depth of 500 feet, and was reported to "still show well at the bottom." From January 1884 to March 1885, the mine yielded about $1 million worth of silver bullion, with the company mill at Daggett reportedly averaging $40,000 to $50,000 per month. Each ton of ore was reported to yield about $30 to $45 in silver (at about $1.11 to $1.06 per ounce), and to cost about $18 total to mine, haul, and mill. Miners were paid about $3.50 per day.

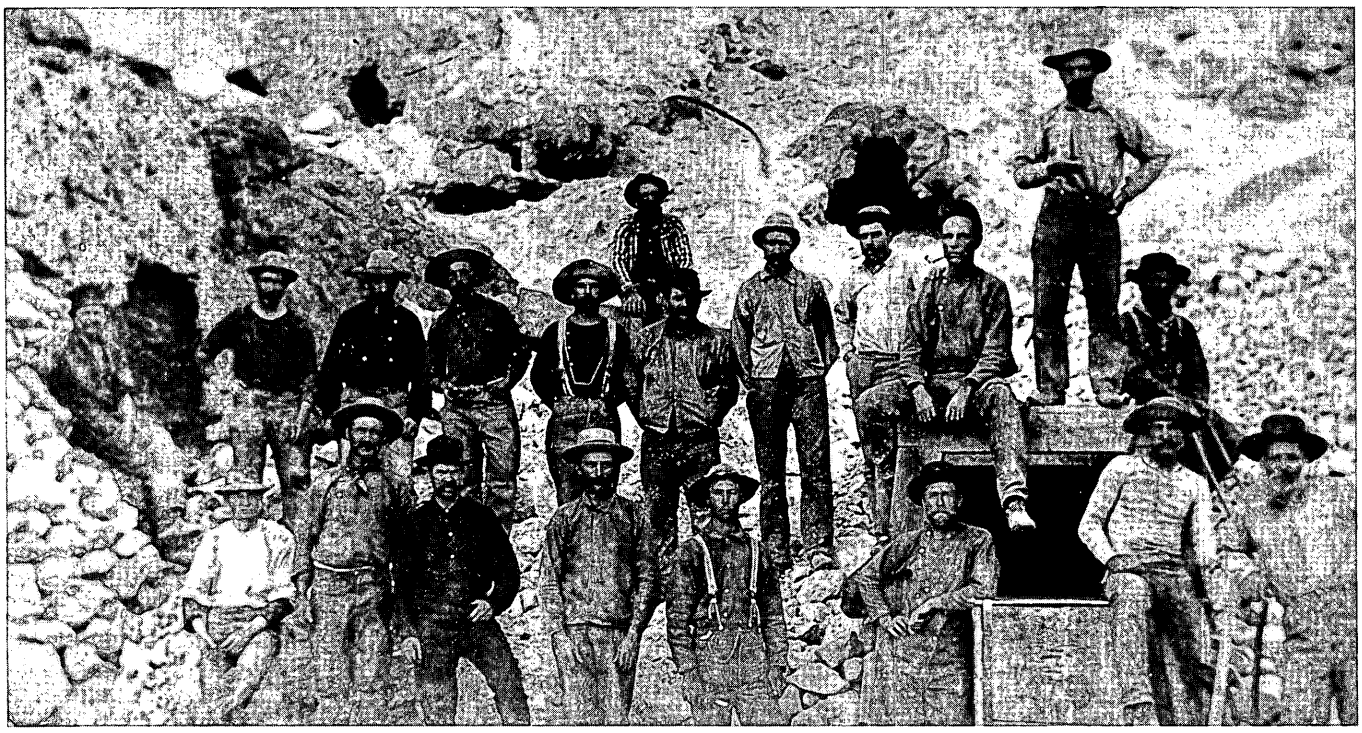
The Sue mine,* northwest of the Silver King, also was prominent; and Barber's mill, just south of Calico, was operating. In East Calico, 10 tons of ore mined daily at the Bismarck mine yielded $100 per ton; and ore from the Cuba mine was processed at Hawley's mill. The Snowbird mine also was active, and the main adit of the Garfield mine had reached a length of 1,000 feet. In West Calico, the Waterloo mine was worked extensively underground, though it is said mostly for rich pockets.

Activity in the district began to decrease after 1884–1885, as the price of silver began to fluctuate downward more sharply from about $1.10 in 1884 to 93



Molten silver is being poured from a melting pot into a bullion mold by J. Bert Osborne, 1924. Silver probably was recovered from ore taken from the Sioux mine, which was worked by Osborne at that time. O. A. *Russell Collection.*

* Probably same as mine later spelled "Sioux".



Early day miners at Occidental mine. Gopher-like workings, typical of most of East Calico, are in background. O. A. *Russell Collection.*

cents by 1889; in addition, once the richer deposits near the surface had been mined, operators were forced to mine deeper, leaner ore, which cost more to mine, as well as providing less revenue. Thus the Waterman mine ceased operations in 1886; and activity in the region probably became very light by the end of 1888, although the Oro Grande Company accelerated its operations (constructing a new 60-stamp mill in 1888). An event of note was the visit to the district in December 1886 of Waldemar Lindgren, a young mining engineer and geologist, later to become perhaps the most eminent in his field.

Two events then served to stimulate mining in the Calico district briefly: the first, late in 1888, was construction by the Waterloo Mining Company (successor to the Oro Grande Company) of a small railroad which extended from the Silver King and Waterloo mines to the company milling facilities at Daggett. This railroad reduced the cost of ore haul from about $2.50 to 12 cents per ton. The second event was passage of two Congressional Acts: the Bland-Allison Act and the Sherman Purchase Act of 1890, which enabled the Government to purchase silver for monetary use. The consequent administration of these laws drove the price of silver upward significantly, even though the Acts were soon defeated by their opponents (as was William Jennings Bryan, the famous proponent of "16 to 1" bimetallism.) Thus, during the period from 1889 to 1892, mining was revived: in September 1889 about 100 tons of ore from the Silver King mine and 50 tons from the Waterloo mine were reported being mined daily; in addition, it was reported that in December 1891 the Garfield mill was taking ore from the Odessa, Oriental, and Occidental groups. At one point during the period, it was reported that 700 men were employed in the district, 150 stamps were operating in mills, and about $200,000 per month in bullion was being produced.

Soon, though, the price of silver dropped again, from about $1.05 in 1890 to about 64 cents by 1894. The Waterloo was forced to close down in March 1892, with 130 men losing their jobs. In 1896 the Silver King Company apparently ceased hoping that the price would somehow rise again, for it shut down operations at its Occidental and Oriental groups. The Odessa mine also was closed.

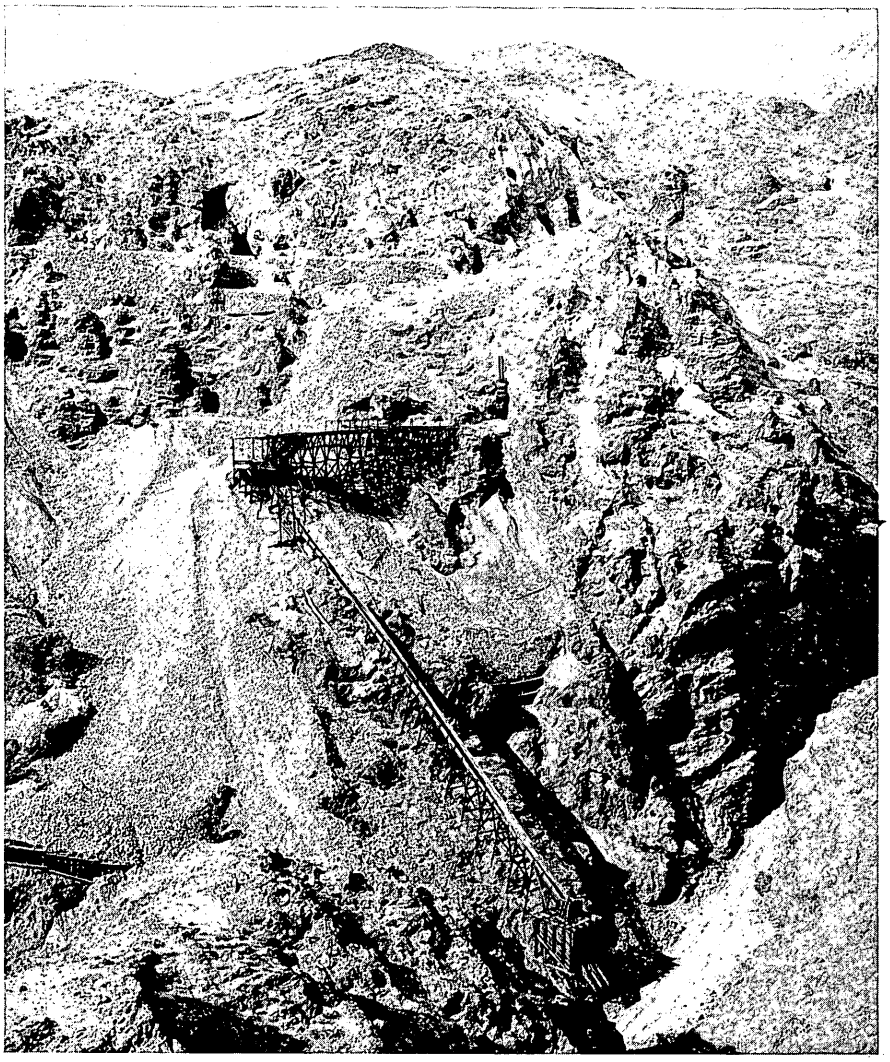
The district remained nearly dormant from about 1900 to 1915, when the price of silver again began to rise. From a low of about 48 cents in 1915, the price rose briefly to about $1.38 late in 1919, before it began to decrease. The rise was caused principally by industrial demand and international monetary needs (re-

sulting in the Pittman Act) caused by World War I. With this rise in price, the district became very active again, but the activity was not reflected in significant production of silver.

The period from 1915 to the mid-1920's did contain several relatively important events though: The Calico-Odessa Company was organized in 1915 by J. R. Lane, and subsequently explored and mined on a small scale in a wide area east of Wall Street Canyon; the Daggett Reduction Company and others treated some of the old mill tailings by cyanidation; and some ore mined in the district was sent to smelters.

In 1926 the total output of the district was reported as 157 tons of ore, which yielded 35 ounces of gold, 582 ounces of silver, 115 pounds of copper, and 190 pounds of lead. Also in 1926, the Zenda Company acquired the assets of the Waterloo Mining Company, and began an exploration and development program on the Silver King property, though the price of silver had dropped to about 62 cents. The company core-drilled 2 holes, and subsequently sank 2 shafts, of 550 and 350 feet, to explore deeper parts of veins whose upper parts formerly had been so productive. A 50-ton shipment of ore from these workings to a smelter in 1930 is said to have averaged 67 ounces of silver and no gold per ton. But the price of silver continued to fall (to about 32 cents by late 1930), and operations ceased in November 1930, when 47 men were laid off.

From that time until the present (early 1966) the only metal mining operations in any of the Calico mines have been very small and intermittent. Mill tailings, discarded after treatment of earlier mined Calico ores, continued to be processed by cyanidation through the 1930's, even though recovery apparently averaged only about 1 ounce to 2 ounces of silver per ton (with the range of recovery about 1 ounce to 9 ounces per ton). These tailings could be processed economically by cyanidation mainly because less efficient processing methods had been used at Calico dur-



View west-northwest in 1951 shows old workings of Odessa silver mine, on west side of Odessa Canyon, East Calico, mined principally from 1882 to 1896. Rugged topography is cut in andesite. Ubiquitous, gopher-like workings resulted from expedient mining of near-surface, "bonanza" deposits. *Photo by O. A. Russell, Yermo.*

ing the early mining years (cyanidation was developed in the late 1880's, and not used in California until 1891). Through the 1930's and 1940's small mining operations continued at such mines as the Sioux (by J. B. Osborne), the Waterloo (by Morris Mulcahy), the Burcham (Gold-Lead, also by Mulcahy), and the Zenda (by Lawrence Coke).

During the 1950's ore mined from several properties was processed for recovery of silver, lead and barite: such operations took place at the Le Montain and Silverado mines (by R. C. Buch and associates) and at the Silver Bow mine (by W. S. Hubbard). From 1957 to 1961, Oil Base, Inc. mined and processed relatively large tonnages of low grade barite ore at the Leviathan silver mine. Barite recovered in the district has been used as a weighting material in oil well drilling fluids. During 1964–65, the Alexander-Wattell mill was constructed near Barstow for recovery principally of silver and gold.

Perhaps because there have been no large, significant silver mining operations in the Calico district since the 1890's, and no mining operations at all from 1962 to 1965, the Calico district might be considered to have very little or no potential as a future source of silver. A pamphlet, issued in August 1965 by the United States Bureau of Land Management, which describes the recently established "Calico resource conservation area," states that

> "The Calico Mountain area, once rich in silver, which spawned the brawling, lusty mining town of Calico, now a County recreation facility, is still an attraction to campers, hikers, and rock hounds."

Such a statement sounds almost like an epitaph for mining.

Actually, as the year of 1966 began, chances for renewed and significant silver mining in the Calico district seemed better than at any time since the 1890's, when the larger early day operations were closed down. These chances were in the form of very significant interest shown in the district by the mining industry since about 1963. This interest stemmed from an increase in the price of silver from about 91 cents an ounce in November 1961 to $1.293 per ounce in June 1963. (In November 1961 the U.S. Treasury stopped sales of its silver at the price of 91 cents, and the free market price gradually rose to $1.293 per ounce, the United States monetary value of silver). Because of the higher price, and the possibility for an even higher price accompanying anticipated increased United States and world industrial and monetary demand, interest in older districts with significant silver production, such as Calico, became very logical.

Especially of interest to large mining companies in the Calico and other districts are very large, very low grade deposits, measured in tens and possibly many scores of millions of tons of potential ore, and scores and possibly a hundred million ounces or more of silver. Such deposits can be mined by simple, low cost

Red Cloud mine, part of Oriental group. Early day work in west end of Mammoth stope, which was reported to be 60 feet wide. Highest of four miners seems to be carefully working part of steeply dipping vein that consists of highgrade ore. Middle of three lower miners may have handcobbed and sorted ore before carrying it from stope in wheelbarrow. O. A. *Russell Collection.*

methods (such as open pit), taking advantage of modern techniques and equipment (such as giant earth-moving equipment); and the ores processed with the most modern of metallurgical techniques: with barite, lead, copper, or gold also recovered as byproducts.

Indeed, the Calico district still remains an "attraction" to the mining industry, as well as "campers, hikers, and rock hounds". If the district could speak out, it might use Mark Twain's famous words:

"The reports of my death are greatly exaggerated."

A list of references will accompany the last article on the subject of Calico, to be published in a future issue of this magazine.

CALICO

— Highlights of its history —

1881: April 6, claims are located for future Silver King mine.

1882: Spring; mining is underway; about 100 people live in Calico camp. Fall, mining gathers momentum, as smaller properties consolidated, and the part of Atlantic and Pacific Railroad nearby is completed. Price of silver, about $1.14 per ounce.

1883: At beginning of year, active mines include Silver King, Oriental, Burning Moscow, Garfield, Odessa, Bismarck, Blackfoot and others; also Waterman mine, to west.

1884–1885: Productivity is at peak, with perhaps 2,500 people living in district. Beginning of 1884, Silver King mine is developed to a depth of 500 feet; January 1884 to March 1885, Silver King yields $1 million in bullion. Price of silver about $1.09.

1886–1889: Productivity decreases, as price of silver drops to 93 cents by 1889. In addition, deeper, more expensive mining is mostly in leaner ore. Many mines are shut down.

1889–1892: Mining stimulated briefly by (1) short-lived Congressional Acts which briefly raise silver price to $1.05 in 1890, and (2) completion of narrow gauge railroad from Waterloo and Silver King mines to mill at Daggett.

1892–1896: In 1892, Waterloo mine is closed; by 1896 most other mines are inactive.

1915–1919: Activity in district is stimulated as price of silver rises from 48 cents in 1915 to $1.38 in 1919, before beginning to fall. But the activity is not accompanied by important production of silver.

1926–1930: Zenda Company begins deep exploration program at Silver King mine in 1926 when price of silver is 62 cents an ounce. Program ceases in late 1930, as price falls to about 32 cents.

1930–1950: Small and intermittent mining operations for recovery of silver, as well as gold, lead and copper, take place. In addition, old mill tailings are processed for silver.

1957–1961: Oil Base, Inc. recovers barite from barite-jasper vein material.

1963–1966: As price of silver rises to $1.29 per ounce, interest in district is greatly accelerated. Ironically, as "ghost" town tourist operation grows, chances also grow for important future silver mining operations.

Total production of silver: Estimated roughly at between $13 and $20 million; mined mostly between 1882 and 1896.

Portal of unidentified mine, showing sacks of handcobbed, presumably highgrade ore ready for shipment to mill. O. A. Russell Collection.

GEOLOGIC GUIDEBOOKS REPRINTED

GEOLOGIC GUIDEBOOK OF THE SAN FRANCISCO BAY COUNTIES

The book, issued as *Bulletin 154,* is now in its fourth printing in fifteen years. It deals with a region that has contributed greatly to the color and character of the West: not only to its tales and legends, its swashbuckling history, and its fabulous wealth, but also to its steady economic and cultural evolution to its present position as one of the nation's important centers.

The natural features and factors that helped the area attain its eminence are the subjects of the guidebook. Of the twelve counties treated, nine (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma) border on the shores of San Francisco Bay, and three (Sacramento, San Joaquin, Yolo) are in the delta region of the San Joaquin and Sacramento Rivers, yet all twelve unite to form one large unit, naturally, historically, and industrially. Although a diversity of scenic beauty is found in the twelve counties, from the rugged relief of mountain ranges to the wide expanse of ocean waters, or the flat monotony of fertile delta lands, the story of each is bound to the other, and the complete story of the landscape not only tells the story of the background against which the human history of the San Francisco Bay area took place but also shows the natural reasons for the course of that history.

The perceptive reader and the earnest student will derive much enjoyment from the 32 authoritative articles that comprise the book. Each was prepared by a technical expert, yet they are written in an easily understood manner, and are grouped into seven logical parts, including, "Historical background," "History of the landscape," "Geologic history," "Prehistoric life," "Mineral industry," "Water," and "Places to go and routes to travel." The casual reader, too, will find the 28 authors have prepared for him a tale in words and pictures – nearly 300 illustrate the text – that will stir his interest and enthusiasm. Because the 392 text pages cannot present an exhaustive study of the natural history and resources, nearly all of the articles append a bibliography that will serve as a useful beginning for further research. Those who like to roam will find Part VII, "Places to go and routes to travel," an invaluable collection of motorlogs for short trips in the San Francisco Bay area; this section, together with the seven colored strip maps of the 12 counties showing the geology and roads forms a handbook that will enhance their driving pleasure. Because it is necessary to introduce in the text some unfamiliar technical words, a convenient glossary has been included.

The book, containing 392 pages and more than 300 photographs, drawings, and maps, is bound in sturdy tan cloth. It may be purchased for $2.50 plus tax.

GEOLOGIC GUIDE TO YOSEMITE VALLEY

Originally prepared for the annual meeting of the American Association of Petroleum Geologists held in California in 1962, *Geologic guide to the Merced Canyon and Yosemite Valley, California,* has been out of print recently, but is again available.

Issued as Bulletin 182, the book contains "Summary of the pre-Tertiary geology of the western Sierra Nevada metamorphic belt, California," by Lorin D. Clark; "Granitic rocks of the Yosemite Valley area, California," by Frank C. Calkins and Dallas L. Peck; "The geology, geomorphology, and soils of the San Joaquin Valley in the vicinity of the Merced River, California," by Rodney J. Arkley; "Geomorphology of the Yosemite Valley region, California," by Clyde Wahrhaftig. Included also are road logs for "do-it-yourself" geologic guiding.

Price of the bulletin, bound in paper, is $1.50, plus 6¢ tax for California residents.

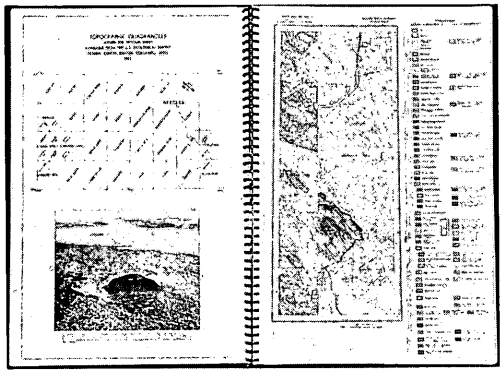
Half Dome from Glacier Point. *Photo by U. S. National Park Service.*

NOW AVAILABLE....

GEOLOGIC ATLAS

The geologic atlas of the State of California was prepared by the California Division of Mines and Geology to present an integrated summary of current knowledge of California geology. Preparation of these maps began in 1952, after the popular 1938 edition of the 1:500,000 scale state geologic map went out of print. This atlas, the first sheet of which was published in 1958, has been designated the "Olaf P. Jenkins Edition" in recognition of the stimulus Dr. Jenkins provided to geologic mapping in California during the 29 years he served as Chief Geologist and later as Chief of the Division of Mines, and in recognition of his personal direction of the atlas program at its inception.

The atlas consists of 27 map sheets which show the regional distribution and interrelationships of the various rock units and the major geologic structures that are present in California. One hundred and twenty-four cartographic units representing plutonic, volcanic, marine sedimentary, and non-marine sedimentary rock types of different geologic ages are delineated in the atlas. The many hundreds of formational units recognized in California preclude the possibility of depicting each of these separately on the map sheets; therefore, the formational units have been grouped in "time-rock units" according to their generally accepted age assignments. Contact lines of two different weights are used on the maps, the lighter weight being used to represent depositional or intrusive contacts, and the heavier weight being used to represent faults.



ATLAS BINDER. A loose-leaf, library size binder (16-½ inches by 22-½ inches) in green cloth with gold lettering. Included with the binder are enough adhesive strips to accommodate all of the sheets of the geologic map and all of the data sheets, as well as a title page and instruction sheet. Price $7.00, plus 28¢ tax.

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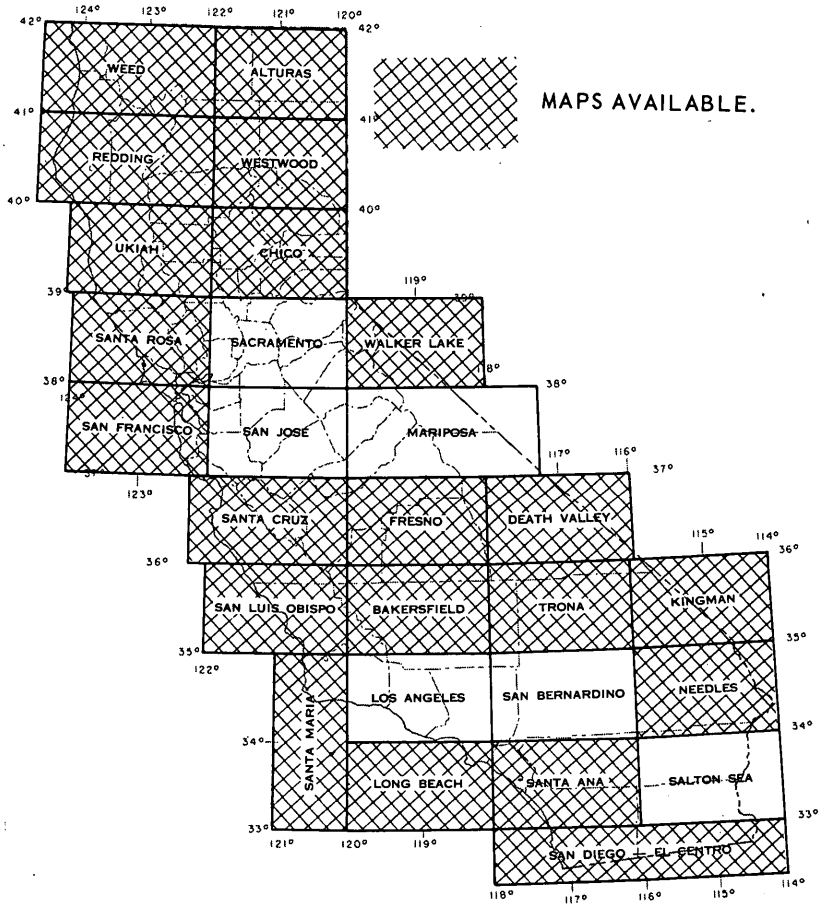

Individual sheets of the geologic map may be purchased from the Division of Mines and Geology, Ferry Building, San Francisco, California, 94111. Each sheet is accompanied by a data sheet which explains more fully the map units, and also lists the sources of information used in preparation of the map. The price of each map and data sheet set is $1.50, plus tax. Map sheets on which the geologic units are not colored are available for 50 cents.

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THESES

The following theses and dissertations have been completed and are on file at the colleges and universities indicated:

The Dumont dune system of the northern Mojave Desert, California. By Angus Andrew MacDonald. 1966. 106 pp., 8 maps, 28 figures, 1 graph. M. A. Thesis. On file at San Fernando Valley State College, Northridge, California. Includes dune terminology and mechanics, migration of the dune system.

Geohydrochemistry of the San Gabriel Valley area, Los Angeles County, California. By Sanford L. Werner. Copyright, 1965. M. S. Thesis. On file at University of Southern California, Los Angeles. Abstract on file in Division of Mines and Geology Library, San Francisco. Emphasizes the use of chemical analyses of various types of water as a basic tool to show geohydrochemistry.

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MINERAL INFORMATION SERVICE

A PUBLICATION OF THE CALIFORNIA DIVISION OF MINES AND GEOLOGY

VOLUME 20 NUMBER 1

JANUARY 1967

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STATE OF CALIFORNIA ■ THE RESOURCES AGENCY ■ DEPARTMENT OF CONSERVATION ■ DIVISION OF MINES AND GEOLOGY

MINERAL INFORMATION SERVICE

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Branch offices:

Los Angeles: Los Angeles State Office Building, Room 1065, 107 South Broadway, 90012

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MINERAL INFORMATION SERVICE is designed to report on the progress of earth science in California, and to inform the public of discoveries in geology and allied earth sciences of interest and concern to their lives and livelihood. It also serves as a news release on mineral discoveries, mining operations, statistics of the minerals industry, and new publications. It is issued monthly by the California Division of Mines and Geology. Subscription price, January through December, is $1.00.

Other publications of the Division include the Annual Report of the State Geologist; the Bulletin, Special Report, Map Sheet, and County Report series; the Geologic Map of California; and other maps and publications. A list of the Division's available publications will be sent upon request. Communications to the Division of Mines and Geology, including orders for publications, should be addressed to the San Francisco office.

MARY R. HILL, *Editor*

FILMS

In this column, which will appear from time to time, we hope to list films concerning the earth sciences. We would like to borrow a review print from film makers or distributors who have films for use by schools, mineral societies, technical organizations, or other groups. Please indicate the audience for which the film was prepared (i.e., primary, secondary, college, general, professional groups), how and where prints may be obtained, and the price of purchase or rental. The title, maker, and date of copyright would also be helpful. Please send film to:

Mary R. Hill, Editor
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San Francisco, California 94111

The Beach: A river of sand. 1965. Encyclopaedia Britannica Films, Earth Science Series, produced in collaboration with the American Geological Institute. 17 min. 16mm. color, or b-w. Science Advisors: Douglas Inman and John S. Shelton. (Dr. Inman is a specialist in beaches at Scripps Institute of Oceanography; Dr. Shelton is Chief Science Advisor for the AGI-EBF Earth Science Program.) Producer: Stanley Croner; Director-Editor: Warren Brown; Cameramen: I. Mankofsky, Frederic Goodich. Available by purchase from Encyclopaedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Illinois 60091. Price: color, $240; black-and-white, $120.

By means of time-lapse, animation, and fast-motion techniques, *The Beach* explores the environment of the shore, with special attention to the sand that makes up the beach. The film shows where sand along the California coast comes from (rivers on shore), how it is moved (by the waves and longshore currents), and where it goes (into submarine canyons).

By concentrating on the sand and its movement, and by using numerous methods of illustrating the behavior of the sand and the waves that move it, including underwater, aerial, and wave-tank sequences, the film maintains a high pace and achieves a unity, both uncommon in earlier educational films. It has been the unfortunate fate of many films in the earth science field to have contained errors that made earth scientists squirm. This reviewer detected none in *The Beach*. Other films, although technically correct, have been cinematographically bad or exceedingly dull, or both. *The Beach* is neither.

The EBF-AGI Earth Science Series was especially designed for junior high school students. They, or anyone interested in beaches (including the many mineral societies), should find it interesting and informative. . . . M.R.H.

Wilderness quest. Promotional Films, Inc., sponsored by The Red Wing Shoe Company. 29 min. Color. Consultants and actors: Montana Department of Fish and Game; Charles L. Sommers Wilderness Canoe Base, Region 10, Boy Scouts of America; U.S. Park and Forest Services; University of Minnesota Museum of Natural History. Producer: Alfred Peterson; Written by: Cliff Sakry; Production: George Daugherty. Available from: Boyd Film Company, 1569 Shelby Avenue, Saint Paul, Minnesota. 16mm.

The out-of-doors is colorfully displayed in this film, with an emphasis on "scenery." There is not much coherence—the film is rather like a slide show—but the mountains, valleys, and water are of sufficient interest in themselves to make this a good film for the general audience. Clubs and organizations should find it excellent program material.

The Red Wing Shoe Company, sponsors of the film, are to be congratulated on their desire to present the wilderness as a conservation topic. There is no advertising.

It is to be wished that the film makers had as much knowledge of the subject as the sponsor had good will. At no point is the fabric of the out-of-doors seen closely; almost all the shots are "postcard views" with obtrusive people and a never-ceasing narration that drowns out even the sounds of the nature it intends to portray. Moreover, several scenes showing doubtful outdoor manners will not gladden the heart of conservationists (including this one): a woman picks a wild flower (a merciful cut almost saves the scene); a man carries a pistol in a side holster; and, worst of all, while the narration talks about "water pure enough to drink," man, woman, and child wash in a running stream. . . . M.R.H.

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Bonanza in the lonely desert

SILVER DEPOSITS OF THE CALICO DISTRICT

By F. Harold Weber, Jr.

Second of three parts *

Silver was first discovered in the east-central Mojave Desert of southern California during the mid- or late-1870's, when the desert still was very remote. In the region near the discoveries a small community grew and was named Calico, probably by prospectors. The bright, splotchy patterns of parts of the nearby terrane probably made these men away from home think of Calico cloth, so popular in those days for ladies' dresses. They probably realized too that the Calico-like areas were the best to prospect, for they comprised the Tertiary sequences of continentally deposited sedimentary rocks, intruded by volcanic rocks, which even then were known to be the hosts for "bonanza" deposits of silver and gold. The "small community" shortly was renamed Daggett, in favor of a Lieutenant Governor of the state, and the name "Calico" moved 6 miles north to a mining camp and mountain range, where the major silver discoveries were made in 1881, and where the rock patterns of the region are the brightest and the splotchiest.

Important mining operations began in the Calico district in 1882, and continued until 1896. Since that time, little silver has been mined, because of the generally lower price of the metal, and because ore rock that remains is generally deeper and lower in grade. The total value of silver produced is estimated at between $13 and $20 million. Also obtained from the deposits in more recent years have been much smaller-valued amounts of barite, lead, copper, and gold. Borax also was once mined in the region, and crushed and broken stone for a variety of roofing granules is produced today from the multi-colored rocks. But most significant to the region in early 1966 was the fact that the price of silver had risen during the past few years from about 92 cents to $1.29 per troy ounce, and, with other factors, had created renewed interest by the mining industry in the Calico district.

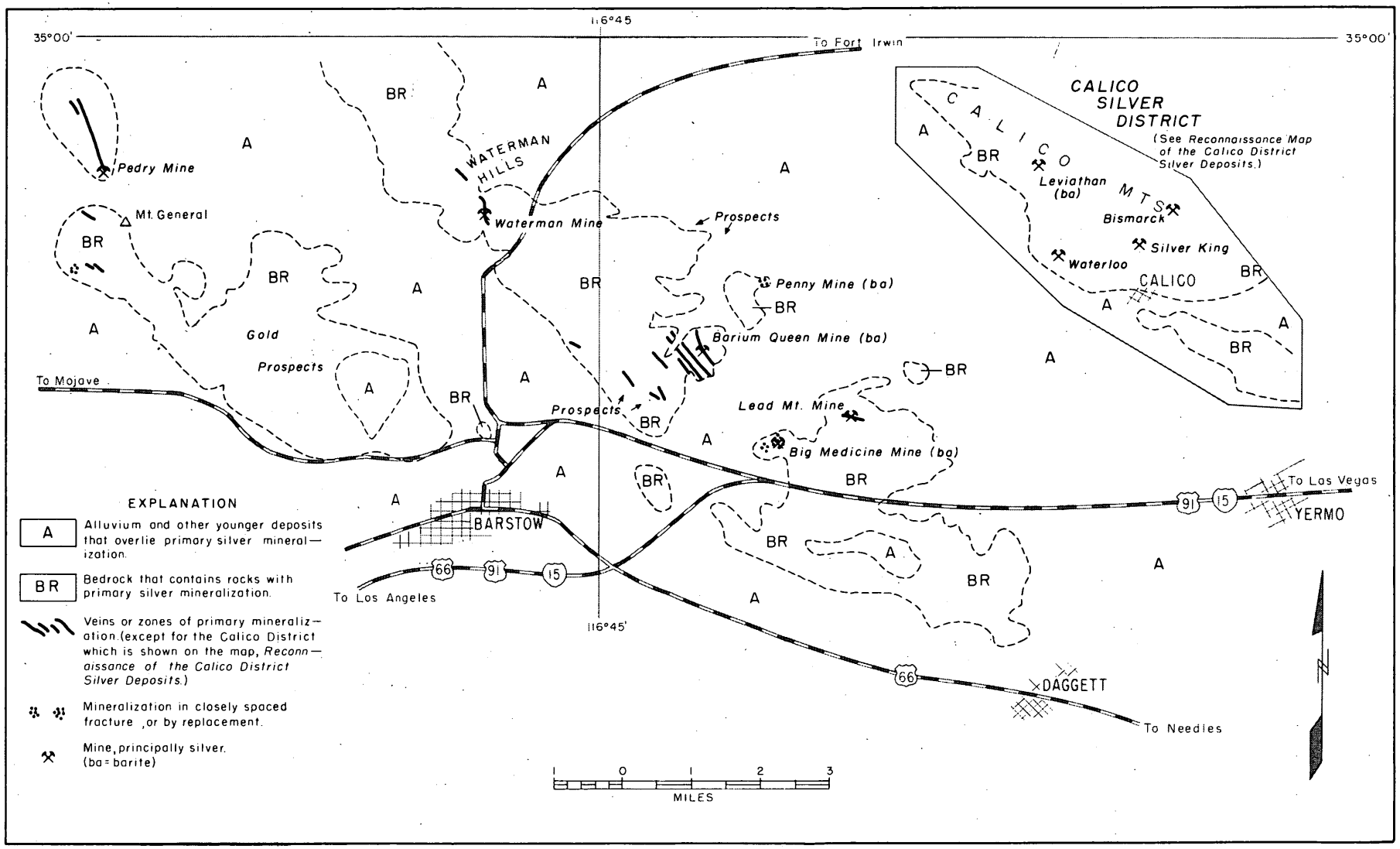
The central Mojave Desert comprises small to moderate ranges and groups of hills separated by small to broad valleys which commonly contain playa lake beds. The ranges and hills generally are blocks of rock that have been faulted relatively upward, and the valleys blocks that have been faulted relatively downward. Most of the blocks have been faulted along lines that trend northwest, generally parallel to the San Andreas fault, whose nearest point lies about 50 miles southwest of Calico. This fault, which dominates the structural geology of southern California, is believed by most geologists to have moderate to very large right lateral movement, whereby the rocks on the northeast side of the fault have moved southeastward relative to the rocks on the southwest side. Similar movement along faults of the central Mojave Desert has been shown by Dibblee (1963) and others.

The Calico Mountains themselves constitute a range which trends generally northwest but is irregular in plan. Silver deposits are mainly in the southwest portion, known as the Calico mining district, which has peak elevations of about 3,000 to 4,000 feet. The range is bounded mostly by nearly flat alluvial areas, as low as 1,900 feet, and is separated from the lowlands to the west and south by a steep northwest-trending front, along the base of which is the Calico fault zone —the predominant structural feature of the region.

To many people, the most spectacular sights in the Calico Mountains are steep-sloped hills, commonly capped with resistant volcanic rocks (which are dark shades of gray, red, or green) and underlain by much softer sedimentary rocks (such as sandstone or tuff, which are pale green, pale yellow, or buff). The resistant volcanic caps have shed trains of bouldery fragments down the steep slopes, giving the overall appearance perhaps of chocolate syrup dribbling down scoops of ice-cream. Such sights can be seen at the steep southwest edge of the mountains, even from a car, while travelling along Interstate Highway 15 near Yermo. At other localities, colorful sedimentary strata are steeply tilted or spectacularly folded, and penetrated by deep canyons, especially Wall Street Canyon, which extends northward from the reconstructed "ghost" of Calico town, at the southwest edge of the mountains.

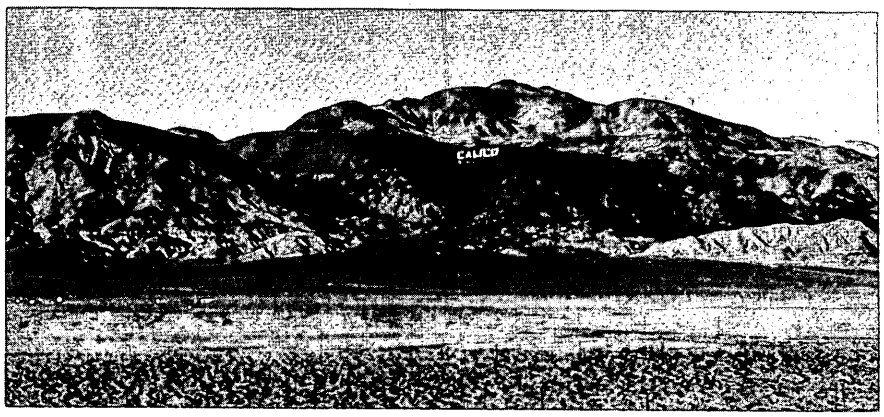
Geologic terrain somewhat similar to that of Calico also underlies other mining districts in the Mojave Desert, including Mojave, Randsburg, Stedman, and Lava Beds. But the classic illustration of a "bonanza" deposit is the Comstock lode, at Virginia City, Nevada.

* The first part of Mr. Weber's series on Calico appeared in the May, 1966 issue of this magazine.



CALICO SILVER DISTRICT AND VICINITY

View north-northeast shows portion of southwest Calico mountains. The word "Calico" lies at the crest of King Mountain, with the Silver King and Oriental mines just below, and the town of Calico at the base of the mountain. Wall Street Canyon lies to the left of King Mountain, and Odessa Canyon lies to the right. The Burcham mine is shown near the left edge of the photo, which was taken in 1959.



The ore deposits of the Calico region have been studied briefly by many geologists and engineers. The most eminent is Waldemar Lindgren (1887), who formulated the "hydrothermal" classification for the origin of certain ore deposits. The areal geology of the mountains has been mapped in detail by T. H. McCulloh (1965), as part of a regional study.

The oldest rocks in the Calico Mountains region consist principally of the Waterman Gneiss, which may be as old as Precambrian. Next younger are metasedimentary rocks of Paleozoic age, and granitic intrusive rocks of probable Jurassic or Cretaceous age. Together, these older rocks compose the "basement," rocks formerly at great depth but uplifted irregularly along faults during late Cretaceous or early Tertiary times, creating mountain ranges and valleys. Material eroding from the ranges into the valleys during the Tertiary period created the sedimentary rocks, into which the volcanic rocks were intruded. Such a cycle of sedimentation and subsequent volcanism, stimulated by faulting and uplift, has been repeated at least several times since the beginning of the Miocene epoch of the Tertiary period, about 25 million years ago.

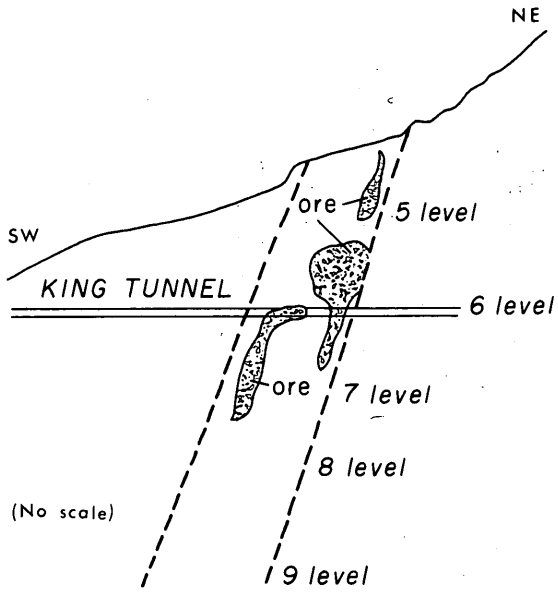
In the Calico district, the principal sequence of rocks consists of faulted and gently tilted tuff, tuff breccia, granite breccia, and sandstone, which was named the Pickhandle Formation by McCulloh (1965). It is probably middle Miocene in age. This sequence has been faulted, gently tilted, and intruded by volcanic rocks which range in composition from rhyolite to andesite. The earliest silver-bearing deposits occur within veins that cut the Pickhandle Formation and intrusive volcanic rocks (as shown on the accompanying map of the district). Related to the veins in the Pickhandle Formation are silicification, baritization, and other forms of alteration.

Composing the remainder of the bedrock, but apparently not containing veins, are the younger Barstow Formation and the Burcham Formation of McCulloh (1965), both probably of late Miocene age. These rocks mainly border the Calico fault zone on the southwest, and also lie within an embayment into the Calico Mountains, where they are mostly surrounded by the older, middle Miocene rocks. The Barstow and Burcham Formations consist mostly of sandstone, mudstone, and conglomerate, along with limestone and other rocks. These rocks appear fresh and unaltered, except in the Waterloo mine area, where probably they were altered as mineralization of the Calico fault zone occurred. They appear to be younger than the primary veins, but do not seem to contain clasts of the vein matter.

Lying above the Tertiary rocks are deposits of uplifted, unconsolidated terrace gravels, probably as old as early Pleistocene or possibly even Pliocene. The youngest deposits consist of Recent alluvium.

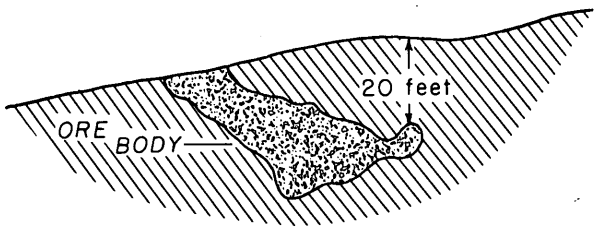
Silver has been sought in the Calico district from three closely related types of deposits: most obvious are veins or vein-like zones which lie north and northwest of Calico and include the Silver King mine ; less obvious, and southeast of the principal veins ("East Calico"), are areas of near-surface stockworks; and west and northwest of Calico lie deposits (including the Waterloo mine) that are associated with the Calico fault zone.

The vein and zone deposits are the basic (primary), oldest, and most widespread silver-bearing occurrences of the district. Veins consist of elongate, tabular bodies which generally consist principally of red jasper and white barite, commonly thinly interlayered parallel to the sides of the veins, with much smaller proportions of manganese, iron, silver, and other minerals. Zones consist of closely spaced thin veins or vein-like features which contain principally stains of iron oxide minerals. The veins trend mostly northwest to north-northwest, and make up a northwest-trending belt roughly 4 miles long and a quarter of a mile to a mile wide. This belt extends from the northwest corner of the Calico Mountains, with a bend near its middle, to points north and east of the town of Calico, where it seems to evolve into the area of stockworks.

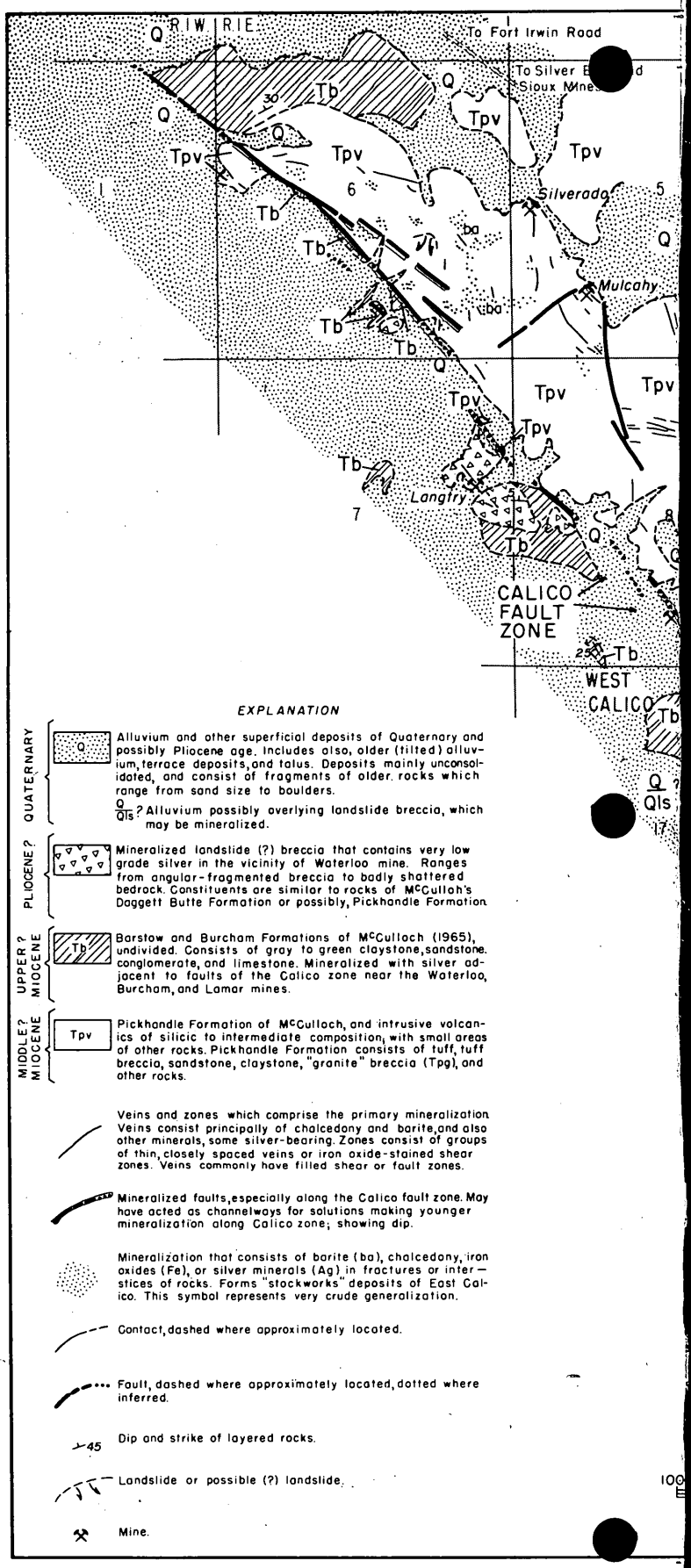


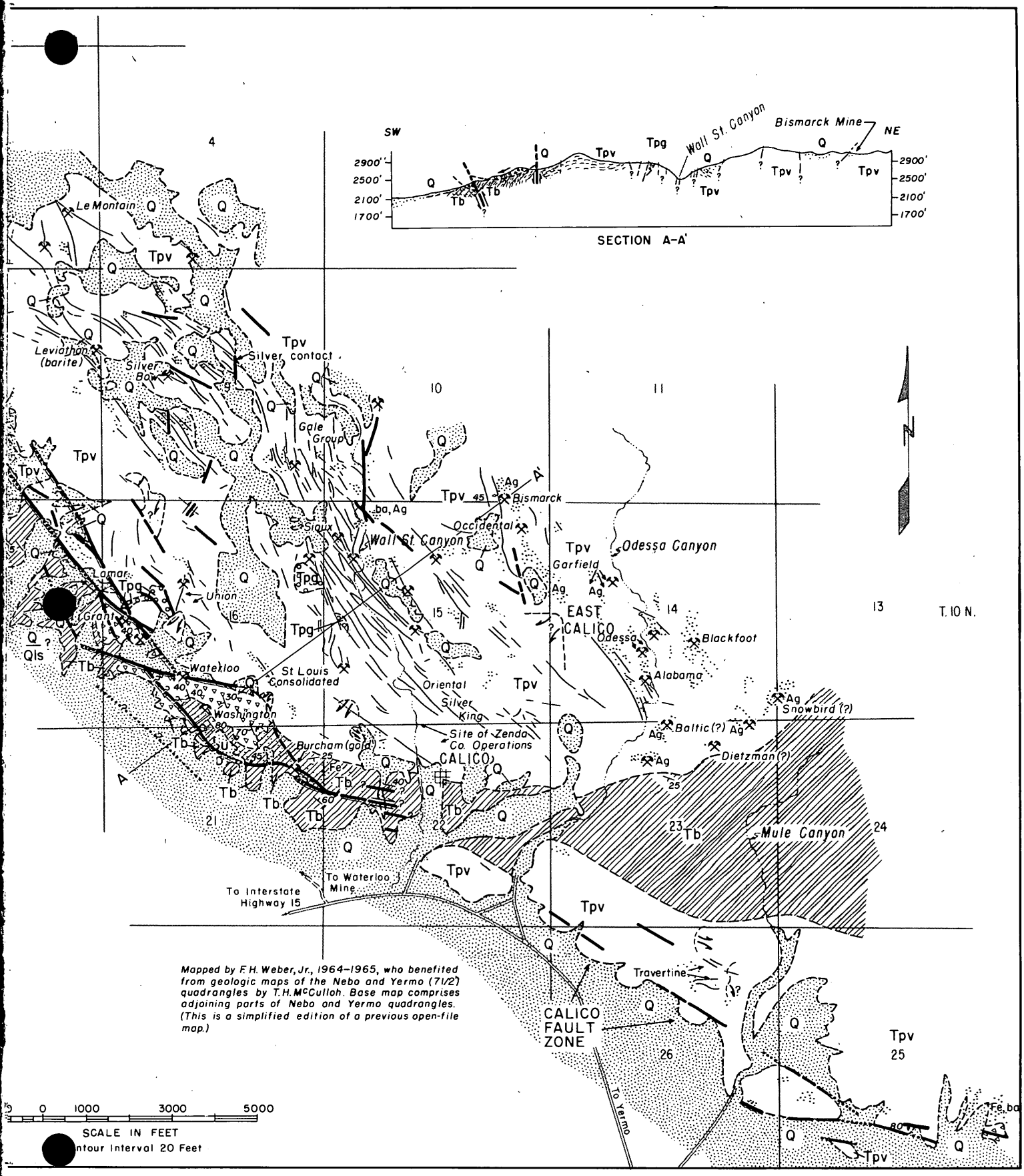
Silver King mine; cross section showing ore bodies of secondary minerals in upper part of steeply dipping zone, which cuts layered and intrusive volcanic rock. Sketch was drawn in the late 1880s for court trial (Storms, 1893).

RECONNAISSANCE MAP OF THE CALICO DISTRICT SILVER DEPOSITS



Blackfoot mine showing in cross section one of the shallow ore bodies as seen in active mine by W. Lindgren (1887). Silver minerals fill fractures in tuff (called "tufa" by Lindgren) with body of minerals following layering of tuff.




SECTION A-A'
SW
NE
Wall St. Canyon
Bismarck Mine
2900'
2500'
2100'
1700'
Le Montain
Leviathan (barite)
Silver Bow
Silver contact
Gale Group
Bismarck
Occidental
Sioux
Wall St. Canyon
Odessa Canyon
Garfield
EAST CALICO
Odessa
Blackfoot
Alabama
Lamar
Union
Grant
Waterloo
St Louis Consolidated
Washington
Oriental
Silver King
Site of Zenda Co. Operations
CALICO
Burcham (gold)
Baltic (?)
Snowbird (?)
Dietzman (?)
Mule Canyon
To Waterloo Mine
To Interstate Highway 15
Travertine
CALICO FAULT ZONE
To Yermo
T. 10 N.
Mapped by F.H. Weber, Jr., 1964–1965, who benefited from geologic maps of the Nebo and Yermo (7½') quadrangles by T.H. McCulloh. Base map comprises adjoining parts of Nebo and Yermo quadrangles. (This is a simplified edition of a previous open-file map.)
0 1000 3000 5000
SCALE IN FEET
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The veins and zones range in length from less than 50 feet to about 4,500 feet. The veins range in width from less than a quarter of an inch to perhaps 50 feet (at the Leviathan mine, where barite has been recovered), and most commonly from about half a foot to several feet. Most of the veins dip steeply, commonly 75 to 85 degrees west. Parts of some veins that are very thin (less than 2 or 3 inches) can be traced remarkably continuously for many hundreds of feet along the surface. One vein, for example, which is as much as 7 to 8 feet thick, where exposed in the Silver Bow mine shaft, can be traced southeast along the surface from the shaft, though less than one inch wide, for nearly 500 feet. This continuity helps to suggest that the vein may widen at some point beneath the surface, southeast of the shaft, below possible constrictions, which may have acted as traps to the mineralizing solutions. Possibly the constrictions were caused by a change in lithology. In other areas, a rock unit that seems to have a constrictive cap-like effect on vein deposits is pale-yellow weathering lithic tuff of the Pickhandle Formation. An example of this effect is at the St. Louis Consolidated deposit.

The richest vein deposits, near the southeast end of the belt, consist of zones that once contained rich bodies of so-called secondary silver minerals in their upper parts. Examples were the ore bodies for the Silver King, Oriental, and nearby mines (see accompanying illustration). Deeper parts of these veins are composed nearly wholly of primary minerals; and primary ore minerals are common near the surface in the north-central part of the vein system, at the Silver Bow, Le Montain, and other deposits. The primary deposits generally have been lower in grade than the secondary ones.

The most economically important variation apparently in the character of the principal veins, in the southeast part of the belt, is that with depth they decrease in grade. The best example of this economically unfortunate phenomenon is exposed by the Silver King mine, where ore yielded less silver as mining proceeded—mostly downward. Another variation is that the veins of the central and northwest part of the belt contain principally primary sulfide minerals in their upper parts, and no rich secondary deposits, as do the veins to the southeast. Thus these deposits have been infinitely less important economically than the ones to the southeast. For example, the thick Leviathan deposit is reported to be very low in silver.

Southeast of the belt of veins lie the areas of stockworks, where veins or zones also occur, some in conjunction with the stockworks. The Bismarck and Garfield deposits comprise a combination of veins and stockworks. The stockworks consist of shallow networks of multitudinous fractures in tuff, sandstone, and other rocks which are filled with silver minerals. The Blackfoot mine is characteristic (as shown in the accompanying diagram). At least some of these deposits are restricted to a single layer, or to adjacent layers (such as perhaps the Occidental mine).

The third type of deposit includes those that are associated with the Calico fault zone, which extends along the southwest edge of the range. Silver minerals occur in vein-like deposits in faults of the zone, and as deposits of stockworks in sandstone and shale of the Burcham and Barstow Formations, which are adjacent to the zone. Potentially important, very low grade deposits, explored during 1965–66, constitute disseminated silver minerals in bodies of a landslide breccia, which is associated with the Calico fault zone. In addition, the only gold deposits of the district (the Burcham mine, particularly) occur in the zone.

West of the Calico Mountains, in the hills beyond the broad lowlands, lie additional deposits, including the rich Waterman mine, the Lead Mountain mine, and the Penny, Big Medicine, and Barium Queen barite deposits (as shown on the accompanying map). Most of these deposits seem to be primary veins, with the Waterman mine having contained rich secondary deposits.

A bibliography on the Calico district will accompany the third part of this series.

Order form on page 2

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STATE OF CALIFORNIA ▪ THE RESOURCES AGENCY ▪ DEPARTMENT OF CONSERVATION ▪ DIVISION OF MINES AND GEOLOGY

MINERAL INFORMATION SERVICE
State of California
The Resources Agency
Department of Conservation
Division of Mines and Geology
Headquarters office: Ferry Building, San Francisco 94111

Branch offices:
Los Angeles: Los Angeles State Office Building, Room 1065, 107 South Broadway, 90012
Redding: State Building, 2135 Akard Street, 96001
Sacramento: 1416 9th St. (9th and O Sts.) 95814

MINERAL INFORMATION SERVICE is designed to report on the progress of earth science in California, and to inform the public of discoveries in geology and allied earth sciences of interest and concern to their lives and livelihood. It also serves as a news release on mineral discoveries, mining operations, statistics of the minerals industry, and new publications. It is issued monthly by the California Division of Mines and Geology. Subscription price, January through December, is $1.00.

Other publications of the Division include the Annual Report of the State Geologist; the Bulletin, Special Report, Map Sheet, and County Report series; the Geologic Map of California; and other maps and publications. A list of the Division's available publications will be sent upon request. Communications to the Division of Mines and Geology, including orders for publications, should be addressed to the San Francisco office.

MARY R. HILL, *Editor*

MAP PRICES GO UP

The U.S. Geological Survey has announced that, as the result of a recent analysis of costs, map prices will be increased. The new prices and discounts became effective October 1, 1966, and they have been announced by the Survey as follows:

The list price of topographic quadrangle maps at scales 1:24,000, 1:31,680, 1:62,500, 1:63,360, and 1:125,000 is 50 cents each. The list price of topographic maps at scale 1:250,000 is 75 cents each. National Park and other special topographic maps are individually priced. A price list is available from the U.S. Geological Survey, Washington, D.C., upon request.

AWARD TO LYDON

Philip A. Lydon of the Division of Mines and Geology staff has been made the recipient of a Sigma Xi grant-in-aid. The grant, presented by Dr. Harlow Shapley, Chairman of the Sigma Xi Grants-in-Aid of Research Committee, was made in order to assist Mr. Lydon in his study of the geology of the Butt Mountain area, a source of the Tuscan Formation in northern California. Mr. Lydon has been on educational leave for two years, and began study of this area at the University of Oregon in Eugene, Oregon, where he is a candidate for the Ph.D. degree.

FIRST LADY TO RECEIVE MINERAL BROOCH

The American Federation of Mineralogical Societies is directing the preparation of a special jeweled brooch for the First Lady, Mrs. Lyndon B. Johnson. The brooch will contain at least one gem or mineral from each of the fifty states. California will be well represented by three contributions: several ounces of gold were contributed by the San Francisco Gem and Mineral Society; pink tourmaline was donated by Mrs. Goldie E. Wood, of the Los Angeles Lapidary Society, and by Captain John Sinkankas; and rare benitoite was contributed by Glen A. Frost. Among other interesting gems and minerals in the brooch are Arkansas diamonds, a North Carolina ruby, Hawaiian black coral, and petrified wood from West Virginia.

After receiving this unusual piece of jewelry at the National Gem and Mineral Show in Washington (June 29-July 2, 1967), Mrs. Johnson will present it to the Smithsonian Institution for the use of all First Ladies.

FILMS

In this column, which will appear from time to time, we hope to list films concerning the earth sciences. We would like to borrow a review print from film makers or distributors who have films for use by schools, mineral societies, technical organizations, or other groups.

Erosion: leveling the land. Copyright 1964. Encyclopaedia Britannica Films, Earth Science Series, produced in collaboration with the American Geological Institute. 14 min. 16mm. color or b-w. Chief Science Advisor: John S. Shelton. Producer: Stanley Croner; Director: H. William Varney; Photographers: I. Mankofsky, Paul Leimbach. Available by purchase from Encyclopaedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Illinois 60091. Price: color, $150; black-and-white, $75. Suitable for Junior High, High School.

Purpose of the film is to show how erosion, acting through wind and weather, wears the mountains down to dust. As is true of others in the EBF-AGI Series, it succeeds admirably. It is a good film to introduce geology to a naive audience.

Particularly effective are shots of Cleopatra's Needle, taken a century apart; a nail rusting, a milk bottle freezing, artificial rain wearing away limestone—all while one watches, thanks to time-lapse techniques.

Teachers who have attempted to encourage students to see in three dimensions will be very interested in a clay model that is used to reveal structure by means of a table knife. The clay strata are artificial, but a natural sand dune in another shot is just as neatly sliced by a shovel (in the hands of the science advisor), and shows just as tidy banding.

The Airborne magnetometer. n.d. Produced by the U. S. Geological Survey. 34 min. 16 mm., black-and-white. Available on loan from Information Offices, U. S. Geological Survey, 300 North Los Angeles Street, Los Angeles; or 468 Custom House, Denver, Colorado; or Room 2647, Interior Building, Washington, D.C. 20242.

The longer version is detailed presentation of the methods of aerial magnetic surveying. For those wishing to know how to make such a survey (university classes, for example), this is a thorough introduction. It is not suitable for younger or nonprofessional groups. . . . M.R.H.

Genesis of riches

SILVER DEPOSITS OF THE CALICO DISTRICT

By F. Harold Weber, Jr.

Third of three parts *

The principal silver mineral of the Calico district and vicinity has been cerargyrite (naturally occurring silver chloride, colloquially called "horn silver"). It is a soft, waxy-looking mineral, which at Calico has ranged in color from pale gray to pale green. A similar mineral found in the district, but much less commonly, is embolite. These two minerals are called "secondary" minerals, because they have formed near the surface of the earth, generally by dissolution of the original primary silver-bearing minerals of veins, and subsequent redeposition. The primary minerals include tetrahedrite, tennanite, stromeyerite, proustite, argentite, galena, and chalcopyrite. Gangue minerals—in addition to chalcedony (mainly variety jasper) and barite—include hematite, pyrite, and secondary manganese oxides.

Precise data for grade and character of the ore mined at early Calico are not available, as engineering records for those operations apparently no longer exist. The best general idea of grade can be gained from reports of mill returns, keeping in mind two factors: that roughly 75 to 90 percent of the silver generally was recovered from the ore, and that some of the rich ore shipped was carefully hand mined or hand selected from rock mined, thus yielding a higher grade than the rock in place. Generally the earliest reports showed the highest grade not uncommonly to have been 50 to 100 ounces of silver per ton. But a better idea of true grade probably is shown in a report of Goodyear (1888) for the important Silver King mine. This report shows that the mine apparently yielded about 36 ounces per ton from 1883 to 1886, with a maximum of 64 ounces in 1883, diminishing to 20 ounces in 1886. The range of yield for 1885 may have been about 28 to 43 ounces per ton of ore. Another idea can be gained from a report by Lindgren (1887), who said that the grade was "seldom below $20, and often in the hundreds" (price then about $1.00 per ounce). Another old report suggests that the very productive Waterloo mine may have averaged about 25 ounces per ton, though lower grade ore and rich pockets yielding 2,000 ounces per ton also were mined. Additional examples are the Garfield mine: about 36 ounces per ton, during 1886–1887; and the Waterman mine: about 45 ounces during 1883.

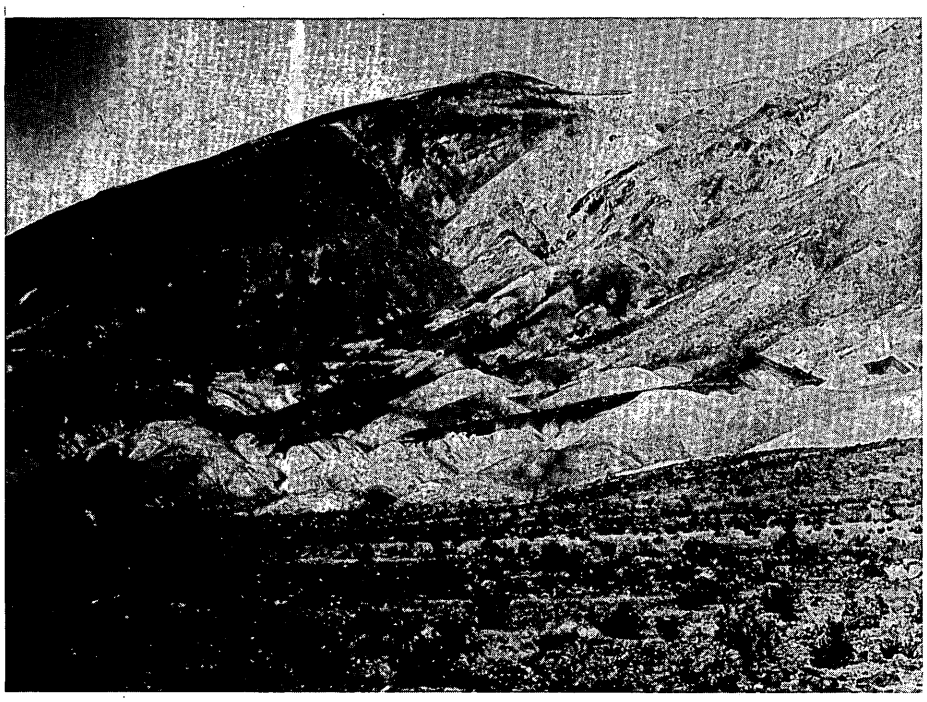
More recent data regarding grade are from the activities of the Zenda Company, which in 1930 shipped ore to a smelter from its deep shaft in the Wall Street Canyon area, just before it ceased operations, as the price of silver dropped to less than 35 cents an ounce. Reports indicate that the rock shipped apparently yielded about 50 ounces of silver per ton, though it might have been at least partially hand selected. Another source of data is a consulting report on the Burcham gold mine which shows that the two principal veins, with assay widths of 2 inches to 4 feet, average 0.03 to 0.31 ounces of gold, and 0.1 to 3 ounces of silver. One of the veins also averages 1 to 3 pounds of lead per ton. The average ratio of silver to gold, both veins, is about 5 or 7 to 1.

Unfortunately, not nearly enough is known of the relationship of the areal geology to the mineralization to be able to understand well the genesis of the deposits, and hence, to predict additional occurrences. What follows, therefore, is only a very general guess as to "how the silver got there" and where there might be more.

The earliest mineralization—which formed the belt of primary veins of the Calico district—perhaps took place during early late Miocene time. The belt of northwest-trending fractures that the vein matter filled may have represented an ancestor of the present Calico fault zone, in the same area as even prior ancestral faults, which had been avenues for the upward intrusion of lavas (the probable instigator, if not the basic source, of the silver and barite mineralization). The volcanic rocks had intruded the middle Miocene Pickhandle Formation—sandstone, conglomerate, tuff, and other strata—during perhaps late middle Miocene time. These events, including emplacement of the veins, took place at unknown depths, but deep enough so that the temperatures must have been relatively high and the chemical systems involved at least partially confined.

The primary, silver-bearing deposits must have formed specifically as the result of the interaction of

*The first part of Mr. Weber's series on Calico appeared in the May, 1966 issue of this magazine; the second part in January, 1967.



View north shows part of southwest edge of Calico mountains, at area of Burcham mine. Large, dark-colored mass of rocks in upper left part of photograph constitutes landslide mass, which contains lower-grade silver mineralization. Calico fault zone skirts base of steepest slopes shown, with Barstow Formation in gully areas to left and Pickhandle Formation to right.

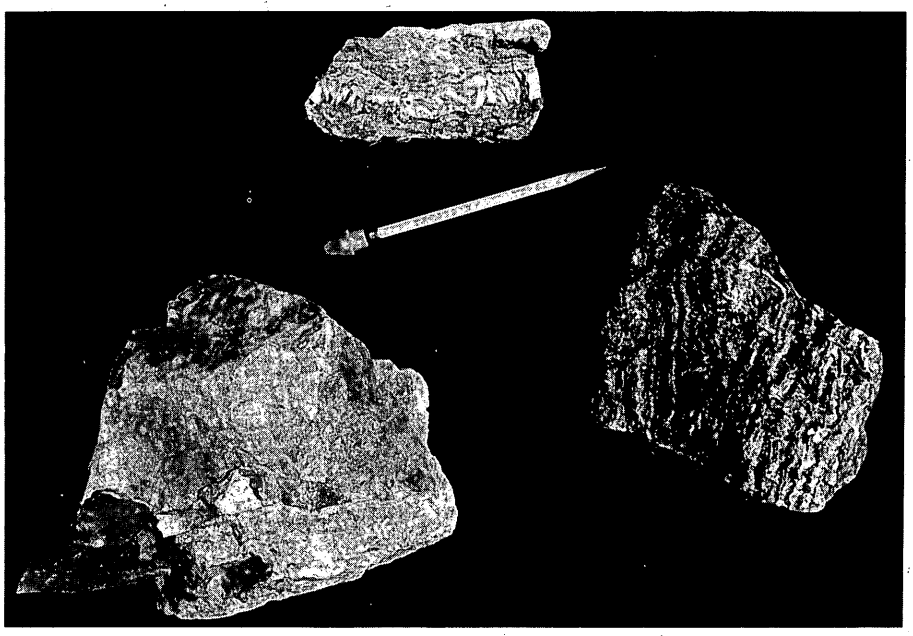
certain fluids (including waters), or the reaction of fluids with certain rocks. These fluids may have been hydrothermal (which rose along faults from deep-seated igneous activity); or they may have been derived from, or associated with, shallow igneous (volcanic) activity; or they may have included connate waters (indigenous waters within the sedimentary rocks) or meteoric (rain) waters circulating through the ground (beneath playa lakes, and within faults, alluvium, and other rocks). Any of these fluids may contain at least minute quantities of practically any element, which may be indigenous or gained by absorption from rocks through which the liquids passed, and with which they may have reacted.

The thin interlayering of chalcedony and barite (along with formation of silver minerals) within many of the primary veins must have been the result of a cyclical change in the character of the fluids entering the fractures, and at least partly precipitating. The change may need not have been extreme, but was distinct. It may have been caused by changes in tectonic conditions (renewed fault movement, for example), changes in deep volcanic activity, or changes in climate (changing the volume of downward circulating waters). But the exact process by which silver and other metals are gained by solutions, then phenomenally concentrated by precipitation into rich deposits, is not understood completely.

After essentially vertical emplacement of the veins, perhaps also during early late Miocene time, the rocks that make up the present day Calico Mountains were uplifted along the present Calico fault zone. With this uplift, the rocks in the west and northwest parts of the mountains seemingly were raised higher than rocks to the east and southeast. Thus, lower parts of the veins in the west and northwest parts apparently were raised higher than veins to the east and southeast, as shown in the accompanying diagram. Consequently, with this uplift, tilting, and subsequent bevelling by erosion, deeper parts of veins were exposed at the surface to the northwest than to the south and southeast.

During this period also, as the faulting and uplift continued during early late Miocene, the upper parts of the veins or zones were being removed by intense erosion. Consequently, the rich secondary silver deposits were being formed by downward and lateral drainage just beneath the surface of the eroding terrain. These deposits formed within zones (the Silver King mine for example) and as areas of stockworks away from veins (as at the Bismarck mine, for example). This process involved the dissolution of the primary silver minerals, as weathering and erosion continued, with the solutions then being carried directly downward into fractures in the zones and redeposited, or out into the surrounding rocks and redeposited (especially in easily mineralized tuff and tuff breccia). These deposits were formed, dissolved, and reformed in a continuing process as the rocks were eroded, with the presentday deposits finally formed perhaps as the period of uplift ended.

Slightly later, during late Miocene time, the lake and other beds of the Barstow and Burcham Formations were deposited against and onto the rising block of the Calico Mountains. As faulting and uplift con-



Specimens of vein material from Calico district. *Lower left:* Pale gray vein barite at bottom is in contact with grayish red andesite wallrock. Barite is broken away at lower left, to show smooth surface of vein wall. *Upper center:* Specimen of cross section of thin vein, with coarse-grained barite in middle, and banded barite-jasper rock in outer portions. Specimen is liberally sprinkled with very fine-grained silver-bearing sulfide minerals. *Right:* Specimen across thin vein; similar to upper specimen, but jasper more abundant, and more concentrated toward middle.

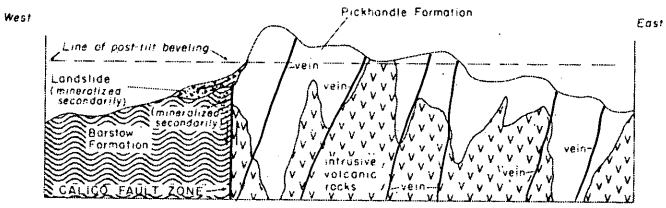
tinued into the Pliocene, the appearance of the terrain was much different than today, though the general position of ranges and valleys probably was similar. But the climate was much more humid than now, with vegetation relatively abundant, hot springs along the active Calico fault zone, and perhaps small lakes. Silver minerals were being deposited by hot waters circulating in the Calico fault zone and adjacent rocks, with the silver gained perhaps from primary or secondary deposits being eroded nearby. Weathering and erosion were intense, cutting the present gorge-like canyons into the range as it was being uplifted; and great masses of broken-up material were being carried out from the range and deposited as alluvium. Mass wasting was common, with the occurrence of the landslide * that led to the mineralized breccia. This slide, which headed down the steep southwest slope of the range, over the Calico fault zone, probably was derived from bedrock now mostly eroded away. After sliding it was mineralized by the previously noted silver-bearing solutions percolating upward in the Calico fault zone.

Barely enough is known of the mineral deposits and geology of the Calico district and vicinity to guess as to the possible location of additional ore deposits. Especially unknown are the rocks which lie beneath the broad stretch of alluvium west and south of the Calico Mountains, beyond the Calico fault zone. For example, the northwest end of the primary belt of veins and zones extends to the Calico fault zone, west of which lies alluvium. Presumably the mineralization is dying out to the northwest, but possibly it might increase in intensity at some point beyond where the belt renews on the other side of the fault, probably to the northwest, beneath alluvium.

Also offset by the Calico fault zone is the mineralized landslide breccia; portions of this faulted mass may be buried nearby, beneath alluvium.

Additional silver deposits may lie somewhere beneath the broad stretch of alluvium that extends westward from the Calico Mountains to the hills which contain the Waterman and Lead Mountain mines. Even the Calico Mountains themselves contain alluvium, with unknown rocks beneath. Silver mineralization also may have enriched rocks that lie below the Barstow-Burcham Formations, provided that these formations are younger than the belt of primary veins and zones and the deposits of stockworks. Especially, such mineralization might occur beneath the lobe of the Barstow Formation which lies just south of East Calico.

* Also interpreted by others as being of tectonic origin.



Hypothetical and exaggerated cross section across ancestral Calico Mountains, showing possible tilting of rocks along Calico fault zone, which raised deeper parts of veins to west and northwest higher. Subsequent bevelling by erosion exposed deeper parts in the west and northwest than in the east and southeast.

Silver-bearing deposits may also be associated with the volcanic rocks which are nearly surrounded by alluvium or younger rocks west of Calico, in the vicinity of the Waterman and Lead Mountain mines. In these areas, prospecting might be aided by an understanding of why silver and barite occur together at the Waterman and Lead Mountain mines and barite occurs alone at the Barium Queen and Penny deposits.

Within the Calico Mountains themselves, very low silver enrichment with economic potential may exist in rocks other than the landslide breccia.* For example, certain tuffs within the Pickhandle Formation of East Calico, which were mined for rich pockets at the surface, might contain additional deposits of voluminous though extremely low grade mineralization (tuff is known as an absorber of minerals from solution). Fractured volcanic rocks, filled partly with barite, occur especially at several localities in the northwest part of the range, but a possible link with silver is not known.

Another factor concerning exploration for silver at Calico is the relationship of known deposits to depth. Though the grade of the deposits is known to diminish downward in mines, nothing is known about these deposits at much greater depths (thousands of feet).

In conclusion, though California never has been a great silver producing state, the metal has been mined at many localities, which suggests a variety of possibilities for renewed exploration and mining if the price continues to rise. Perhaps presently uneconomic deposits can be developed whereby silver and other metals or minerals are recovered together from very large tonnages of low grade rock considered previously to be noneconomic. In this respect, the Mojave desert, and the region to its north and east, contain many districts in many types of terranes, along with complex regional geology and great stretches of alluvium which cover possible deposits. Unfortunately, very few geological workers in the region today are studying the academic geology of metal deposits. However, more and more regional geologic data are being accumulated and perhaps such data will be utilized by economic geologists of the future to uncover additional deposits. Who knows, there may be another Comstock Lode somewhere out on the desert in some least suspected locality, buried beneath just a few hundred feet of alluvium—possibly even near the Calico Mountains.

* This subject was discussed in several papers by F. B. Weeks.

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A limited supply of a more extensive bibliography on the Calico district has been prepared by Mr. Weber and is available at no charge upon request.

THE HISTORY BOOKSHELF

Walker's R.R. Routes—1853, by Pat Adler and Walt Wheelock. La Siesta Press. 61 pages, maps, photos, drawings. 1965. Price $4.50.

Orders should be addressed to La Siesta Press, Box 406, Glendale, CA 91209.

The role played by Joseph R. Walker in the history of California is significant as he was, perhaps, one of the first guides who led mapping and exploratory companies through the territory. His discovery of the pass at the southern tip of the Sierra Nevada which now bears his name became the topic for heated debate when the choice of routes was being discussed. The pass was easily accessible, and was travelled by many coming into California in search of gold or land. The practicality of this route having been demonstrated, it is difficult to comprehend why it was not selected. One reason may be found in the conditions that existed in Congress. As the authors summarize, "It would not be exaggerating to say that this [the] Benton-Fremont alliance was the most powerful single force in the development of the western routes. . . ." Their influence, exerted against a southern route, was too great and expediency was substituted for practicality.

—*Albert D. Ortiz.*

The Songs of the Gold Rush. Edited with Introduction by Richard A. Dwyer and Richard E. Lingenfelter; music edited with guitar arrangements by David Cohen. University of California Press, Berkeley and Los Angeles, 2d printing, 1965. 200 pages, illustrated. Price $3.50.

A collection of 88 gold-rush songs, drawn chiefly from such contemporary song-books as *Put's Original California Songster* (1855), *California Songster* (1855), *The Gold Diggers' Song Book* (1856), and *Johnson's Original Comic Songs* (1858). The songs are grouped by subject under various headings— "Ho! for California!", "Seeing the Elephant", "An Honest Miner", "Life in California", etc.—and each group is introduced by a short commentary on the sundry gems that it contains.

The songs, say the authors in their introduction, "exhibit . . . every facet and mood of the great rush—the voyage around the Horn or by the Panamanian isthmus, the trek across the plains, the humor and drudgery of mining, the hopes and the disillusionment of the miners, the hardships and humbugs of life in California, and the last reminiscences of the days of '49": this for the "buff" of gold rush history or romance. He who would like actually to *sing* the songs will find this collection has an advantage over many others: he is not left—in most instances, at least—to scour his memory for some tune a hundred years dead ("Air: I Get in a Weaving Way"; "Air: Lucy Long"; "Air: Rosin the Bow"). Words, guitar chording, *and music* appear together on the page.

To order, address University of California Press, Berkeley, CA 94720; the book is not distributed by the Division of Mines and Geology. E.L.E.

Inyo 1866–1966. Sponsored by Inyo County Board of Supervisors. 95 pages, many illus. 1966. Price $3.27, paperback; $6.39, hardback; price includes tax and handling charges. Address orders to Miss Mary Cavitt, County Librarian, Courthouse, Independence, CA 93526.

Marking the centennial of the formation of Inyo County in 1866, this book, with its beautifully reproduced illustrations and interesting text, recounts the history of Inyo, from the first attempts at settlement to the County's current productions and activities. The many short articles that make up the book cover a multitude of subjects—pioneer resident Samuel Bishop, who drove cattle from Fort Tejon to Owens Valley in 1861; Camp Independence, the Civil War fort of adobe, which stood until the earthquake of 1872; mining; agriculture; forestry; the interdependence of Inyo and that old water pirate, Los Angeles; tourism and recreation; and many others. E. L. E.

THE GEORGE A. GROTEFEND MINERAL COLLECTION

By Irene Kitchell

During his lifetime, George A. Grotefend acquired an extensive mineral collection, including many excellent specimens from the mines in Shasta and Trinity counties. In 1950 he loaned this collection to the California Division of Mines for display at the Redding office. When the provisions of his will were revealed after his death in 1951, it was learned that he had bequeathed his mineral collection to the Division of Mines with the stipulation that it be kept on exhibit and displayed at the local office. Visitors are welcome to see the display at our Redding office, which is located at 2135 Akard Avenue, Room 10. Office hours are 8:00 to 12:00 and 1:00 to 5:00 daily, Monday through Friday.

Dr. Grotefend came from pioneer stock in Shasta County. His father, August Grotefend, was born in Germany in 1824 and came to St. Louis with his family in the same year. Lured by the stories of gold discoveries, he came to California to seek his fortune, settling in Shasta County in 1849. After several unsuccessful mining attempts he discovered a rich pocket of gold ore in Schaeffer Gulch, from which he removed about $18,000. In 1853 or 1854 he married Emilie Zumdahl and engaged in the mercantile business in the town of Shasta, where he was very successful. The remains of his store are still preserved as a part of the Shasta State Historical Monument.

George Adolph Grotefend was born in 1869, the next to the youngest son of August and Emilie Grotefend. He was educated in the local schools and the Methodist College in Napa. He then attended the University of Pennsylvania, graduating in dentistry in 1889. He returned to Redding where he opened an office in 1890, which he maintained for 20 years, in the Odd Fellows Building. He was considered Redding's leading dentist, keeping abreast of all modern techniques and equipping his office with the finest fixtures available.

About 1909, together with Bill Foster, Dr. Grotefend organized the Trinity Farm and Cattle Company. The firm had headquarters near Trinity Center and grazing land in the Bald Hills. Actually the doctor made his money in his mining ventures and invested the proceeds in the land and cattle company. He held the controlling interest in this company at the time of his death.

George Grotefend had considerable mining interests throughout his lifetime. Probably his most outstanding mining venture was the purchase, about 1930, of the Washington mine in the French Gulch mining district. Lode gold was first mined in Shasta County in 1852 at the Washington mine; thus it ranks among the earliest lode locations in California. By 1890, total production was estimated at $500,000 to $600,000. The mine was continuously active until 1865, after which it was operated only intermittently by lessees. He bought all the stock of the mine "for a song" and put several men to work driving what is known as the H level, sometimes called the 350 level. The level was driven ahead about 150 feet, where it encountered a nice showing of ore. About 100 tons of ore was mined and stockpiled on the dump, as the old Washington mill had deteriorated to a point where it would have to be rebuilt before the ore could be milled. About that time J. H. Scott came to the French Gulch district, having so far been unsuccessfully engaged in mining ventures. Dr. Grotefend agreed to sell him the Washington mine for $10,000 down and 25 percent royalty to apply on the purchase price of $70,000 for the mine. Scott paid the $10,000 down. He shipped the ore on the dump to the smelter and recovered over $13,000 from the 100 tons. Another $800,000 worth was mined from the shoot of ore before he was forced to shut down the mine during World War II.

George A. Grotefend. Photo courtesy *Redding Record-Searchlight.*

Dr. Grotefend had once married, but the marriage ended in divorce, and there were no children. From

the seven children born to his mother and father, only one grandchild grew to adulthood. This niece, Bessie Prehn, was never married and died in 1957, leaving the Grotefend family with no descendants. Dr. Grotefend retired from active practice in the early 1940's and spent the last twenty-five years of his life living at the Golden Eagle Hotel. [This old landmark, built in 1888, burned to the ground in 1962.] He died there in 1951 at the age of eighty-two. His will, made only two months before he died, contained some unusual and surprising provisions. After bequests to several friends, he bequeathed his extensive mineral collection to the California Division of Mines and set up three trust funds.

The third fund, an amount of about $261,000 was set up as a scholarship fund for students who spend four years in Shasta County high schools and who desire to go to college. There are very few restrictions and the students are able to choose their own schools. They must be worthy and in need of help other than can be afforded by their parents but it is not necessary that they be of the current graduating class, so that students already in college are eligible.

The scholarship fund is administered by three trustees: the principal of Shasta Union High School, the county superintendent of schools, and a third member to be selected by them. This third member currently is Superior Court Judge Richard B. Eaton. As much as $20,000 has been given in a single year. Beneficiaries of this program who have graduated include doctors, nurses, dentists, ministers, and teachers.

The Grotefend story is in a sense the story of America—thrift, energy, wise investment, and charity. The Division's Grotefend Mineral Collection symbolizes the physical aspect of that story and the George A. Grotefend Scholarship Fund symbolizes its more human aspects. It is hardly possible that the doctor could have left his fortune for a more worthy cause, or a more fitting memorial to perpetuate the name of Grotefend.

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Redding Searchlight, February 22, 1898, page 48.

Henry Carter, personal communication, 1956.

Judge Richard B. Eaton, personal communication, 1965.

Wanda Grooms, personal communication, 1965.

Raymond V. Darby, personal communication, 1966.

The mean velocity of a sound wave in a crystal of quartz is 9,811 miles per hour.

GOWER LEGAL SERVICE ADDED TO LIBRARY

Through the generosity of Mr. Philip R. Bradley, Chairman of the Mining and Geology Board, the Division of Mines and Geology Library in San Francisco is proud to announce that we now have a subscription to the Gower Federal Service in Mining. This publication is specifically devoted to legal decisions concerning mining, and it appears in three sections. Selected decisions of the Bureau of Land Management and Hearing Examiners are printed on white sheets. All opinions of the Solicitor on mining are printed on green sheets. And, from time to time, significant judicial decisions are reported or abstracted; they appear on yellow sheets. A full year's index appears at the end of each year.

A binder containing the 1966 issues will be placed on the DMG Library shelves for public use and study. As new decisions appear, they will be added to those already shelved.

Another set of the decisions, which are published by the Rocky Mountain Mineral Law Foundation at the University of Colorado, will be placed in the Division's Library in Los Angeles. This set is being provided by courtesy of the California Mine Operators Association.

NEW INVENTIONS USE AUTO SCRAP TO OPEN NEW SOURCES OF IRON, ZINC

Two processes that promise increased use of the metal in millions of old autos discarded each year are among new U.S. Bureau of Mines inventions patented by the Department of the Interior.

A less costly method for reclaiming zinc from die-cast zinc-aluminum alloys used for carburetors, trim, and other parts of automobiles is the objective of one invention. Bureau researchers found that an iron compound can be used to convert the aluminum in such alloys to easily separated forms at lower temperatures than are required by the distillation method used conventionally.

Besides reducing the amount of fuel required to reclaim the zinc in relatively pure form, the process yields aluminum chloride as a marketable byproduct.

Also aimed at wider use of scrap automobiles is the process invented by the Bureau for using the metal in them to beneficiate off-grade iron ores which, though abundant domestically, have so far remained unused. These ores, a form of taconite, lack the magnetic property possessed by other taconites now being developed commercially.

In the Bureau's process, scheduled for demonstration-scale tests in the near future, auto scrap conveys magnetic properties to the off-grade ores when mixed with them and roasted in a rotary kiln.

MINERAL RESOURCES OF LIBERIA

By A. E. NYEMA JONES

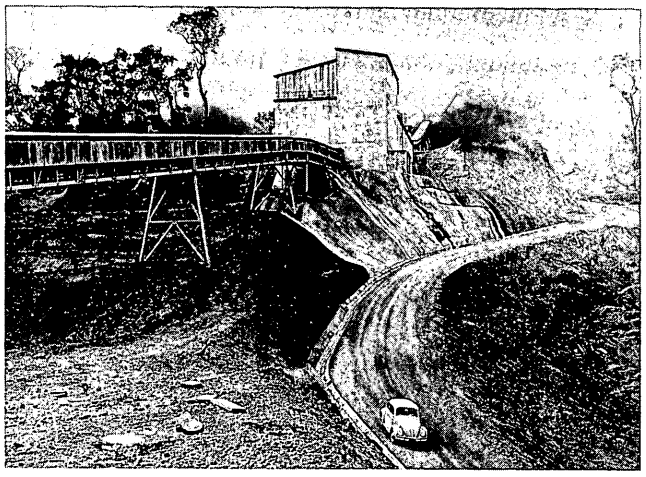
The following article was written especially for this magazine by one of its readers, Dr. Nyema Jones, now Chief of the Liberian Geological Survey, a branch of the Bureau of Natural Resources and Surveys. We thought our other readers would enjoy a brief view of the geology and resources of another country half a globe away.

. . . M. R. H.

Liberia is Africa's first and oldest republic. It lies in the western bulge of the continent, four to eight degrees north of the equator, with an area of 43,000 square miles and a continuous coastline of 350 miles along the Atlantic Ocean.

The Republic of Liberia had its origin in the efforts of several American philanthropic societies to provide an asylum on the west coast of Africa for freed American Negroes. In 1822 a settlement was established at the site where the city of Monrovia now stands, and on July 26, 1847, Liberia was declared an independent state. Its capital city, Monrovia, was named after James Monroe, fifth president of the United States of America.

The Constitution of Liberia provides for a democratic republican form of Government, and is modelled after that of the United States of America. The Government consists of three separate coordinate branches —Legislative, Executive, and Judicial. The country is divided into nine counties and five territories, each administered by a Superintendent appointed by the President of the Nation.



Conveyor belt from mine to railroad loading station at Seca Valley, Nimba, Liberia.

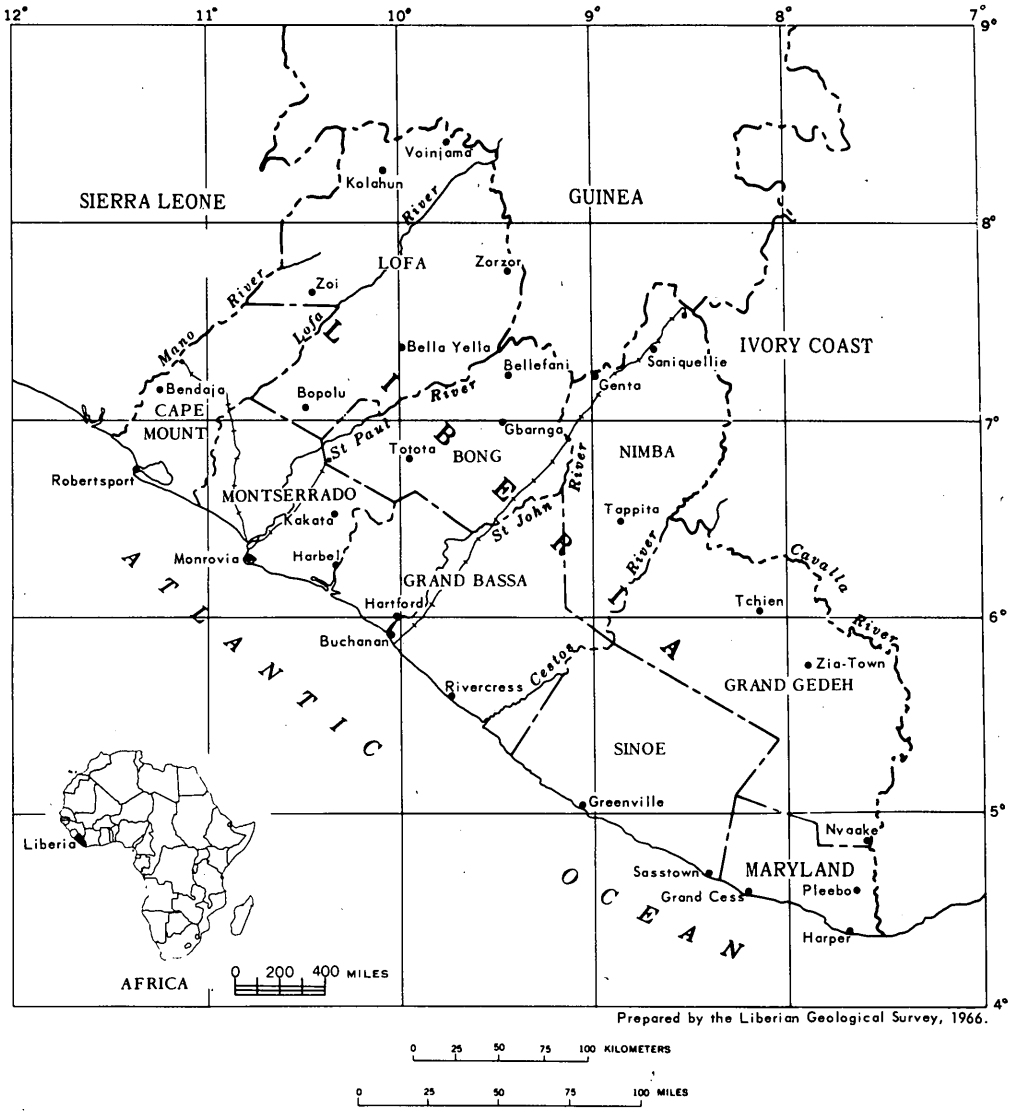
Liberia has a population of approximately one and a half million people. These people are descendants of the early settlers, and of indigenes who lived in that area several centuries ago, some of whom migrated from the north and east. Although relatively small in area, Liberia is occupied by 28 tribes of hospitable and friendly people. Each tribe has its own language, customs, and traditions, but English is the official language and is widely spoken and taught throughout the country.

Geography

Since Liberia is situated in the equatorial rain forest belt of West Africa, its climate is tropical and humid, with alternating dry and rainy seasons of almost equal duration—the former from November to April and the latter from May to October, approximately. The duration of the dry season increases northward with distance from the equator. The average yearly rainfall varies from 80 inches in some parts of the interior to as much as 200 inches at elevated areas on the Atlantic Coast, such as Cape Mount. In the coastal areas there are two weeks of steady sunshine in the middle of the rainy season, known as the "middle dries".

Although Liberia is close to the equator, it does not have the extremely hot and unhealthy climate usually associated with the tropics. On the coast, the climate is tempered by the almost constant seabreeze, while most parts of the interior are cool and comfortable because of the higher altitudes, particularly in the mountainous regions. The relative humidity varies from 60 to 100 percent. Average daily temperatures are 75 to 80 degrees Fahrenheit, with extremes of about 50 degrees and 95 degrees Fahrenheit. The lower temperatures occur during the night. Because the constancy of temperature and the accompanying humidity is favorable to luxuriant plant growth, there is an abundance of evergreen vegetation.

The physiography of Liberia is characterized by coastal plains, rolling hills, dissected plateaus and mountain ranges. Three promontories are in the coastal region, forming capes on the Atlantic Coast. Cape Mount near the Sierra Leone border is 1068 feet above sea level; Cape Mesurado at Monrovia rises to approximately 300 feet, and Cape Palmas near the Ivory Coast border is about 100 feet above sea level. There are several mountain ranges in the country, with the



Index map of Liberia.

highest elevations almost 5000 feet above sea level. The highest mountains are the Wologisi, Nimba, and Bong.

The country is drained by six principal rivers and several smaller rivers which flow from north to south into the Atlantic Ocean. The largest lakes are the Fisherman's Lake in Grand Cape Mount County, and the Shepherd Lake in Maryland County.

Geologic structure

Liberia forms a part of the West African Shield, which is a large Precambrian region consisting predominantly of ancient crystalline rocks. The rocks forming this crystalline shield are a series of granite, gneiss, and schist beds which have been subjected to intense folding and faulting.

With the exception of sandstone beds along the Liberian coast, the rocks comprising the basement complex are of Precambrian age. Iron-bearing formations (itabirites) are interspersed in this basement complex and appear to be a part of the Precambrian formation. The original sediments of the iron-bearing formation have undergone great physical and chemical changes resulting in metamorphosed and migmatized rocks.

Volcanic rocks occur along the coast, forming promontories at Cape Mount, Cape Mesurado, and Cape Palmas. The capital city, Monrovia, is built on a ridge of diabase about four to six miles long by a mile or two wide. Diabase and gabbro occur as basic rock intrusions in the interior of Liberia, forming numerous dikes. Bands of amphibolite which follow the trend of foliation in the gneisses are also common.

The igneous and metamorphic rocks of Liberia have been intensely deformed and metamorphosed by tectonic and metamorphic forces acting on a regional

scale. Some structural features in these rocks are uniform over relatively large areas. Gneissic structure and schistosity dip at high angles in most places and are often vertical. The predominant strike is NE-SW.

More knowledge about the geology of Liberia will be obtained during the course of the joint mapping activities of the Liberian Geological Survey and the United States Geological Survey which are now in progress. It is anticipated that, after 1966, geological maps of sections of the country will be published, and, by 1972, a complete geological map of Liberia will be available.

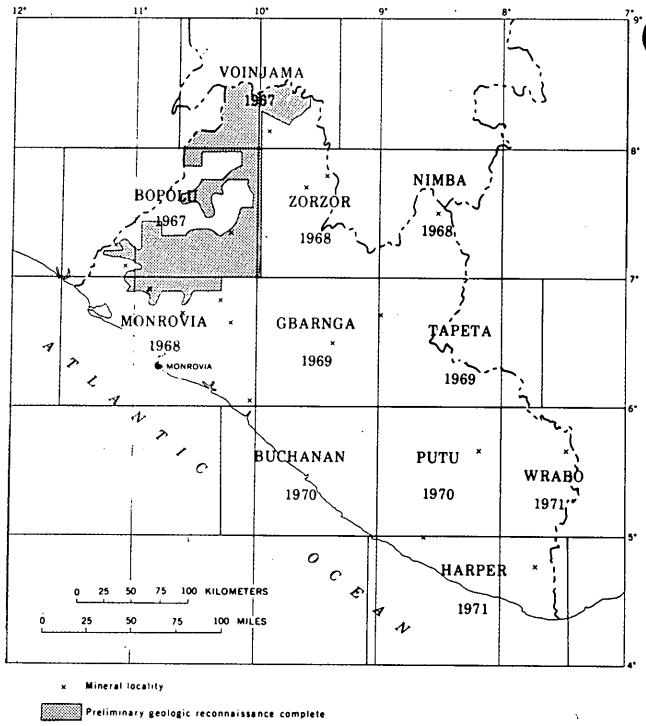
Mineral resources

Liberia is now the largest producer of iron ore on the continent of Africa, and the third largest exporter of iron ore in the world. Gold and diamonds are other minerals which are found in economic quantities and are being extracted for local use and for export. In addition, many other minerals are known to occur in Liberia, but their economic potentials have not yet been determined. These minerals are presently being investigated by geologists of the Liberian Geological Survey and the United States Geological Survey, under a joint geologic mapping and mineral appraisal program.

The following are known mineral occurrences in Liberia:

Asbestos	Kyanite
Barite	Lead
Bauxite	Manganese
Chromite	Mica
Clay	Monazite
Columbite-tantalite	Platinum
Copper	Quartz
Corundum	Rutile
Diamond	Talc
Gold	Tin
Graphite	Tungsten
Ilmenite	Uranium
Iron	Zircon

The Liberian iron ores consist mainly of hematite, magnetite, and itabirite. The Bomi Hills deposit, located about 50 miles northwest of Monrovia, was the first iron ore deposit to be discovered and developed. It contains proven reserves of 50 million tons of high grade magnetite ore yielding 68 to 70 percent pure iron, and 150 million tons yielding 35 to 50 percent. This deposit is being developed by the Liberia Mining Company, which is the pioneer mining company in Liberia. Total exports in 1965 reached two and half million tons.



Index map showing areas of coverage of scale 1:250,000 geologic map series and scheduled completion dates of reconnaissance mapping

The largest iron ore deposit in Liberia is located at Mount Nimba near the Guinea and Ivory Coast border. Total reserves are estimated to be 250 million tons of high grade hematite ore yielding 65 to 69 percent pure iron. In addition, there is a considerable amount of low grade ore. The Nimba deposit is being mined by LAMCO (Liberian American-Swedish Minerals Company). The first iron ore shipment by LAMCO was made in April, 1963. In the year 1964 this company exported six and half million tons of iron ore, and eight million tons in 1965.

Other iron ore deposits of lower grade occur in the Mano River area near the Sierra Leone border, and in the Bong Range, 50 miles northeast of Monrovia. The estimated reserves of iron ore are 50 million tons in the Mano River Mine, and about 250 million tons in the Bong Mine yielding 35 to 45 percent pure iron. The National Iron Ore Company is developing the Mano River deposit. Two and half million tons of iron ore were exported in 1964, and three and half million tons in 1965. The Bong Range deposit, which went into production in April 1965, is being developed by DELIMCO (German Liberian Mining Company). Its export of iron reached three million tons in 1965.

Extensive iron deposits are also known to occur in the Bie Mountains of Grand Cape Mount County and the Wologisi Range in Lofa County. Detailed appraisal of these deposits has been undertaken by the

Railroad loading station at Seca Valley, Nimba, Liberia.

Liberia Mining Company and the Liberian Iron and Steel Corporation, respectively, to determine their economic potential.

Gold and diamonds occur in stream and river beds in various parts of the country. Individual miners are engaged in placer mining by hand methods. Several diamond concessions are engaged in more systematic and productive methods of alluvial mining by mechanical means. Kimberlite, an ultrabasic rock which is believed to be the source rock of most diamonds, has been found in three different areas in Western Liberia. One of these areas is at Weasua, near the Lofa River, where there is much activity in prospecting and mining for diamonds.

Joint mapping project

Under the terms of a project agreement between the Government of Liberia and the United States Agency for International Development, a geologic mapping and mineral appraisal program was initiated in 1964. This program is being implemented jointly by geologists of the Liberian Geological Survey and the U.S. Geological Survey.

The primary objectives of the program are twofold:

(1) To prepare a geological map of Liberia at a scale of 1:250,000 and establish a systematic geological mapping program at larger scales to support detailed mineral exploration.

(2) To evaluate the mineral resources of Liberia and prepare recommendations for future mineral exploration and development.

Aerial photographs and mosaics are utilized in the field as base maps for accomplishing reconnaissance geologic mapping along rivers, foot trails, and motor roads. Traverse lines are cut in areas not accessible by trails and roads. Heavy mineral concentrates, stream sediments, and soil samples are collected systematically for laboratory studies.

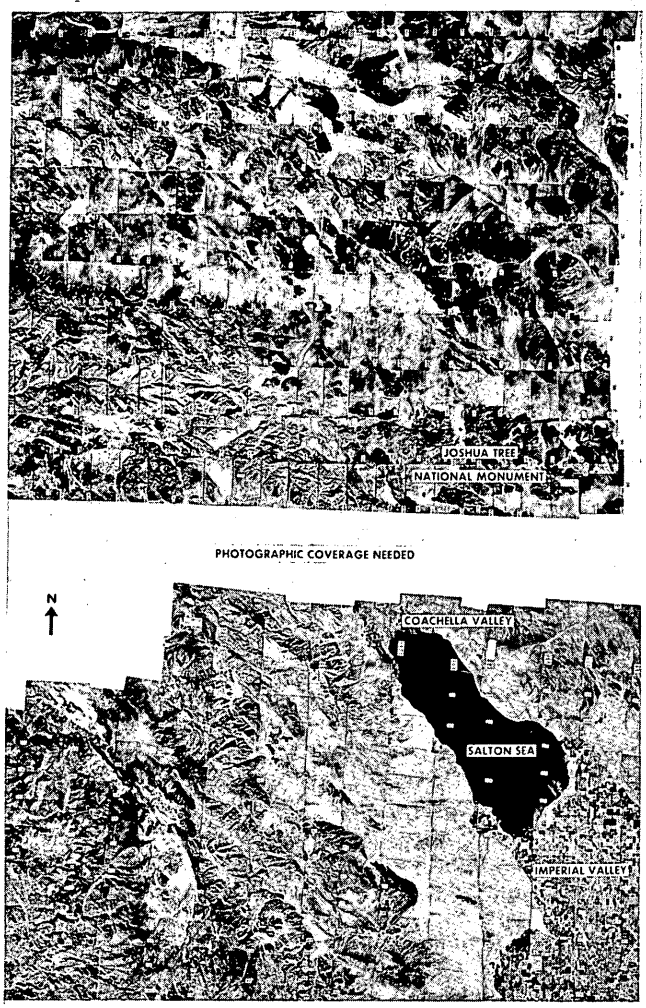
Field methods employed for mineral exploration include conventional prospecting and detailed geologic mapping, as well as geochemical and geophysical exploration. The appropriate techniques are applied if areas of economic mineral interest are found as a result of geologic reconnaissance mapping.

In equatorial rainforest regions such as Liberia, relatively few bedrock exposures are visible due to the dense, luxuriant vegetation and the thick overburden caused by lateritic weathering. The application of geochemical exploration methods under these conditions could result in new mineral discoveries through systematic sampling and analyses of soils, rocks, sediments, and stream water. Geophysical surveys are also applicable, since they serve to detect discontinuities or changes in character of concealed geological formations, and to outline certain mineral bodies which differ in physical properties from their surrounding country rock.

It is anticipated that the implementation of this geological exploration and resources appraisal program will ultimately result in significant new mineral production and mineral industries in Liberia.

Monrovia, Liberia
November 10, 1966

MAPPING BY U. S. SPACECRAFT



Photos courtesy U. S. Geological Survey.

Some of the practical results of the Gemini mission are shown in the two photographs above. To the left is a mosaic of the more than 500 aerial photographs needed to show the area around the Salton Sea and Joshua Tree National Monument. Some of the photographs are missing; the area has not yet been covered by conventional aerial mapping methods.

To the right is the same area, shown in one photograph taken by Gemini. It is not necessary to spend many laborious hours to compile a mosaic; in addition, there are no missing areas.

REVIEWS

VISIBLE GEOLOGY

Geology illustrated. By John S. Shelton. Drawings by Hal Shelton. Published by W. H. Freeman and Company, available at bookstores. 1966. 434 pp. Price $10.00.

An interestingly organized book on "visible" geology. The Shelton brothers, here in concert, have together produced a book that is a new look at old subjects; in addition, it will serve many an author as a good source book for illustrative material, particularly for Dr. John Shelton's air photos.

SOUTHERN CALIFORNIA STUDIED

Engineering geology in southern California was released in October 1966 by the Association of Engineering Geologists. This publication, edited by R. Lung and R. Proctor from 39 contributors, contains a wealth of information pertaining to geologic hazards and problems of interest to engineering geologists working in southern California, including landslides, flood control, earthquakes, faults, nuclear reactor sites, and many more. Numerous case histories of failures due to geologic hazards are detailed in the 389-page volume. Extensive bibliographies are presented at the end of each chapter. Chapter titles are:

1. Earthquakes and faults; 2. Aqueducts, dams and tunnels; 3. Highways and freeways; 4. Landslides and urban development; 5. Legal aspects of engineering geology; 6. Grading Codes; 7. Ground water; 8. Subsidence; 9. Flood control; 10. Marine geology and beach erosion; 11. Foundations, soil mechanics and rock mechanics; 12. Nuclear reactor siting.

Three maps have been prepared to show the major geologic and engineering features, landslides, and soil and bedrock distribution.

Engineering geology in southern California may be purchased from the Association of Engineering Geologists, P.O. Box 21-4164, Sacramento, California 95821. The price is $12.00 plus tax.

The Division of Mines and Geology has copies for reference, but none for sale.

TWO NEW EXPANDED SHALE PLANTS

Stimulation provided by geologists of the Division of Mines and Geology has resulted in the enlargement of the expansible shale industry in the San Francisco Bay Area. Following a comprehensive study of expansible shale deposits in the southern San Francisco Bay area, private prospectors and scientists intensified their search for suitable raw materials to sustain the lightweight aggregate industry in the area.

The result is the establishment of two new expanded shale plants, one to be operated by Kaiser Industries, the other by Port Costa Clay Products Company.

The Kaiser plant is located on a 170-acre site north of State Highway 84 between Fremont and Sunol. A deposit of shale will be quarried on the site and processed through a 4.5 million dollar facility centered around a rotary kiln 11 feet in diameter and 170 feet long. The crude shale is crushed and heated to 2100°F. where it expands to form lightweight aggregate. The Sand and Gravel Division of Kaiser Industries hopes to produce 230,000 yards of aggregate per year which will be marketed under the trade name KI-LITE.

The other new plant has been opened near Port Costa on Carquinez Strait by Port Costa Clay Products Co., a subsidiary of the Homestake Mining Co. The raw material is quarried at the plant site from a thick section of marine shale and sandstone of Cretaceous age which lies between Crockett and Martinez. The plant is fully integrated to produce brick as well as lightweight aggregate for concrete.

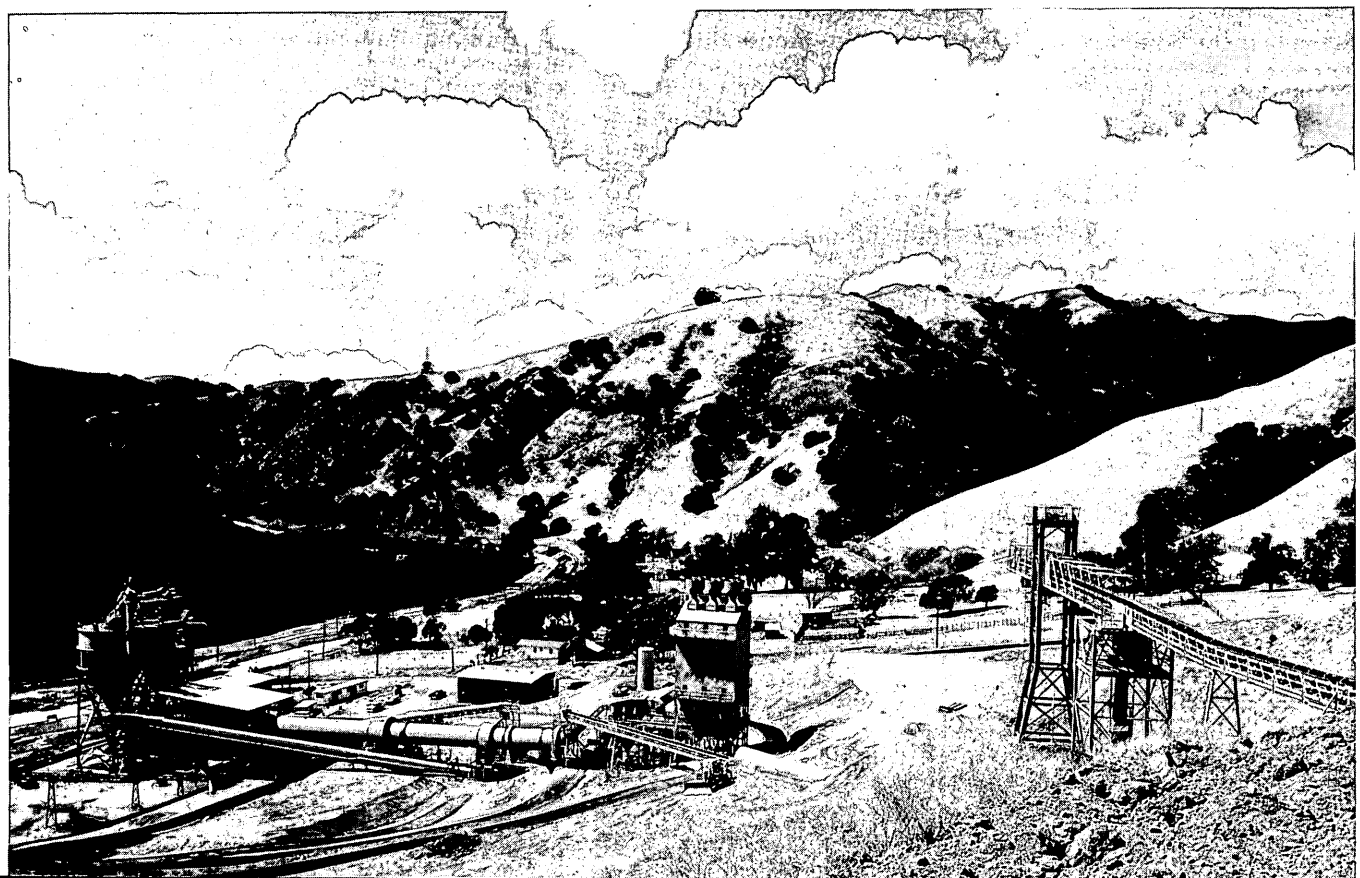
Two other plants have been producing expanded shale aggregate for the Northern California market for many years—the Basalt Rock Company near Napa and the McNear Company at San Rafael.

The results of the intensive study of expansible shale deposits of the area were published in late 1965 by the California Division of Mines and Geology as Special Report 87, written by the principal investigator, staff geologist John L. Burnett.

Special report 87, entitled *Expansible shale resources of the San Jose-Gilroy area, California,* presents an analysis of the marketing economics and raw materials available for the manufacture of lightweight concrete aggregate as well as the field and laboratory methods developed by the Division for appraising deposits of expansible shale.

Copies of the report are still available, and may be ordered by mail from the Division's main office in the Ferry Building, San Francisco 94111, or over-the-counter from any of the branch offices in Sacramento, Redding, or Los Angeles. Its price is $1.50, plus tax.

Kaiser Industries expanded shale plant, Sunol. *Photo courtesy Ki-lite Division, by Kaiser Graphic Arts.*



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WORLD CLIMATE CHANGES RESULTED FROM CONTINENTAL DRIFT

Much of the variation in climate during the geologic past has been caused primarily by the movement of continents across the face of the earth, rather than by worldwide changes in climatic zones, reports Warren Hamilton of the Department of the Interior's Geological Survey.

Dr. Hamilton, who recently completed a study of the earth's ancient climates, supports the theory that continents "drift" about the surface of the earth.

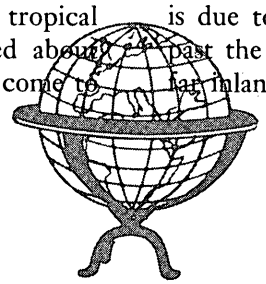
"Each continent," Dr. Hamilton notes, "has its own pattern of climatic variations, rather than a pattern shared with all other continents. Thus, it is likely that climatic zones remain relatively unchanged in width and position, and that the continents have drifted through these zones throughout geologic time."

Past climates are recorded in rock strata by fossils of land plants and marine shells, and by such rocks as the deposits of ancient glaciers and of tropical coral reefs. Tropical climates today are limited to a belt centered on the equator, and the tropical deposits of the past 15 million years show a similar distribution. Farther back in the geologic record, however, tropical deposits become progressively more scattered about the earth, indicating that the continents have come to their present positions gradually and irregularly.

Two hundred and seventy million years ago, tropical coral reefs grew in a warm shallow sea in what are now arctic Canada, Greenland, and Spitzbergen, and at the same time great glacial ice caps covered now-tropical parts of India, Australia, and Africa. Neither reefs nor glaciers could possibly have formed where these lands are now, so the continents must have moved to their present positions.

Dr. Hamilton regards the data now available as proving that continental drift has occurred throughout at least the past half-billion years.

"Early concepts of continental drift such as the development of the Atlantic Ocean by the separation of the Americas from Europe and Africa, and the northward migration of the island continent of India until it collided with Asia, are substantiated by abundant new data," he stated. "In addition, however, we can now define complex bending, breaking, and sliding within continents. The San Andreas fault, whose movement caused the 1906 San Francisco earthquake, is due to the northward sliding of coastal California past the interior, and related motion is distributed as far inland as the Rocky Mountains."



Please send me:

. . . .copies, Special Report 87 (Expansible shale resources of the San Jose-Gilroy area), at $1.50 each, plus tax.

. . . .copies, Bulletin 170 (Geology of southern California), in two cloth-bound volumes, at $13.00 per set.

Please note: Orders for all books and maps to be sent to a California address must include 4% sales tax. There is no tax on subscriptions to *Mineral Information Service*.

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Address orders to the California Division of Mines and Geology, Ferry Building, San Francisco, California 94111. Checks and money orders should be made payable to the Division. No postage is required; please do not send stamps in payment.

TECHNICAL TOOLS USED IN DELINEATING THE GEO-MINERALS PROSPECT NEAR CALICO, CALIFORNIA

The geology of the region was of course one of the basic tools used in delineating our prospect. Geochemically we used two different approaches, both of which work upon gas emanation from the earth's crust which moves at low temperatures through the open pore spaces of rocks and soils from which they can escape directly into the atmosphere. A portion of these escaping gases are caught at the surface boundary layer by primarily ionic bonding in the case of mercury gas and in the case of the so-called hydrocarbon gases by certain bacterial oxidizers.

The mercury halo method was first developed in Russia as a guide to sulfide ore deposits by A. A. Saukov[1] and Nina A. Ozerova[2] and was brought to the attention of Americans by Prof. H. E. Hawkes of the University of California in 1958. Since then a tremendous effort has been mounted in the United States by primarily the U.S. Geological Survey, but also by a number of independent investigators. The first of the American papers to be published on this method was by Hawkes and Williston[3]; also the classic publication by Hawkes and Webb[4], Geochemistry in Mineral Exploration in 1962; the next was by S. H. Williston[5] in May of 1964. Starting in the fall of 1964, Vaughn & McCarthy[6] published their classic on instrumental technique for the determination of sub-microgram concentrations of mercury in soils, rocks and gas. In 1965, Gott and McCarthy[7] published their map of Lenado Aspen Quadrangle, Colorado, U.S.G.S. open file report, and also the fact that mercury seems to be associated with all of the epithermal metal deposits studied to date by them, including poly-metallic deposits in the Ely, Nevada and Park City, Utah, area; silver deposits at Hamilton, Nevada, and the gold deposits at Cripple Creek, Colorado. Jolly and Heyl[8] indicate that mercury anomalies may show concealed base metal deposits. McCarthy[9] showed that in 93 samples of Jasperoid from 22 areas, including 14 mining districts, that he analyzed for mercury, that in order of decreasing affinity they showed a statistically significant association with silver, lead, copper, tellurium, zinc, antimony, arsenic, bismuth and molybdenum.

In 1966 Erickson, et al.[10], Gold Geochemical Anomaly in the Cortez District, Nevada; Gott and McCarthy[11], Distribution of Gold, Silver, Tellurium, and Mercury in the Ely Mining District, White Pine County, Nevada; McCarthy, et al.[12], in the Geochemistry portion of Mineral Resources of the San Rafael Primitive Area, California; Cornwall and Stager[13], Silver and Mercury Soil Anomalies in the Tonopah and Virginia City Districts, Nevada; Friedrich and Hawkes[14], Mercury as an Ore Guide in the Pachuca-Real del Monte district, Hidalgo, Mexico; Dinnin and Worthing[15], Determination of Microquantities of Mercury in Sulfide Ores by Penfield Tube-dithizone and Semiquantitative Spectrographic Methods; Warren and Delavault[16], Some Observations on the Geochemistry of Mercury as applied to Prospecting;

Erickson[17], Trace Metals associated with Gold Deposits; and Friedrich and Hawkes[18], Mercury Dispersion Halos as Ore Guides for Massive Sulfide Deposits, West Shasta District, California.

In 1967, W. W. Vaughn[19] published an outstanding paper on a mercury detector entitled: "A Simple Mercury Vapor Detector for Geochemical Prospecting."

While this list of references is not complete, it is believed to encompass sufficient to allow the reader a good background in the mercury halo method of exploration. The U.S. Geological Survey's personnel that have been working upon the mercury halo method of exploration, should receive great credit for causing to be made the first discovery of a metal using this method in the United States, with the discovery by the Cortez joint venture group of gold at Cortez, Nevada, as shown on Page 126, Engineering and Mining Journal, April, 1967. This discovery is the result of U.S.G.S. Circular #534, 1966.

Our method which we have designated "Geo-Merc"[20] is based on the amalgamation of mercury to gold, and the equipment we use is somewhat similar to W. W. Vaughn's vapor detector shown in U.S. Geological Survey Circular #540. We have found that all of the major mercury mines in California and those gold and silver mines we have run, as well as the tungsten deposits at Atolia, have given clear anomalies using the Geo-Merc method. We have also compared our method with the U.S.G.S. findings in the San Rafael primitive area[12] and find that it compares within 10% in parts per million of mercury that they found. Thus we know our instrument is at least comparable to the U.S.G.S. instrument. All of our samples are taken at the surface of the ground unless special surveys were run, and to the best of our knowledge the U.S.G.S. samples also were taken at the surface. The foregoing is mentioned because of the tremendously high anomaly that we have developed over our Cook and Roberts claims near Calico, as shown on Plate X. Plate XI shows the results of reconnaissance surveying off the Geo-Minerals Company's claims in the Calico area. Plate XII shows comparison of surface and subsurface results at varying depths taken at varying dates on the Geo-Minerals Company's claims. The reason for this special survey was to see if the anomaly was confirmed by subsurface sampling as well as at the surface. The subsurface data is clearly anomalous and thus confirms the anomaly from surface sampling.

For those unfamiliar with the mercury halo method, we quote herewith a portion of Williston's[5] classic paper on this method of exploration:

"The original theory of mercury association with other sulphide minerals was a very logical one and subsequent developments have shown that this association is almost universal. A study of gas emanation from volcanos shows associated mercury vapor almost regardless of the type of material, whether acid, basic or intermediate lavas. We must assume, then, that any ore deposits developed from such magmas should have some

mercury associated with them. Since mercury deposits are always low-temperature deposits, we would expect mercury vapors or solutions to precede other types of ore deposition but, nevertheless, to leave traces behind which should be associated with minerals normally considered of much higher temperatures.

"Once deposited as veins or stock works, the higher temperatures of later additions to the same deposit would tend to drive the mercury farther away both radially and vertically from the point of its original "hesitation."

"Again, at the termination of the formation of the main sulphide deposit, as temperatures fell we might again expect conditions more favorable to the deposition of any residual mercury which might be available.

"Once deposited, these sulphides are subject to alteration by surface waters; and mercury, while not a noble metal, lies close to them in the sequence of the elements. Any oxidation of the sulphur combined with the mercury leaves the metal in such a state that the high vapor pressure of mercury becomes effective.

"As is well known, mercury will evaporate at room temperatures in considerable amounts; consequently, the vapor of the metal will follow any porous voids above an ore deposit. What is less known is that mercury is very soluble even in distilled water. Thus, depending upon the temperature of the metal and the temperature of the water, if a few beads of mercury are placed in distilled water and the container corked up, the air above the water will become saturated with mercury vapor. Hence, a layer of water over the ore deposit is no barrier whatsoever to the migration of the mercury. Further, fine-grain silicas and clays and many other soil constituents readily absorb mercury from the air and from water solutions. The tightness of the bond is dependent on several factors, and much work remains to be done on the migration of absorbed metal.

"LARGER TARGETS FOR DISCOVERY. On near surface soil samples, enough work has been done to indicate that there is some variation of absolute value, though not of relative value, depending on weather and temperature conditions. Since mercury can thus migrate at ordinary temperatures and apparently over long distances, it provides larger targets for discovery than some of the other geochemical methods.

"Russian experiments, confirmed in the U.S., indicate that large anomalies extending out considerable distances from the actual ore deposit can be expected. Thus, the anomaly connected with the Comstock Lode in Nevada extends at least two miles, and probably more, away from the lode.

"Average background of mercury in rocks and soils varies somewhat

area by area. Hence, that part of California underlain by the Franciscan has a high general mercury content. Nevada backgrounds are considerably lower, normally 20 to 30 ppb. Backgrounds in Idaho are frequently lower still, on the order of 5 to 10 ppb. To date, however, we have found no area within the U.S. which does not carry some mercury in the surface soils. The Russians have found, and we have confirmed in this country, the association of mercury with all silver deposits, almost all lead deposits, all zinc deposits except the carbonate, all antimony deposits, some coppers, all low temperature tungsten deposits, and those molybdenum and gold deposits we have checked. The Russians report, and we have confirmed, the association of mercury with at least some pegmatites.

"In general, the lower the temperature of deposition of the material the higher the mercury content in the ore and the higher and broader the surface anomaly. The older the deposit and the lower the content of the mercury in the ore, and the higher the temperature of the original deposition, then the lower the mercury content becomes and the surface expression gives less contrast to background and, presumably, less width of anomaly.

"Russian experience in comparison with ordinary geochemical analyses for copper, lead and zinc, indicates that mercury halos extend out for more than a kilometer. However, the lead, zinc and copper anomalies are closely confined to the area of the deposit, consequently not much wider than the mineralization itself. Sufficient work has not been done in this country to ascertain whether it always holds true here as well, although preliminary work would seem to indicate that this is true.

"Mercury profiles across hot springs in the western states indicate that, in most cases, mercury abnormalities are associated with the hot springs. There is considerable variation in size of these anomalies; and, in most cases, they are relatively small. But it might be assumed that mercury analyses might be quite helpful in ascertaining the depth from which the hot water might come.

"The type of analytical procedure necessary for the detection of mercury depends greatly on the background concentrations with which one is faced."

From the foregoing, we hope, and it has been made evident, that these mercury gases emanate from the metal deposits themselves and are thus a more reliable geochemical indicator of the total ore deposit at depth than surface sampling of mineral flows.

The second tool that we used was our Geo-Pulse[21], which is an instrument that reads the paraffin dirt content of soils. This paraffin dirt which is everywhere in soils is especially concentrated over areas where hydrocarbon gases such as hydrogen, hydrogen sulfide, methane, ethane, propane, etc. are coming to the surface. The first person to use this type of tool in hard rock country was McDermott[22] when he made

a brief reconnaissance across the faulting in the Mother Lode of the Sierra Nevadas. To the best of our knowledge, we are the first people to apply this tool to the location of mineral deposits. The most comprehensive review of this subject has just been published by J. B. Davis[23] and should be read for a thorough understanding of this method. Included herewith are our Plates No. XIII and XIV, which give the results of our Geo-Pulse survey in the area. Lines 2, 3 and 4, Plate XIII, are clearly anomalous, and the peaks as shown on Plate XIV probably represent faulting.

That desert soils have microenvironments, has been clearly shown by R. E. Cameron[24] in his publication. We have found that there is a biocoenose everywhere in the desert which is carrying the aerobic bacteria that we use in our Geo-Pulse method. These range from a very small amount to a surprisingly large amount over gas leakages from the subsurface.

In addition, a geophysical survey employing a resistivity method was made. The details of which follow:

"During the period of May 28 to 30, 1966 a series of ground resistivity tests were made in the subject area (Cook Claim). The equipment used consisted of a simple power amplifier with an RC feedback circuit such that the amplifier oscilated at approximately 1 kc. A signal of 25 to 30 volts rms was delivered to the electrode system. This voltage was monitored with a VTVM. The resistance of the electrode system for the signal source was measured using a simple volt-ohmeter (Simpson Model 260). The signal source electrodes were 1/2" diameter 3' long steel stakes. The resistance between electrodes ranged from 750 to 1500 ohms. Several sending electrode configurations were tested. The most effective consisted of three electrodes in parallel (200' separation) at each pole. The poles were separated by 2000'. The detection electrodes were single iron posts 1/2" dia. and also 3' long. The region where measurements were made was approximately midway between the signal source electrodes. A Volkers Hushed amplifier capable of 3 microvolts rms full scale at maximum sensitivity and an input impedance of 100,000 ohms minimum. Electrode voltage with and without the ground signal was measured at each test station. Two methods of observation were used. Initially, observations were made at successive 100 foot intervals along the signal electrode line. Subsequently, after the large triple signal electrode with 2000 feet spacing had been installed a series of measurements were made using receiving electrodes spaced at 10, 30, 50, 70, 90, 110 feet spacing about a given point. Observations were made on the line between the signal source electrodes and 100 feet above and below this line. In addition, one other sequence of measurements were made in the northwest corner of the Cook claim.

"The RMS value of the signal for each measurement was computed by subtracting the square of the noise value from the square of the signal plus noise measurement and finding the square root of this difference. In order to account for the difference in spacing of the measurement electrodes, the signal value was divided by the spacing between the receiving electrodes;

thus a value of volts per foot was obtained. These values are plotted against the electrode spacing. In the absence of laterally located discontinuities, the spacing of the receiving electrodes is proportional to the depth of penetration of the measured signal. A discontinuity in the volts/foot is indicative of a change resistivity of the structure at a depth approximately at the indication of the discontinuity.

"The attached plates Nos. XV, XVI, XVII and XVIII indicate the location of the various test points and the succeeding plate graphs are the volts/foot as discussed above. The indications of these few measurements are that there is some form of resistivity approximately 90-100 feet below the surface. The conductivity at this level drops to a value almost a decade less than that at the top levels.

"From the data obtained herein and the other information from the geochemical surveys, and the hydrology, it is my belief that this resistivity anomaly is probably a water interface, although there is an outside possibility that it could be some form of mineralization."

(Memorandum to: H. S. Cook, Jr. - From: Eric G. Laue
Dated 4 July, 1966)

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GEO-MERQ ~~YERMO~~ QUAD T 10 N, R 1 E

PLATE X

ALL TEST VALUES IN PARTS PER MILLION OF MERCURY (PPM OF Hg.)

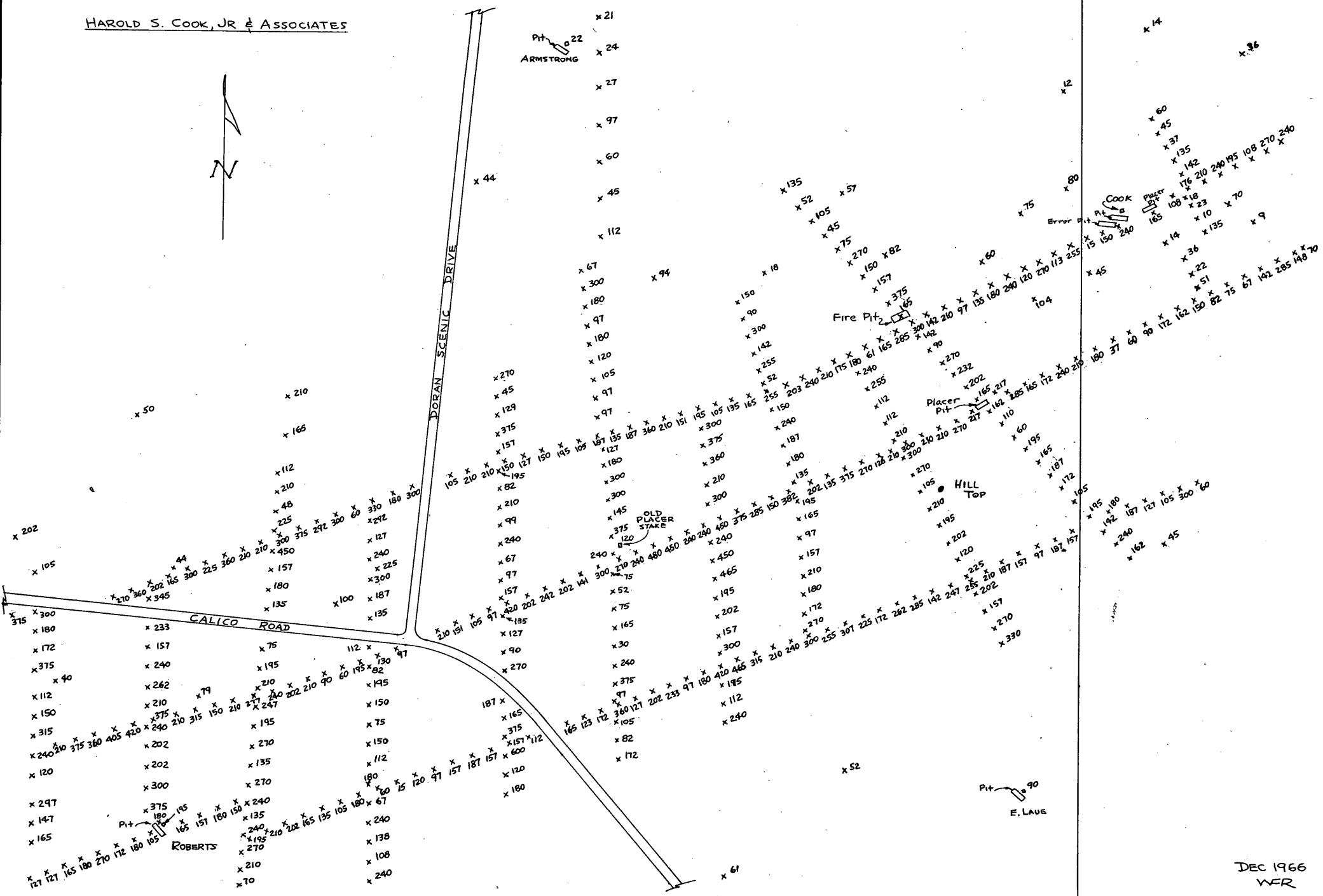
SECTION 22 23

SCALE 1:1,000

MILE 0 .05 .10 .15 .20

FEET 0 100 200 300 400 500 1000

HAROLD S. COOK, JR & ASSOCIATES



DEC 1966
WFR

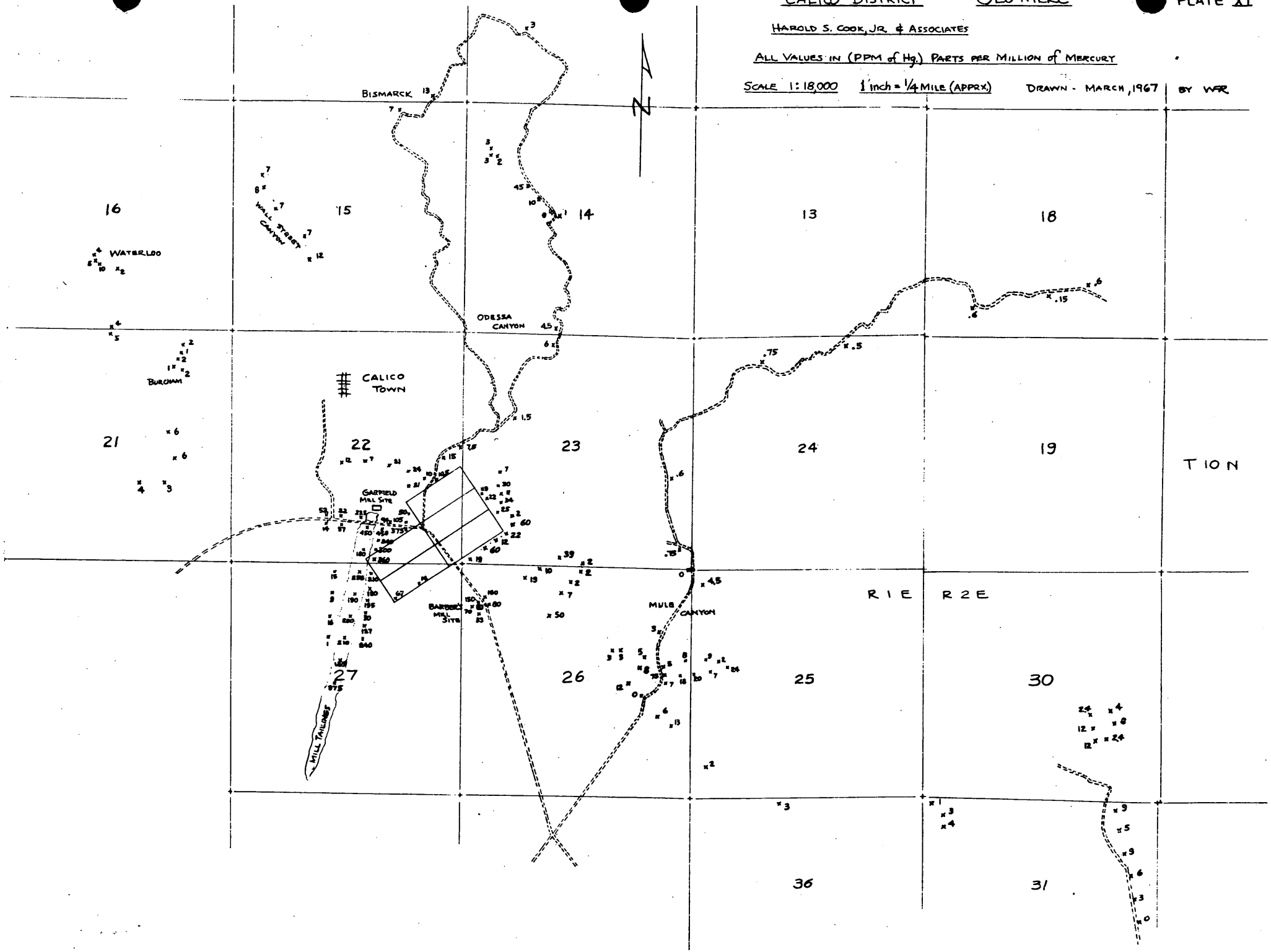
CALICO DISTRICT GEO MERC

PLATE XI

HAROLD S. COOK, JR. & ASSOCIATES

ALL VALUES IN (PPM of Hg.) PARTS PER MILLION of MERCURY

SCALE 1:18,000 1 inch = 1/4 MILE (APPRX.) DRAWN - MARCH, 1967 BY WFR



GEO MERC

YERMO QUAD. T 10 N, R 1 E

HAROLD S. COOK JR. & ASSOCIATES

PLATE XII

SURFACE AND SUB-SURFACE RESULTS ~ (PPM) PARTS PER MILLION of Hg.

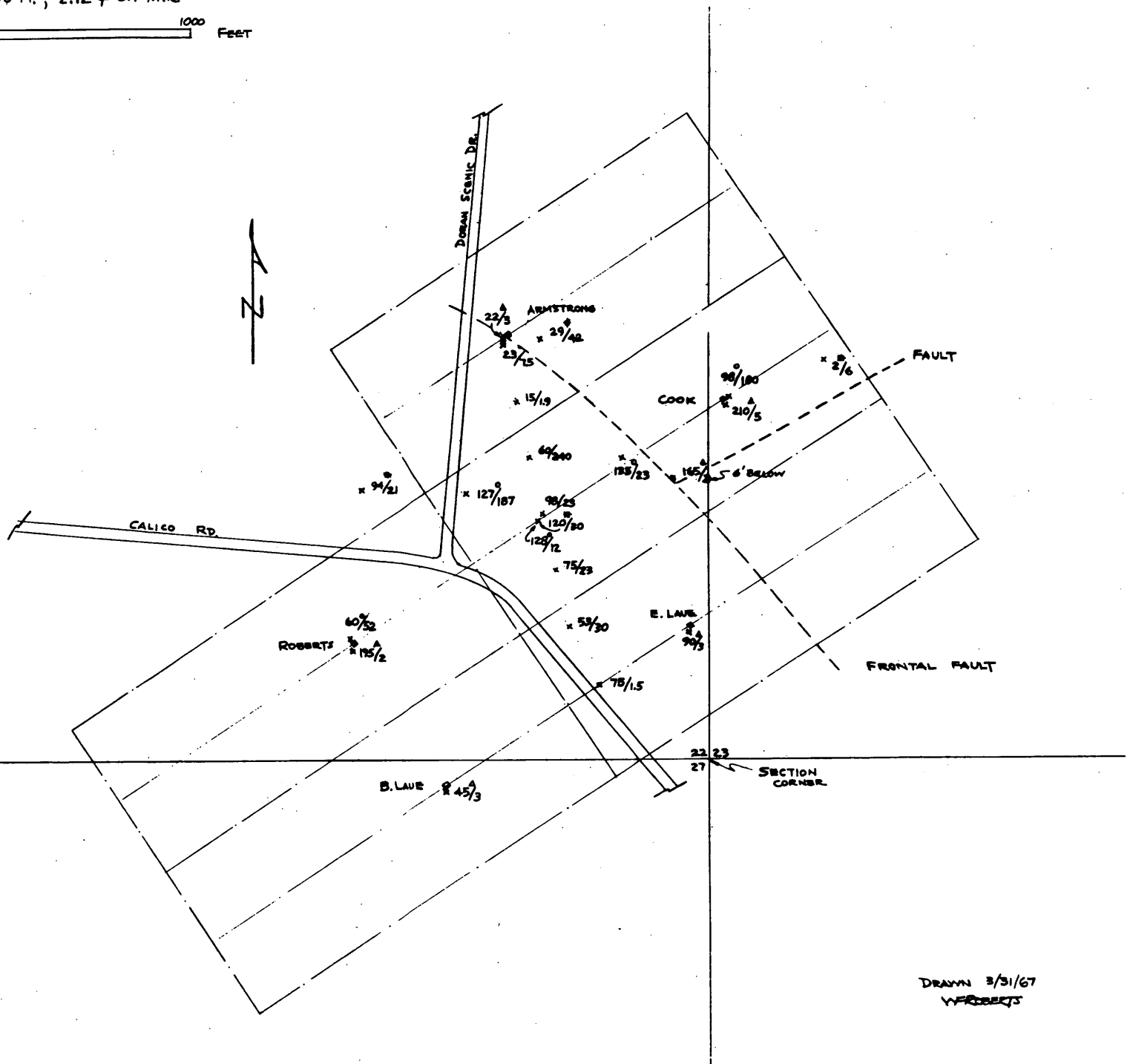
SPECIAL SURVEY

SCALE 1:3,000 1.00" = 250 ft., 2.12" = 0.1 Mile

1000 750 500 250 0 1000 FEET

SYMBOL IDENTIFICATION

- ⊡ = DISCOVERY MONUMENT
- X = SAMPLE LOCATION
- 32/6 = SURFACE/15"-18" BELOW FEB. 1966
- 200/8 = SURFACE/PIT 10' BELOW (UNLESS NOTED) APRIL 1966
- 120/30 = SURFACE/12" BELOW JAN. 1967
- 150/25 = SURFACE/12"-15" BELOW MARCH 1967
- —·—·— = LODE BOUNDARY



DRAWN 3/31/67
W.F. ROBERTS

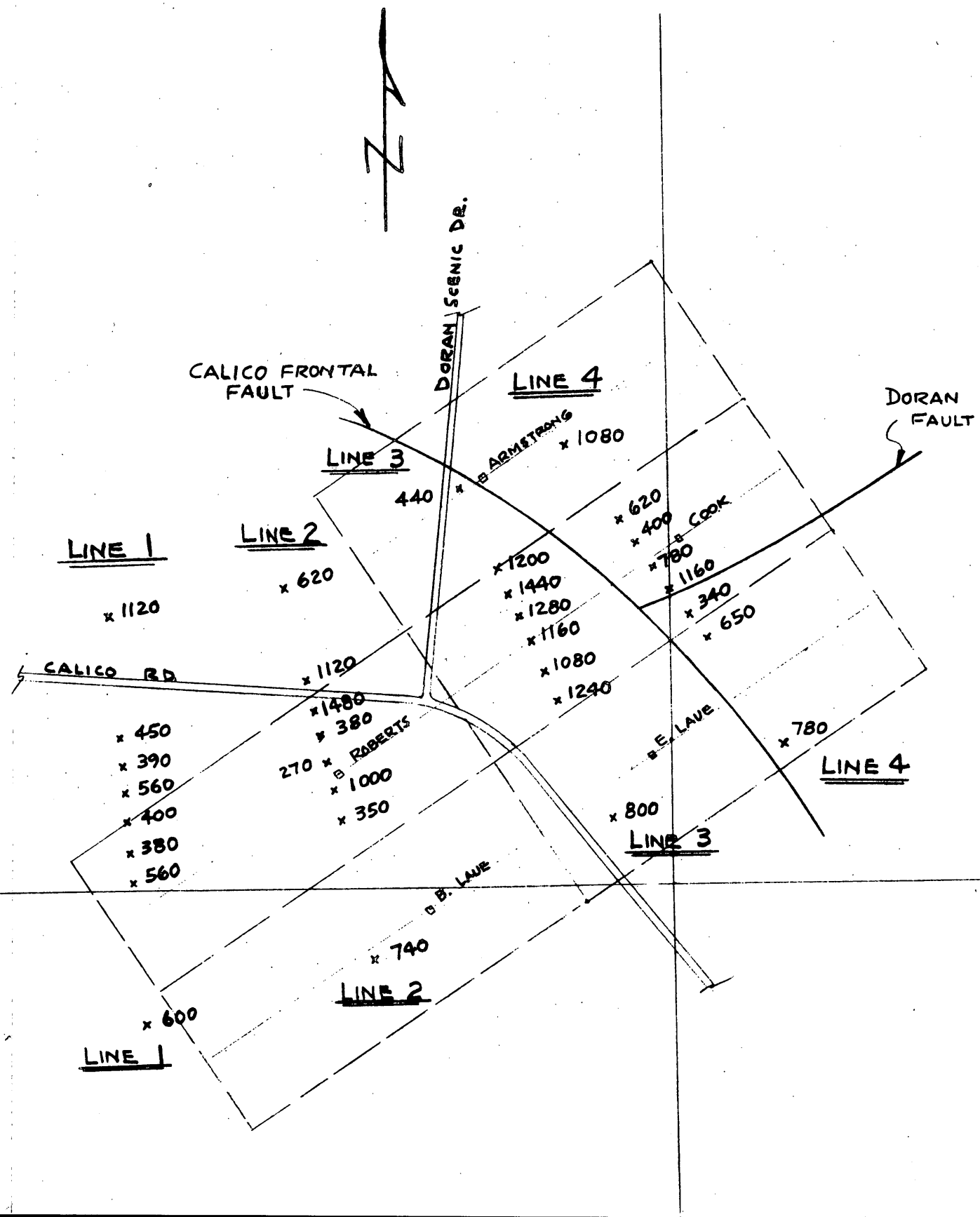
PLATE XIII

GEO PULSE SURVEY

GEOMINERAL CO'S CLAIMS ~ YERMO QUAD T. 10 N., R. 1 E.

HAROLD S. COOK JR. & ASSOC. SCALE 1" = 500' APPRX.

SAMPLES TAKEN NOV. 19 & 20, 1966



GEOPULSE SURVEY ~ GEOMINERAL CO. CLAIMS

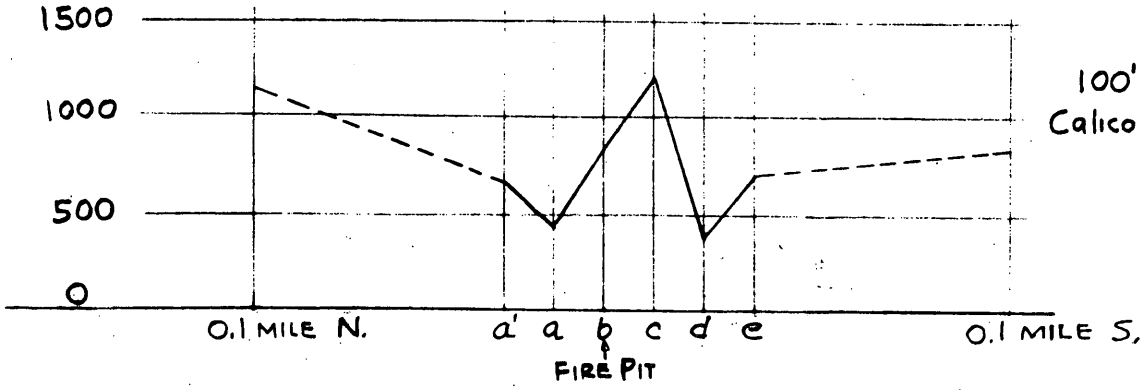
PLATE XIV

PROFILE of RESULTS

SCALE 1" = 400'

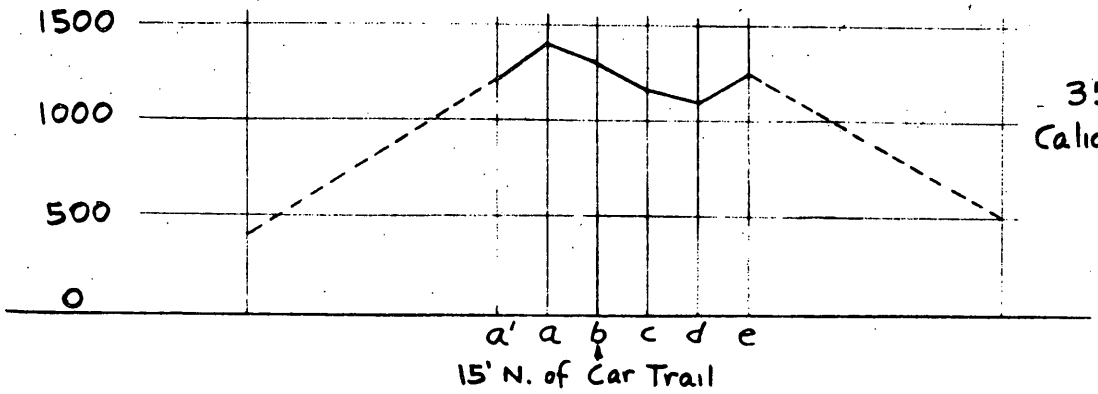
GEOPULSE VALUES

TEST LINE LOCATION



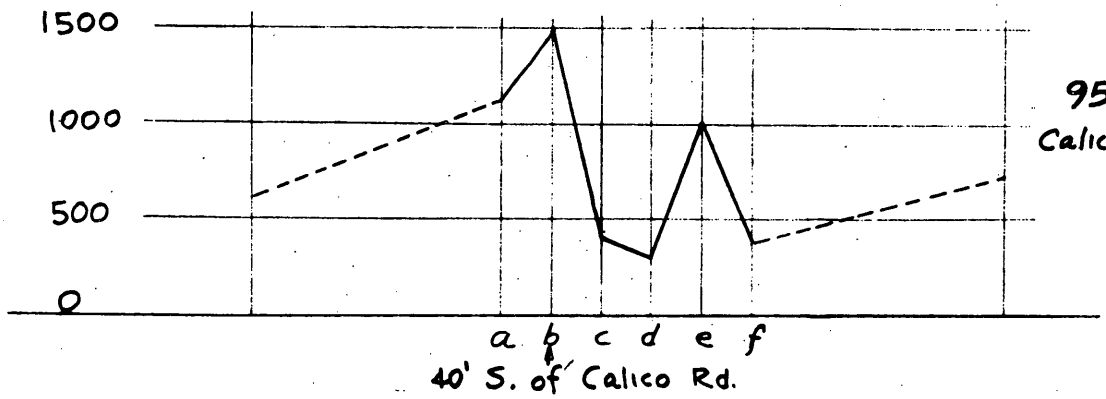
LINE 4

100' N.E.
Calico Frontal Fault



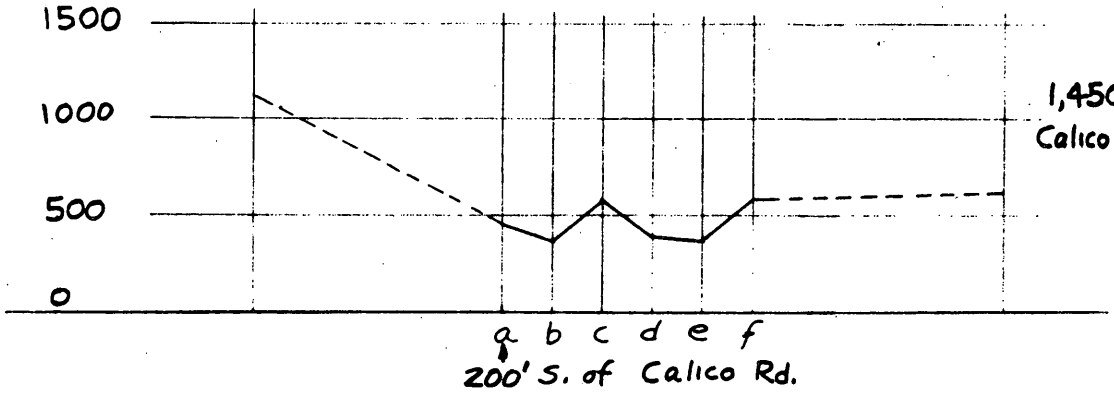
LINE 3

350' S.W.
Calico Frontal Fault



LINE 2

950' S.W.
Calico Frontal Fault



LINE 1

1,450' S.W.
Calico Frontal Fault

LINES 3 & 4 on Cook lode claim
LINES 1 & 2 on Roberts lode claim

ELECTRICAL RESISTIVITY TEST LOCATIONS

PLATE XV

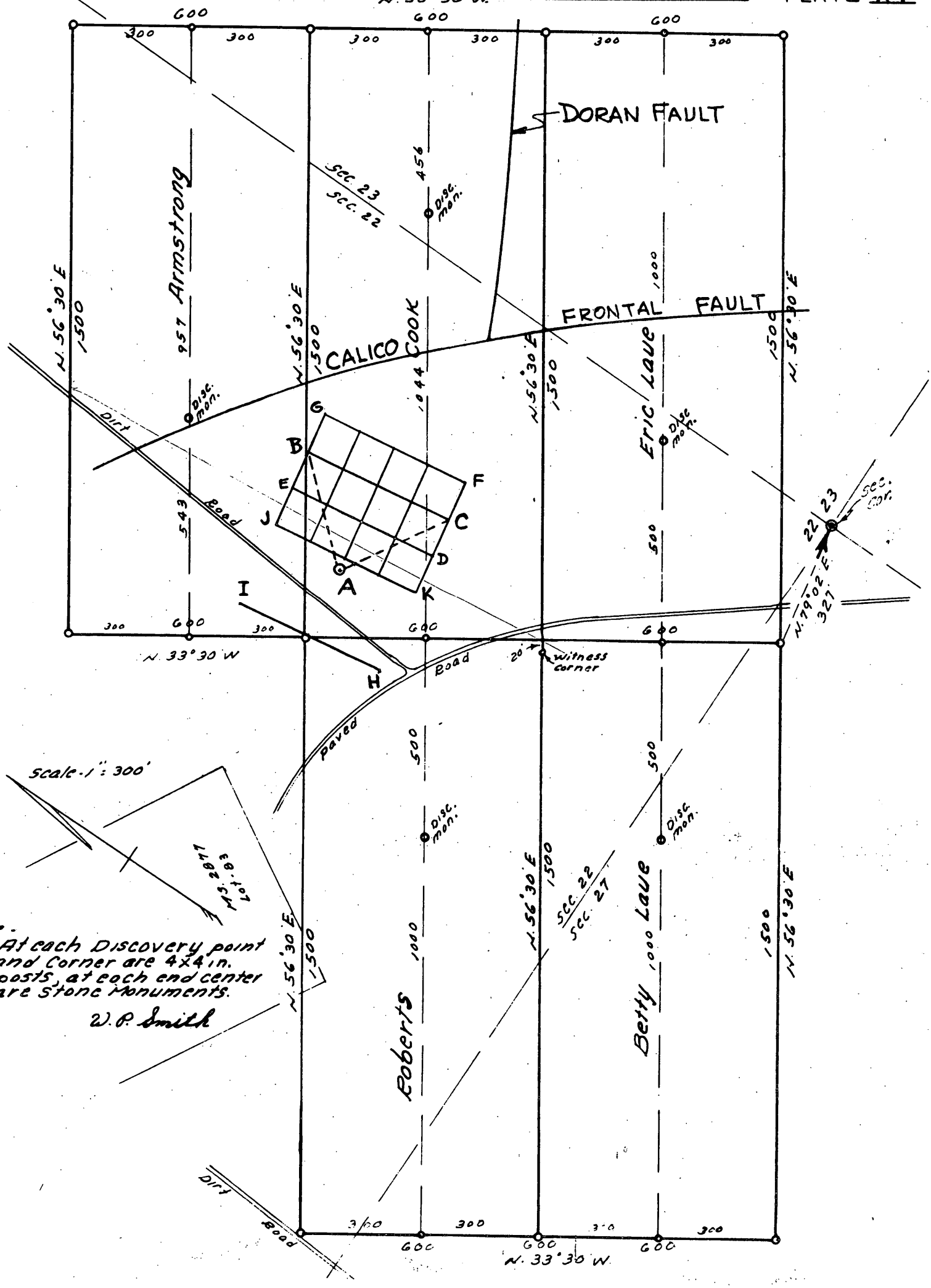


PLATE XVI

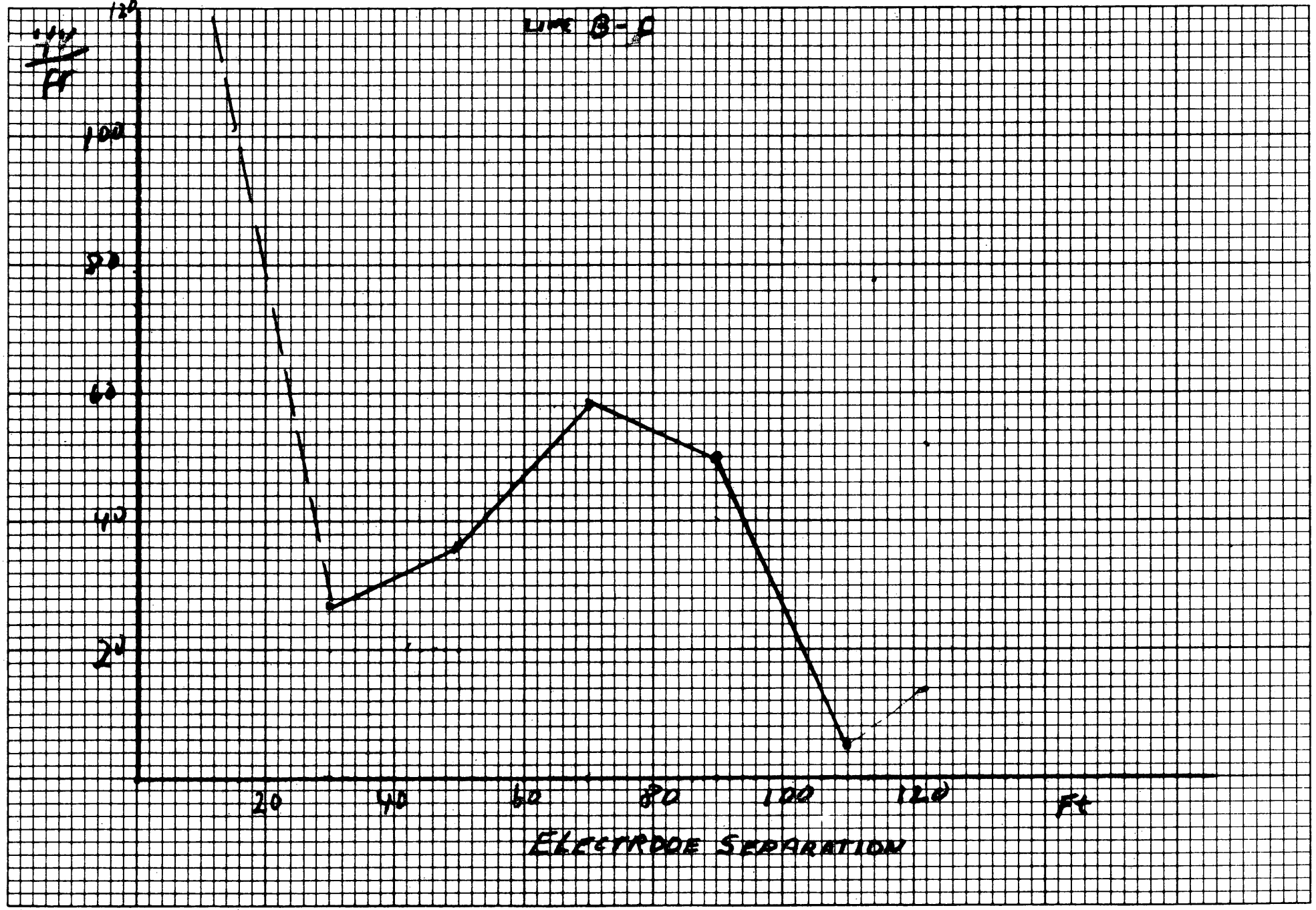

LINE B-C
120
100
80
60
40
20
20
40
60
80
100
120
Ft
ELECTRODE SEPARATION

PLATE XVII

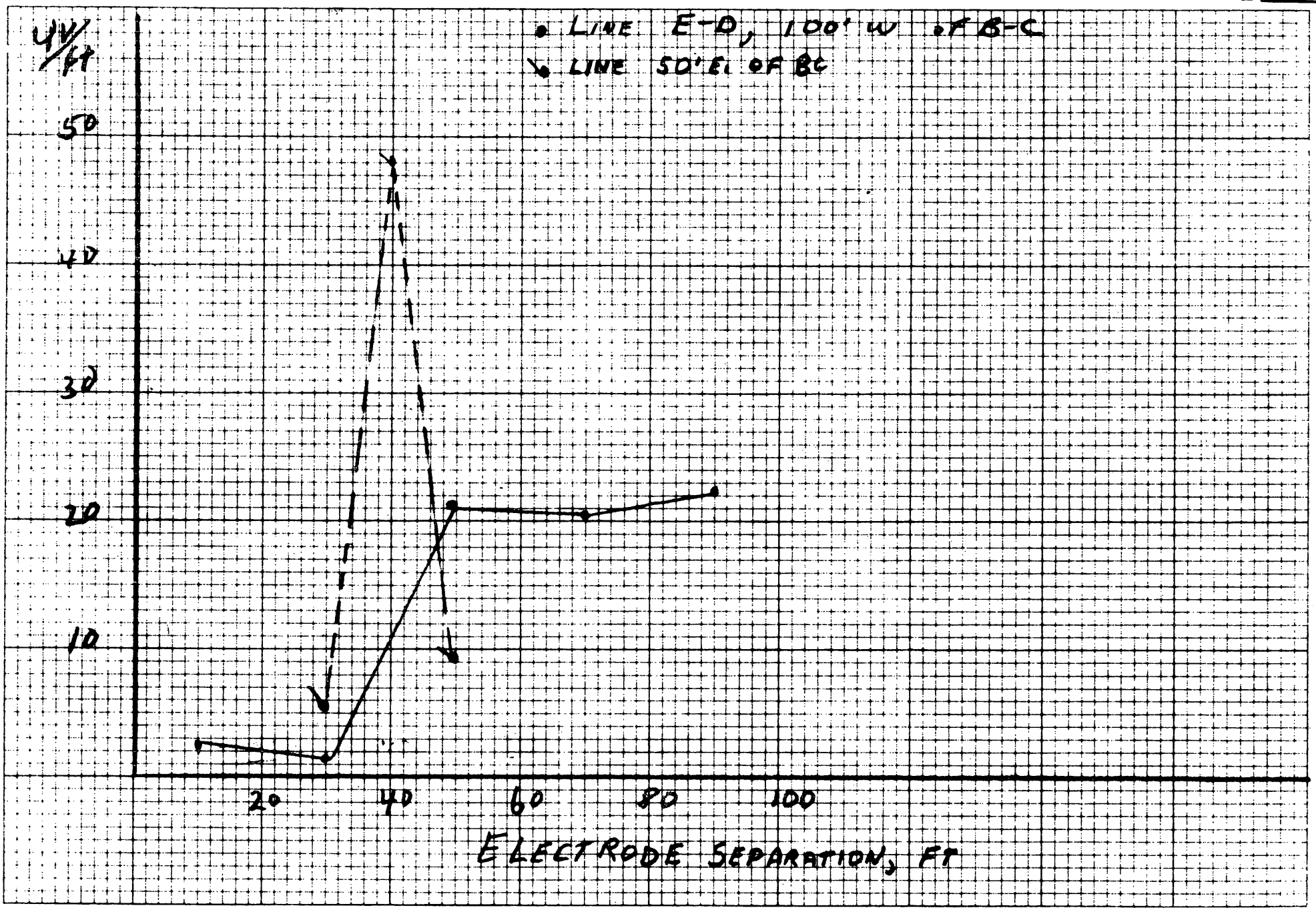
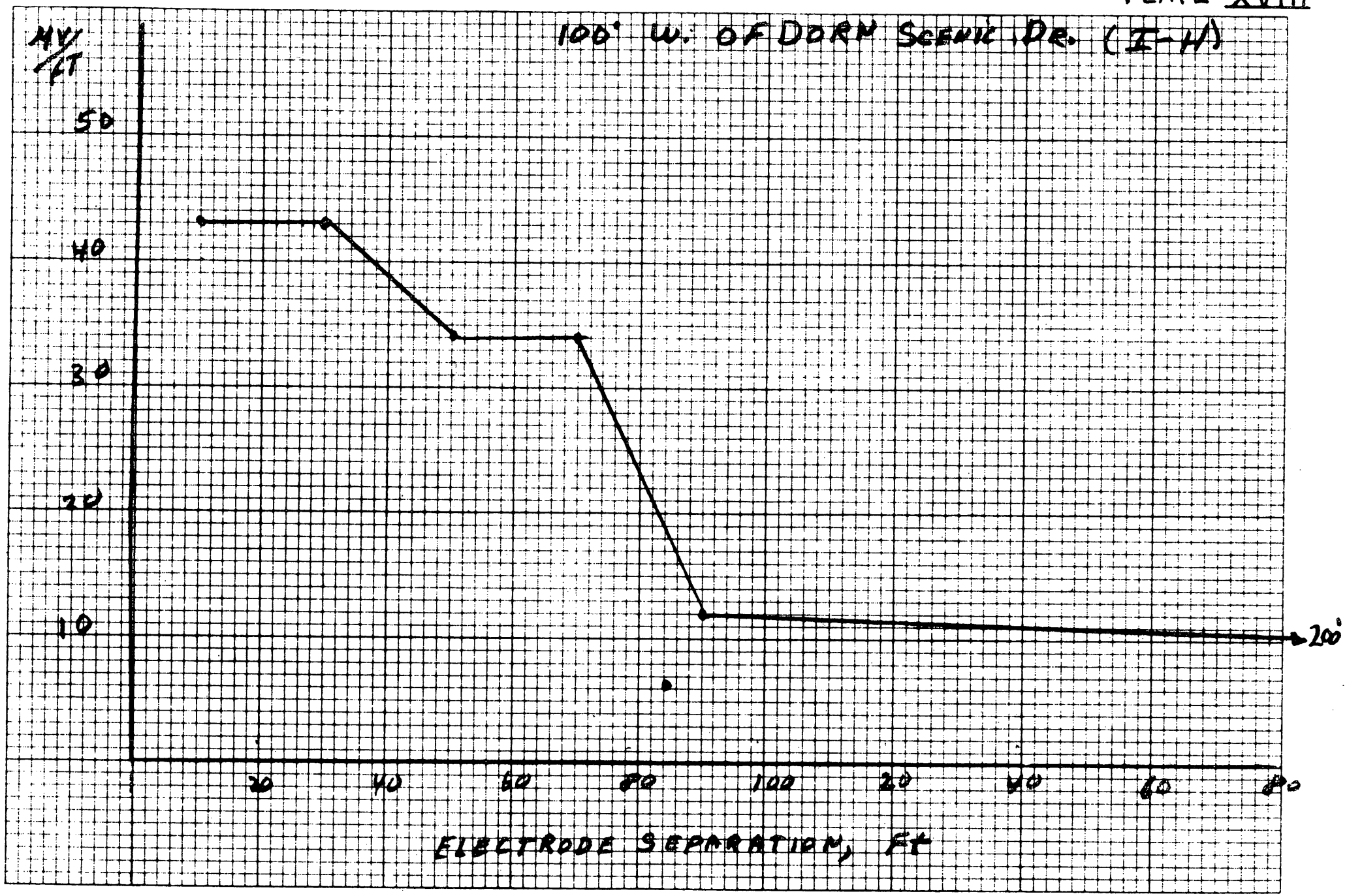

μV/FT
50
40
30
20
10
• LINE E-D, 100' W OF B-C
↘ LINE 50' E. OF BC
20
40
60
80
100
ELECTRODE SEPARATION, FT

PLATE XVIII


100' W. OF DORN SCENIC DR. (I-H)
MV/FT
50
40
30
20
10
20
40
60
80
100
20
40
60
80
200'
ELECTRODE SEPARATION, Ft

PROBLEMS

The following problems have effected the situation in our lode claim filings in the Calico area:

1. The legal situation brought about by the Bureau of Land Management's decision in regards to a portion of our claims. Present policy in the United States does not seem to favor adequate mineral development and the results therefrom have been to make the United States a net importer of almost all minerals with a detrimental effect upon our balance of payments. A most important task before all of us involved in the mineral business is to attempt to educate and change the existing policy.

2. The second problem that effects all mineral explorations is that no definitive tool has yet been developed that will give us sure knowledge of the depth from the surface to the top of a mineralized zone.

3. Shown herewith, as Exhibit "C", is a letter from our consultant, Mr. D. L. Gardner, in which he clearly indicates that he feels the anomaly developed on the Geomineral claim is salted due to aeolian blowing of a portion <u>only</u> of the tailings pile from the Garfield mill. It is with regret that we must disagree in large part with Mr. Gardner's conclusions, and our reasons are as follows:

a. Why would only a portion of the tailings pile be blown eastward?

b. The Geomorphology of Aeolian deposits in general are always advanced on a broad front, and that this is true in the Mojave desert region is clearly shown in U.S.G.S. Water Supply paper #578, plate 8 by D. G. Thompson, (1929). That this did not happen in the area is clearly shown by our geochemical surveys. The reader should note that our anomaly is approximately 500 feet in width, the tailings pile which is athwart our claims is around 7,500 feet in length and the same winds effect all of the tailings pile area. The winds would be a little stronger as you proceeded down the tailings pile, because of the fact that it is more fully exposed to the winds of the lower Mojave valley. (See Plate XI)

c. We cannot believe that it would be possible for higher geochemical values to be shown eastward of the tailings pile than exist on the tailings pile (see Plates X and XI). Additionally, we surveyed geochemically the tailings pile at the Barber's mill, which is also shown on Plate XI and the Oro Grande (later Waterloo Mining Co.) mill near Daggett where the prevailing winds are similar to the

Garfield mill, neither of which show a situation similar to the one that Gardner claims happened from the Garfield mill tailings pile. The results of the Oro Grande mill survey at Daggett may be inspected at this office.

d. What we believe might possibly have happened is that a small portion of the southwestward part of the Roberts' claim may be salted and some of the extremely high anomalous values shown eastward on the balance of the Roberts and Cook claims may be very slightly salted, although we have very serious doubts of this hypothesis.

EXHIBIT "C"

December 27, 1966

Mr. Harold S. Cook
805 Subway Terminal Building
417 South Hill
Los Angeles 13, California

Dear Mr. Cook:

You have asked me to formalize my opinion regarding your claim group in Section 23 of the Calico Mountain area, on the slope to the east of the Silver King Mill (1), and its thousands of tons of tailings, all treated with the "Boss process" (Ibid p. 74). This involves amalgamation with mercury. In this process, it is estimated that "Recovery was 95% from the purest chloride ore and 75-80% from the deeper sulfide bearing ores." (Ibid p. 74) However, some mercury was also lost. I have been told that the tailings run $2-$3, and contain mercury. My informant, who worked the tailings, did not know how much!

As can be seen from the annotated sketch (p. 75), the tailings are extensive and are located athwart the prevailing wind direction (which blows from west to east). This direction is confirmed by the existance of numerous climbing dunes on the west side of all of the hills in the Cady, Alvord, and Cat Mountains, where sand is trapped temporarily enroute to the Kelso dune area.

Thus, the wind picks up grains of all sizes as it passes over the tailings and in less than a mile, rises over the hills in which your claims are located. The resulting decrease in velocity results in the heavier grains being left, as the transport is mostly by saltation. These grains constantly accrete to the surface and make up the upper sandy layer of the soil. They are winnowed by succeeding winds, which by removing the lighter, concentrates the heavier grains. The lighter material remains in suspension (dust) and is carried out of the area. Thus, the entire claim group is salted with grains of tailings, in which the values in silver and mercury probably occur as films and coatings on the 20% to 25% of unrecovered silver minerals. These will be heavier than the gangue particles and thus will constantly be left behind, thereby increasing the grade.

A similiar concentration process does not operate on the west side of the tailings because (1) the wind does not blow consistently from the east, and (2) velocities are not checked by a nearby rise in topography.

The anomolous values for mercury and silver obtained from the near surface sand, are not indicative of any silver concentration. However, the presence of veins, altered zones, and associated faults, with sparse silver values, and the claim location near the main Calico camp justify exploration. Clues to these ore bodies are not a function of surface distribution of mercury or silver anomolies in transported material.

Yours very truly,

Dion L. Gardner

Dion L. Gardner

1. Weber, Harold, "Silver Mining in Old Calico" Mineral Information Service. Vol. 19, No. 5, 1966. page 72.

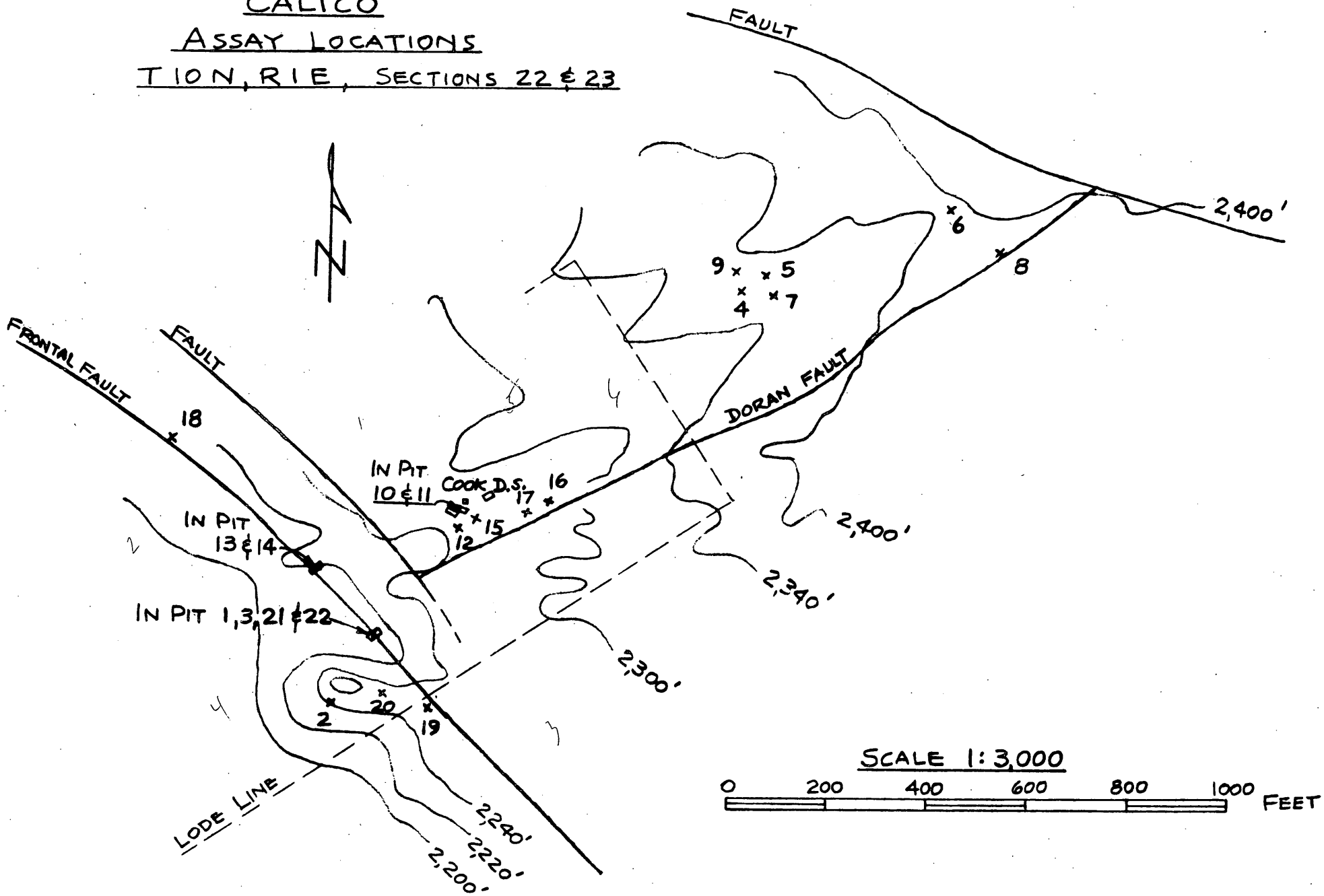
SILVER AND GOLD ASSAYS

Shown herewith are the various assays for silver and gold that we have had run in the Geomineral lode claims area.

All of the assayers shown in the Calico assay results are commercial assayers, except Mr. De Vore, who is one of our associates and ran a number of confirming assays in the Handy and Harman assay laboratories where he is their plant superintendent.

The sites of the assays are shown on Plate XIX, and the results are shown on Exhibit "B".

CALICO
ASSAY LOCATIONS
T 10 N, R 1 E, SECTIONS 22 & 23



APRIL 24, 1967

WFR

PLATE XIX

EXHIBIT "B"

CALICO ASSAY RESULTS - OUNCES PER TON

Sample No.	Gold	Silver	Assayer
1	.18	1.52	De Vore
2	.14	1.56	"
3a	.012	.13	Southwestern
3b	.01	.30	Whitmore
4	.05	3.77	De Vore
5	.12	1.10	"
6a	.021	.11	Southwestern
6b	.005	Trace	Whitmore
7	Trace	.30	De Vore
8	Trace	.10	"
9	Trace	Trace	"
10	Nil	.64	Eisenhauer
11	Trace	2.46	"
12	.01	.72	"
13	Trace	.66	"
14	Trace	1.64	"
15	Trace	3.2	Whitmore
16	Trace	.2	"
17	Nil	Trace	"
18	Trace	Trace	"
19	.08	3.42	De Vore
20	.06	1.84	"
21	.06	.56	Eisenhauer
22	Spectrographic Analysis (See attached page)		

Exhibit B

838-5939
870-3749

PACIFIC SPECTROCHEMICAL LABORATORY, INC.

CHEMICAL AND SPECTROGRAPHIC ANALYSIS
RESEARCH

2558 Overland Avenue
Los Angeles, California 90064

Attn: Mr. T. A. DeVore

December 22, 1966

Report of semiquantitative spectrographic analysis of sample submitted by

Handy & Harman
4140 Gibson Road
El Monte, Calif. 91734

Powdered sample of Andesite

Silicon-	22. %
Aluminum-	11.
Iron-	1.5
Sodium-	5.0
Calcium-	3.4
Magnesium-	1.4
Titanium-	2.2
Barium-	0.11
Boron-	trace
Lead-	0.043
Gallium-	0.0057
Manganese-	0.037
Chromium-	0.020
Tin-	0.0039
Vanadium-	0.0067
Copper-	0.0056
Silver-	0.00040
Nickel-	0.0020
Zirconium-	0.016
Cobalt-	trace
Strontium-	0.083
Potassium-	7.0
Antimony-	not detected less than 0.005
Mercury-	not detected less than 0.05
Other elements-	nil

Respectfully submitted,

Hal W Johnson
PACIFIC SPECTROCHEMICAL LABORATORY, INC.

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SPECIAL GEOGRAPHICAL MAP

There is included herewith as Plate XXI a map showing the Highways, Roads and Railroads in the immediate vicinity of the Geomineral Company's claims. Not showing is the fact that there are oil and gas pipelines at Yermo, California, and also large scale electrical transmission lines, so there is ample power supplies in the area.

Water is readily available in the area, but a desalination plant may be necessary for use with this water. The economics of the transportation and power situation is excellent. The labor situation is good in the area, as is the housing situation.

From an economic standpoint therefore, we believe it would be difficult to locate anywhere in the United States a better mining location if we should be fortunate enough to prove out our claims.

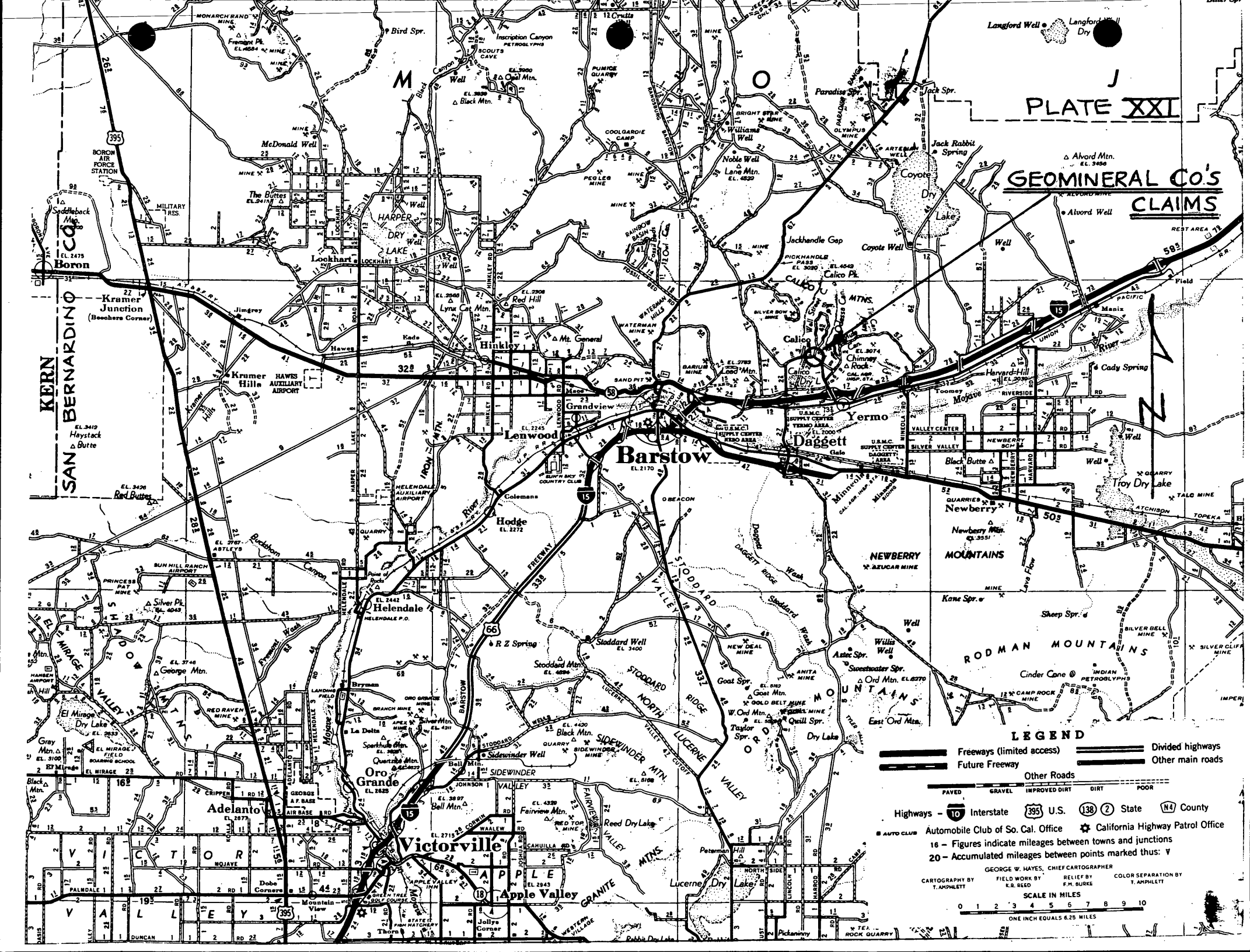


PLATE XXI
GEOMINERAL Co's CLAIMS
KERN
SAN BERNARDINO
Boron
Kramer Junction
Lockhart
Hinkley
Lenwood
Barstow
Daggett
Yermo
Calico
Newberry
Helendale
Hodge
Oro Grande
Adelanto
Victorville
Apple Valley
NEWBERRY MOUNTAINS
RODMAN MOUNTAINS
STODDARD VALLEY
LEGEND
Freeways (limited access)
Future Freeway
Divided highways
Other main roads
Other Roads
PAVED
GRAVEL
IMPROVED DIRT
DIRT
POOR
Highways - Interstate
U.S.
State
County
Automobile Club of So. Cal. Office
California Highway Patrol Office
16 - Figures indicate mileages between towns and junctions
20 - Accumulated mileages between points marked thus:
GEORGE W. HAYES, CHIEF CARTOGRAPHER
CARTOGRAPHY BY T. AMPHLETT
FIELD WORK BY K.R. REED
RELIEF BY F.M. BURKE
COLOR SEPARATION BY T. AMPHLETT
SCALE IN MILES
0 1 2 3 4 5 6 7 8 9 10
ONE INCH EQUALS 6.25 MILES

Status of Mineral Claims as shown by our

Attorney, Mr. R. D. Upp

(see following 3 pages)

PROPOSAL

Geomineral Company proposes to drill ~~two~~ FOUR core holes on their claims as shown on Plate XX, if the results from these ~~two~~ FOUR core hole are satisfactory as to tenor and amount of mineralization present; then after a careful review of these results we would propose to drill a number of additional core holes on proper centers to definitely delineate the mineralization of the claims.

We therefore plan to ask the Office of Mineral Exploration of the U. S. Geological Survey for support in such a project, which will be a two step project as outlined above.

It should be pointed out here that while we believe the predominant mineralization in the area will be a silver-gold situation, there is no positive proof of this, as the technical tools used are not definitive as to the minerals present, but rather indicate only there is a mineralization anomaly of some metallic ore.

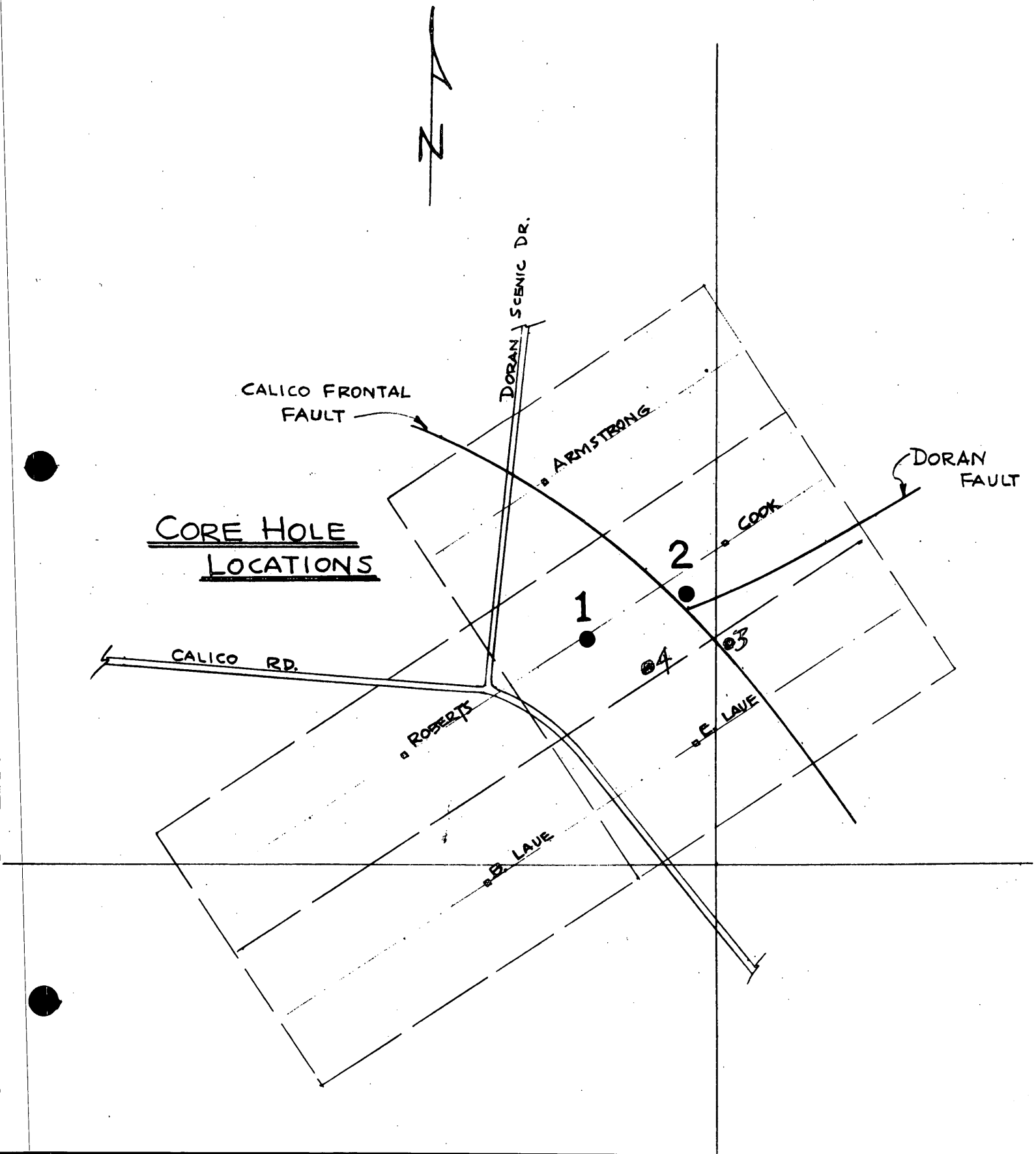
We believe the first ~~two~~ FOUR core holes should be drilled to a minimum depth of at least ~~1,000~~ 500 feet.

PLATE XX

PROPOSED CORE HOLE LOCATIONS ON GEOMINERAL CO'S. CLAIMS ~ YERMO QUAD. T. 10N., R. 1E.

HAROLD S. COOK JR & ASSOCIATES

SCALE 1" = 500' APPRX.



SUMMARY

In summarizing this report, we believe that the salient and pertinent facts have been covered in the Abstract, but before closing it should be pointed out that the risk of locating a new mine is always great. However, because of the advanced technological instruments used in determining our location, we feel that a good chance for success exists.

DEPARTMENT OF INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS GEOLOGICAL INVESTIGATIONS
MAP I-512

EXPLANATION

SEDIMENTARY AND VOLCANIC ROCKS

Cenozoic nonmarine (continental) sedimentary rocks and alluvial deposits

Cenozoic marine sedimentary rocks

Cenozoic volcanic rocks

Late Mesozoic (latest Jurassic and Cretaceous) shelf and slope sedimentary rocks

Late Mesozoic (latest Jurassic and Cretaceous) eugeosynclinal rocks of the Franciscan Formation

Mesozoic sedimentary and volcanic rocks older than the Nevadan orogeny; in places strongly metamorphosed

Paleozoic sedimentary and volcanic rocks; in places strongly metamorphosed; includes some rocks of Triassic age in Klamath Mountains; includes some late Precambrian sedimentary rocks in Great Basin

Precambrian rocks of all types including coarse-grained intrusives

Pre-Cenozoic metamorphic rocks of unknown age

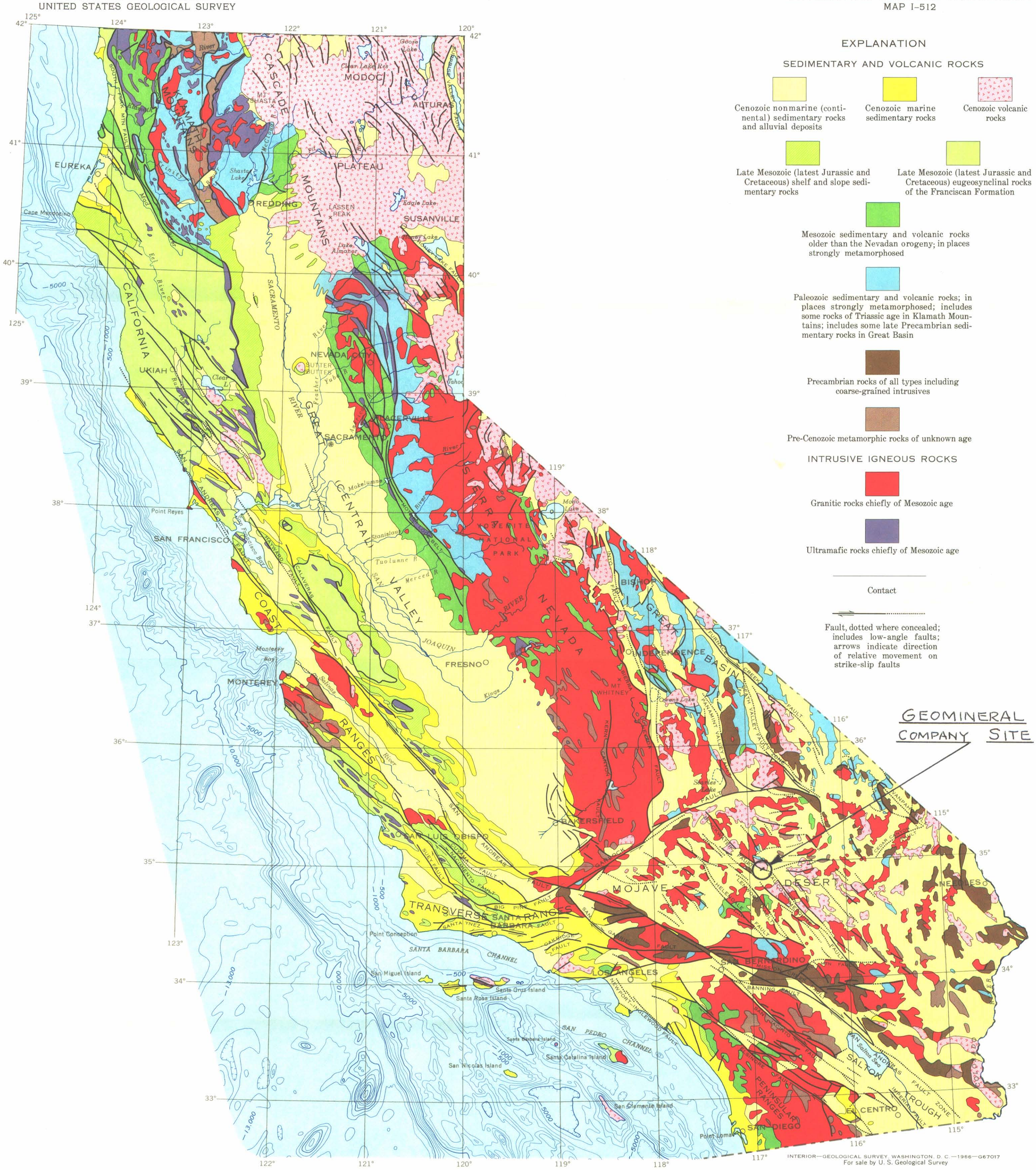
INTRUSIVE IGNEOUS ROCKS

Granitic rocks chiefly of Mesozoic age

Ultramafic rocks chiefly of Mesozoic age

Contact

Fault, dotted where concealed; includes low-angle faults; arrows indicate direction of relative movement on strike-slip faults



INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1966—G67017
For sale by U. S. Geological Survey

GEOLOGIC MAP OF CALIFORNIA

COMPILED BY U.S. GEOLOGICAL SURVEY
AND CALIFORNIA DIVISION OF MINES AND GEOLOGY

SCALE 1:2 500 000

0 — 50 — 100 MILES

SUBMARINE CONTOUR INTERVALS 500 AND 1000 FEET; DATUM IS SEA LEVEL

1966