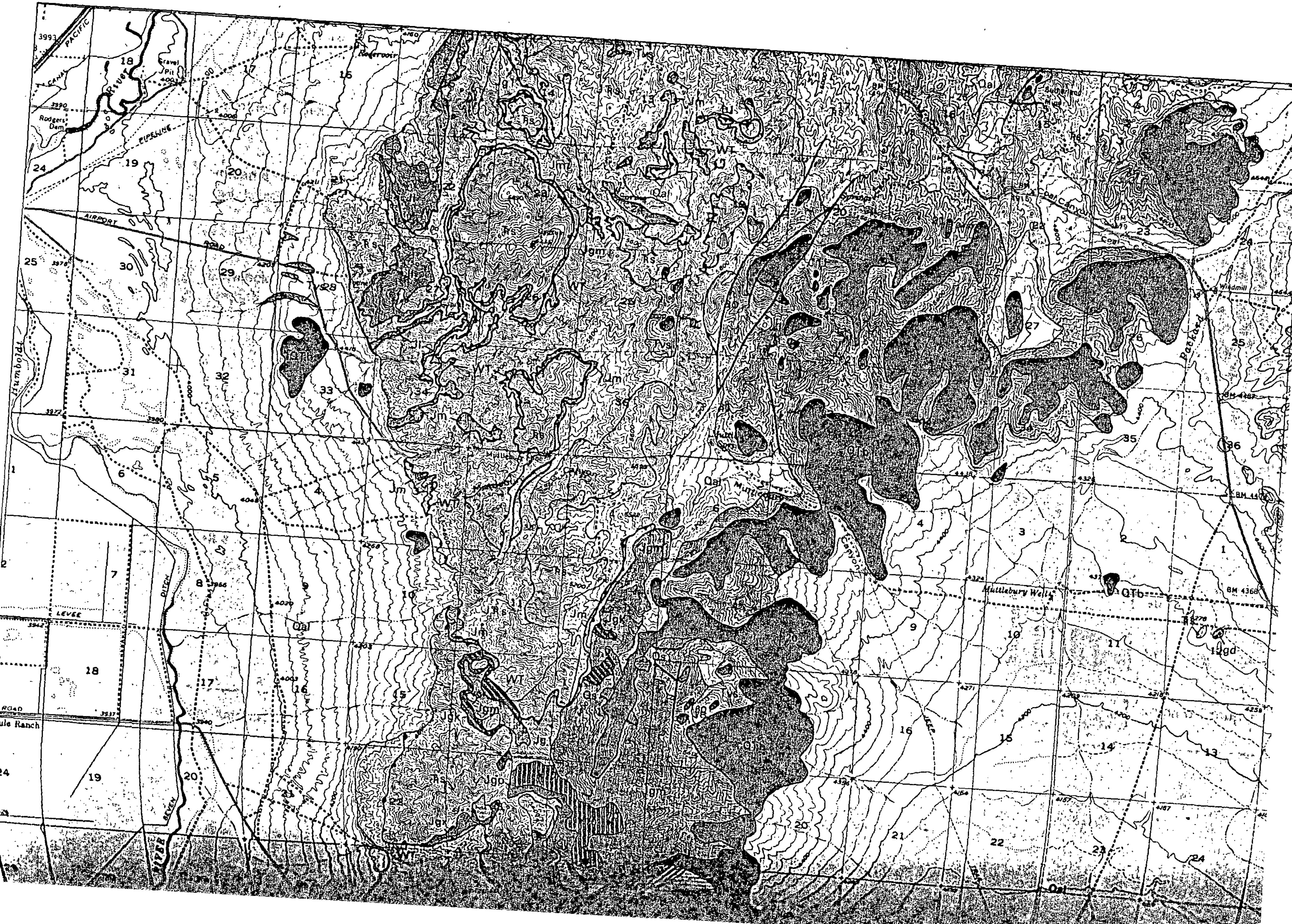
GL01999


PACIFIC
CANAL
River
Gravel Pit
Rodgers Dam
PIPELINE
AIRPORT
Humboldt
Reservoir
LEVEE
DITCH
SEVEN
RIVER
ROAD
Mulleberry Wells
Canyon
Coal Canyon
Windmill
Packard

NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS 60201

DEPARTMENT OF GEOLOGICAL SCIENCES

Dec 17

Dear Mr. Aiblett,

This is the only map copy I have showing Coal Canyon geology. There is more detailed work on various field maps, but they are all originals.

See also Speed (1975) Carbonate Breccia Nappes of the Carson Sink region, Nevada: Geol Soc Amer Bull. v 87, p. 473-486

Good Luck

RCSpeed

P.S. I shall look forward to your logs of cuttings.

Colado

Results of phone Call to Robert C. Speed.
(# & address in case reference file).

Prof. Speed said that he would like to swap information, his mapping (in Lovelock Quad) and stratigraphic information for information from cuttings logs. (I said o.k., after I check with Ross ~~and~~ for information that has been released.

Phone conversation info.

Coal Canyon area rocks (all of northern W. Humbolt Mtns) are allochthonous, but he couldn't say how far down the sole thrust (bottom one) is located.

The Sole thrust is the Fencemaker thrust

The thrusting has not produced breccias, but solution breccias of carbonate, formed by solution of evaporites are present along thrust plains in places.

Coal Canyon stratigraphic map. M.S. Thesis
by Jack Sulima
working for Amax Coal,
Denver, Colorado

UNIVERSITY OF UTAH RESEARCH INSTITUTE
UURI
EARTH SCIENCE LABORATORY
420 CHIPETA WAY, SUITE 120
SALT LAKE CITY, UTAH 84108
TELEPHONE 801-581-5283

December 27, 1979

Professor Robert C. Speed
Department of Geological Sciences
Northwestern University
Evanston, Illinois 60201

Dear Mr. Speed:

Enclosed is a copy of our in-house preliminary report on the cuttings from the drill holes in the Colado, Nevada area. This information will not be formally released for several months, therefore please consider the data for your personal use only until we send notification. Detailed logs were made for only five of the holes. Copies of these are enclosed.

Thank you for the information on the Colado area and lithologies present. I will probably be in contact with you again.

Sincerely,

Bruce Sibbett

Bruce Sibbett
Associate Geologist

BS:srm

enclosure

Jan. 30, '80 meeting with Wayne Shaw

Odin

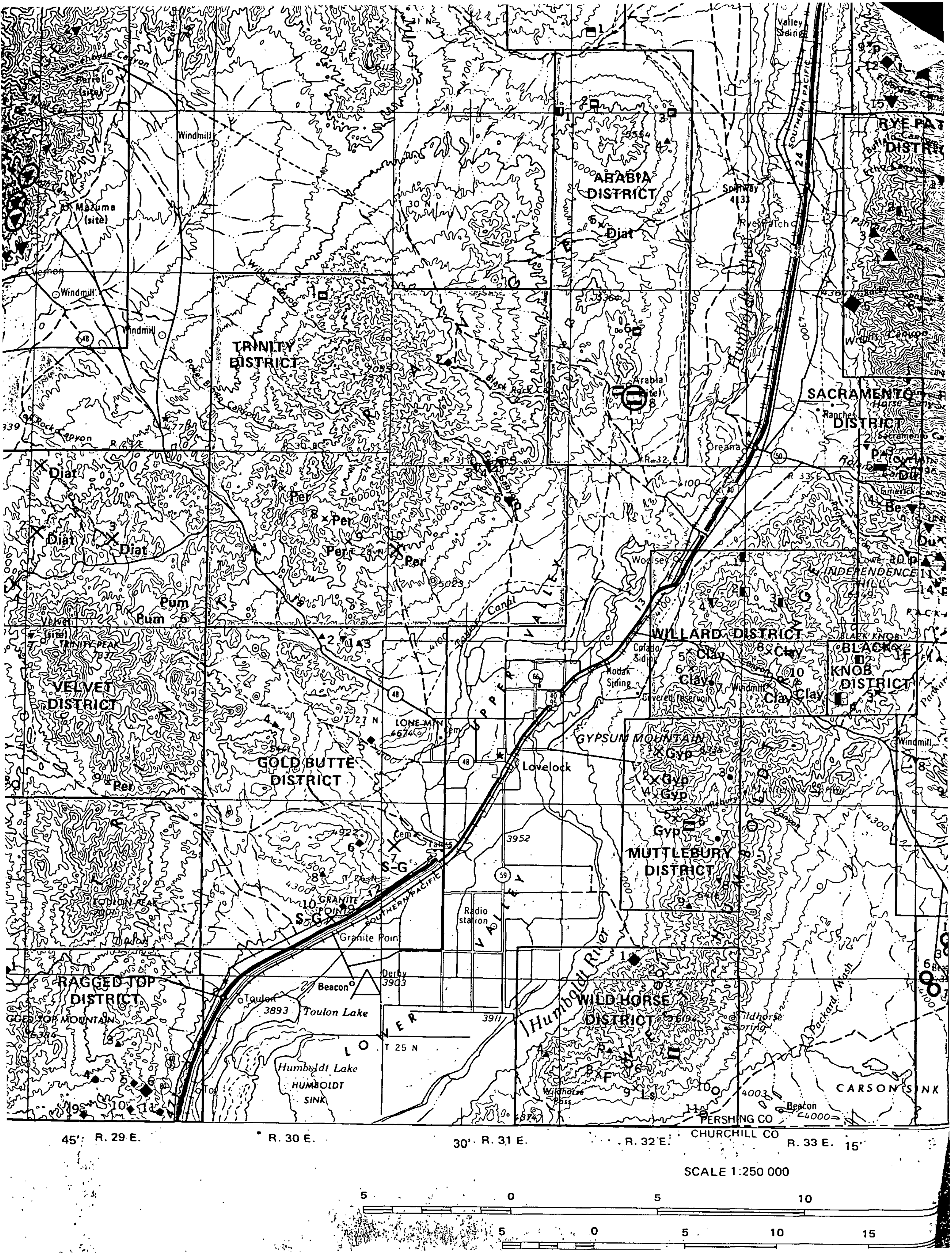
Mg - 2 population, with an enrichment - high values at shallow to intermediate (100-300' mostly) depth in the north East area (14-22, 13-26, 12-26 holes)

As - As high in lower 200' of 14-22 with Mg - halow over & around the As high.

5.8°F/100' gradient in 1165' hole in Sec. 10, near hole 3-10

See Property & hole location map for two Au. exp. holes in Sec 26. These holes were hot, with steam in north hole.

1165 hole in Sec. 10,
Water table and temp jump (35-55°F) at 200'
112°F at T.D.
Second deep hole (1500') will be drilled in section 26.


ARABIA DISTRICT
TRINITY DISTRICT
RYE PATCH DISTRICT
SACRAMENTO DISTRICT
INDEPENDENCE HILL
WILLARD DISTRICT
BLACK KNOB DISTRICT
VELVET DISTRICT
GOLD BUTTE DISTRICT
GYPSUM MOUNTAIN
MUTTLEBURY DISTRICT
RAGGED TOP DISTRICT
WILD HORSE DISTRICT
Mazuma (site)
Arabia (site)
Velvet (site)
TRINITY PEAK
LONE MTN
Lovelock
Woolsey
Oreana
Rye Patch
Valley Siding
Colado Siding
Rodak Siding
Granite Point
GRANITE POINT
TOULON PEAK
Toulon
Toulon Lake
Derby
Beacon
Radio station
Humboldt Lake
HUMBOLDT SINK
Humboldt River
CARSON SINK
Wildhorse Spring
Wildhorse Pass
Packard Wash
UPPER VALLEY
LOWER
SOUTHERN PACIFIC
PERSHING CO
CHURCHILL CO
Windmill
Diat
Per
Pum
Clay
Gyp
S-G
Be
R. 29 E.
R. 30 E.
R. 31 E.
R. 32 E.
R. 33 E.
T 25 N
T 27 N
30 N
31 N
45'
30'
15'
SCALE 1:250 000
5
0
5
10
15

1944; Wallace and Tatlock, 1967), (fig. 13). The dolomite conglomerate is the host rock for mercury deposits on Pershing Ridge (Pershing, Montgomery, Lori, and Eastern Star mines). The relatively high permeability and the intense fracturing of the conglomerate are probable factors influencing the mercury mineralization (Silberling and Wallace, 1969, p. 45).

Crystalline cinnabar occurs in veinlets of calcite, in fractures in limestone, and as large pods in carbonates in most of the mines. At the Red Bird mine, powdery cinnabar occurred with bindheimite and other oxides in a pipelike ore body that was probably a pre-existing lead-zinc ore body (Bailey and Phoenix, 1944, p. 168; Wallace and Tatlock, 1967). Antimony minerals (stibnite, bindheimite, and antimony oxides) occur in the ores of many mercury mines; this association with cinnabar suggests that both minerals were deposited simultaneously (Lawrence, 1963, p. 167–168).

The Hollywood antimony mine is in highly fractured sedimentary rocks of the Grass Valley Formation. Stibnite occurs as pods to 30 inches across, disseminated grains, and individual crystals in quartz veins in slate; most of the ore was mined by stoping from two adits (Lawrence, 1963, p. 165–167). At the Cervantite and Antimony Star mines, stibnite occurs in quartz veins in intensely fractured sandstone, possibly of the post-Dun Glen strata. The antimony mineralization at these deposits apparently was controlled by the fractures that provided open space for stibnite deposition in sandstone overlain by unfractured quartzite and underlain by soft shale (Lawrence, 1963, p. 152–164).

The Relief mine is in the lower member of the Prida Formation near the contact with the underlying Weaver Rhyolite of the Koipato Group. The geologic setting of the Relief mine is similar to that described for the silver deposits in the Unionville (p. 97) and Star (p. 92) districts (Wallace and Tatlock, 1962). Here, as in those districts, rich silver ore occurs near a Lower Triassic topographic high formed by a Triassic (Koipato age) rhyolite porphyry intrusive that may have been the source of remobilized silver (Silberling and Wallace, 1969, p. 26–28).

The limestone and dolomite beds of the Natchez Pass Formation have been prospected for fluorite at the Bohannon prospect and for limestone and dolomite. Here, and elsewhere in the Humboldt Range, are large bodies of limestone of quality suitable for portland cement (Wallace and Tatlock, 1962; Southern Pacific Co., 1964, p. 47). Quartz veins in the volcanic unit of the Natchez Pass Formation have been explored for silver in the eastern part of the district.

Arabia District

The Arabia district is on a small hill at the eastern edge of the Trinity Range, about 4 miles northwest of Oreana, north of the Poker Brown Camp road, the main access road to the mine area. The Poker Brown Camp road connects with Interstate Highway 80 about 10½ miles north of Lovelock. The main mining area is centered in a mile-square area around the townsite (abandoned) of Arabia (secs. 20 and 21, T. 29 N., R. 32 E.); a few small mines and a few prospects are in the foothills to the north.

Production from mines in the Arabia district has frequently been grouped with production from mines in the adjacent Trinity district, 6 miles southwest, under either name; because the geology and the types of ore deposits in these districts are distinctly different, the older usage that restricts the Arabia district to a small area is retained here.

The principal mines are the Montezuma, Electric, and Jersey silver-lead-antimony mines, all located on a series of parallel veins. Separate mining claims along these veins, some traceable for more than 1,000 feet, have given rise to the naming of many different mines (Thompson and West, 1958, p. 453, list 26 mines); only the major producing mines are discussed in this report. The location of many of the mines in the district are shown on figure 14.

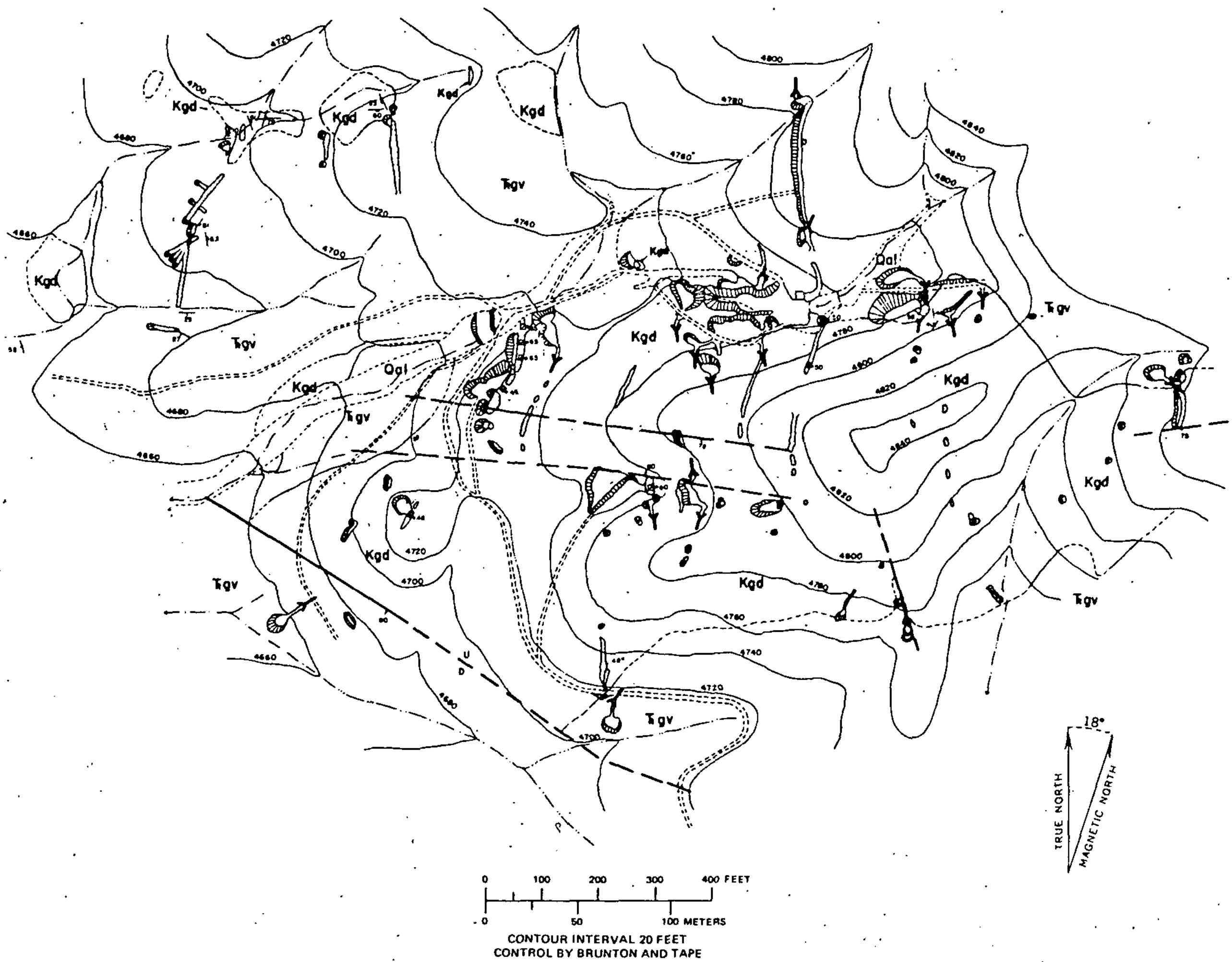
HISTORY

The Montezuma mine, the largest in the district, was apparently the first mine located, a few years after the initial discovery of ore in the Trinity Range in 1859. In 1867, the first smelter[1] operated in Nevada was built at Oreana by the Trinity and Sacramento Mining Co., owners of the Montezuma mine, to treat the argentiferous bindheimite ores. The Jersey mine was located in the spring of 1864, and many other mines were located at about the same time. The district was very active until some time in the 1870's, when, after a series of financial problems despite apparent milling success, the smelter at Oreana was destroyed by fire.

Early production from the district is unknown, but estimates of production from the Montezuma mine based on value per ton of ore indicate a yield of more than $770,000 for that mine, and probably more than $1 million for the district. The ore from the Montezuma averaged 40 to 50 percent lead and antimony, and 60 to 80 oz silver per ton; that from the Jersey mine contained less base metals and about 40 oz silver per ton. Estimates of tonnage produced range from about 7,000 tons for the Montezuma mine to 30,000 tons for the ores treated at the smelter between 1865 and 1880 (Whitehill, 1873, p. 51; Thompson and West, 1958, p. 453).

Mining in the district continued sporadically until 1951; small shipments of silver-lead-antimony ore with minor by-product gold were produced from reworking of slag and tailings from early operations; the Montezuma, Electric, Last Chance, Mohawk, C. W., and G. D. B. claims were mined on a small scale. Antimony production is estimated at more than 500 tons, most of it during the period 1865–80 (Lawrence, 1963, p. 157), and while it is difficult

[1] The smelter consisted of eight furnaces—two for smelting, four for calcining, and two for cupelling—and was capable of reducing 30 tons of ore in 24 hours (White, 1869, p. 34). Crude ore containing lead, antimony, and silver was obtained from the smelting furnaces, then treated in the calcining or sublimation furnaces to produce an alloy of lead and lead-silver ore; the silver was extracted in the cupelling furnaces, and the lead-antimony ore was shipped to San Francisco for type metal (Hague, 1870, p. 301).



EXPLANATION
(Figure 14)

Qal	Kgd	Tr gv
Quaternary alluvium	Cretaceous granodiorite	Grass Valley Formation (Triassic)

- Contact — *Dashed where approximately located*
- Strike and dip of beds
- Prospect pit
- Drill hole
- Fault, showing dip — *Dashed where approximately located. U, upthrown side; D, downthrown side. Arrows indicate relative horizontal movement*
- Strike and dip of joints
- Adit
- Dump
- Inclined shaft
- Shaft
- Creek
- Road

FIGURE 14. Geologic maps of the west workings (above) and main mining area (facing page), Arabia district.

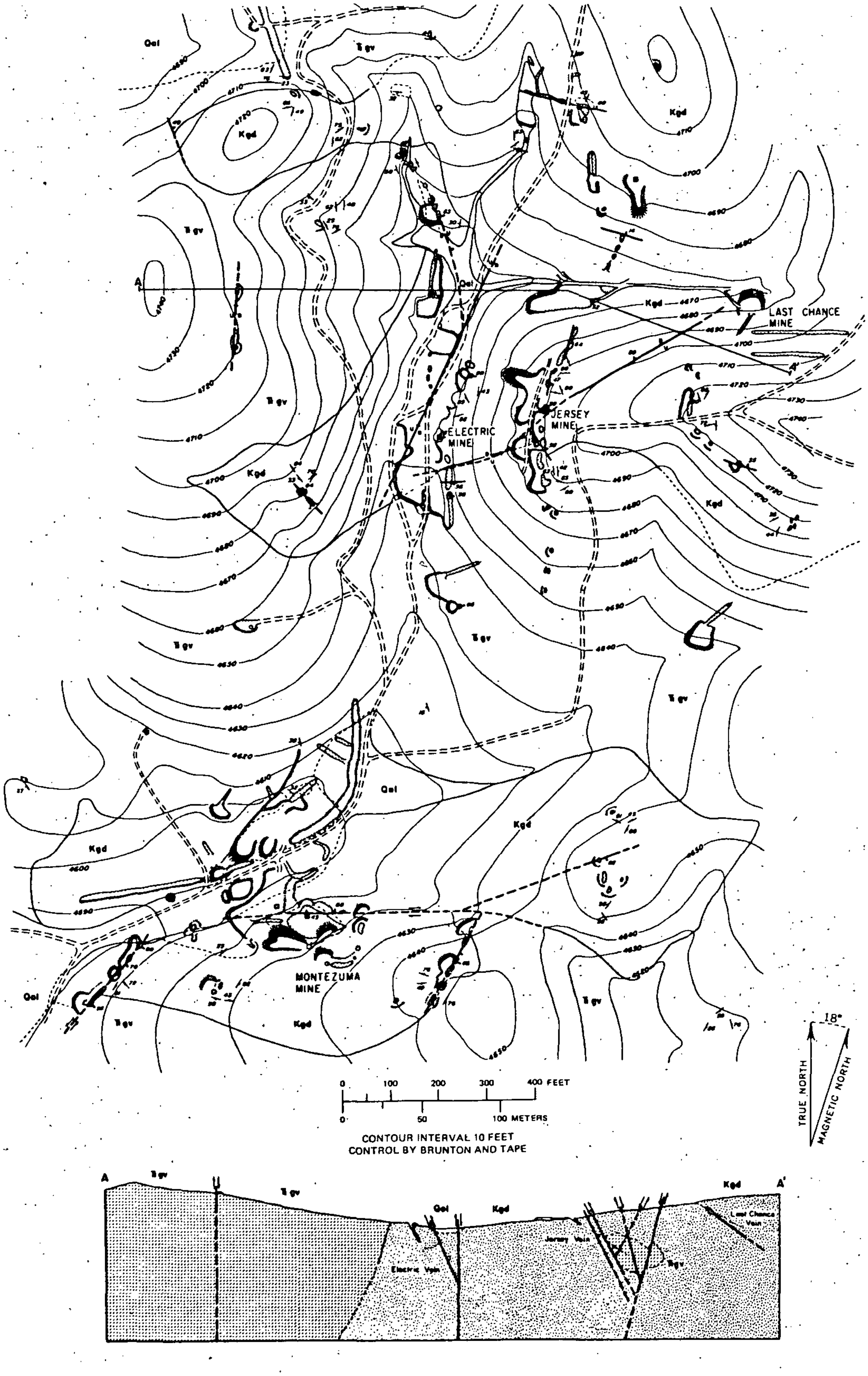


FIGURE 14.–Continued

TABLE 10. Summary of recorded production, Arabia mining district.

[0, no production; blank, no data]

Year	Ore sold or treated (short tons)	Total value[1] when sold $	Gold (ounces)	Silver (ounces)	Copper (pounds)	Lead (pounds)	Zinc (pounds)	Antimony (pounds)[2]
1916–1927	3,904	129,883	2,160	53,207	2,827	633,433	400,154	94,000
1929–1930	118	2,157	5	2,128	149	56,624	0	18,000
1935	14	625	11	326	0	0	0	
1938	5	179	0	99	0	2,500	0	
1944	142	3,729	4	1,346	0	32,900	0	
1950	45	2,199	2	622	0	11,600		
Total	4,228	138,772	2,182	57,728	2,976	737,057	400,154	112,000

[1] Excludes antimony value.
[2] Data from Decker, 1972.

to obtain exact value data, Decker (1972) estimates that antimony was the most valuable ore mineral.

Available production data is given in table 10.

GEOLOGIC SETTING

The Arabia district is underlain by Cretaceous granodiorite that intrudes Triassic and Jurassic slates, quartzites, and metasiltstones. Decker (1972) correlates the metasedimentary rocks with the Triassic Grass Valley Formation as shown on figure 14; this correlation is by no means certain, however, as lithologically similar rocks farther west contain Jurassic fossils. The granodiorite contains scattered xenoliths of hornfels and is commonly sericitized. Locally, silicic ash-flow tuffs of Tertiary age overlie the granodiorite.

The productive veins in the district occupy fracture zones in granodiorite and xenoliths of metasedimentary rocks in granodiorite but are best developed in the granodiorite. Most veins strike N. 10° E.–N. 20° W. and dip 28°–60° E. (Decker, 1972). The Montezuma vein differs from the other veins in the district in that it strikes east and dips 45°–55° N.; the vein apparently ends, both to the east and west, against northeast-trending, steeply southeast-dipping faults. Adits and prospect pits in the area are located on and parallel to the veins, some of which can be traced on the surface for more than 1,000 feet (fig. 14).

The principal ore mineral is argentiferous bindheimite, most commonly deep yellowish brown, amorphous, with a high brilliant pitchy luster, sometimes yellow, compact, and earthy. Plumbojarosite, jarosite, jamesonite, arsenopyrite, and minor antimony oxides also occur. The richer ore bodies contain nearly solid masses of bindheimite, but the leaner ore bodies contain considerable amounts of milky quartz with the bindheimite (Lawrence, 1963, p. 158).

ORE DEPOSITS

The principal mines of the district are well described by Lawrence (1963, p. 157–161), Decker (1972), and Knopf (1918); the following account is summarized from their reports.

The Montezuma mine is developed on the east-trending vein by a pit about 90 feet long, 20 feet wide, and 20 feet deep; an incline shaft was sunk to 120 feet but passed out of ore at 60 feet. The main ore body in the pit was 14 feet thick, but thinned to 6 feet at the level of the pit and from 1 to 2 feet below that level. The vein consists mainly of quartz and gouge, minor calcite, and locally abundant jamesonite and arsenopyrite and antimony oxides; bindheimite occurs as earthy to pitchy pods that fill the entire vein, and other antimony oxides as pods and powdery masses in the vein and adjacent wall rock. Tourmaline and chalcopyrite also occur (Decker, 1972).

The Electric and Jersey mines are on contiguous claims covering numerous slightly arcuate veins that range from a few inches to 6 feet wide (averaging 8 to 12 inches), trend north, and dip 35°–70° E. The veins are composed mainly of quartz and gouge, with minor calcite; plumbojarosite, bindheimite, and other antimony oxides are locally abundant; unoxidized jamesonite occurs rarely. The mines are not developed on a single ore body, but rather, consist of numerous shafts, adits, trenches, and open pits at various localities along the numerous veins where the ore was richest.

Other mines described by Lawrence include the Jaxrace Jewel prospect and the West Group of workings (worked under the name C. W. and G. D. B. claims in 1944 and 1950). The veins and ore minerals are similar to those of the major mines.

OTHER DEPOSITS

Numerous small mines and prospects are located in the eastern foothills of the Trinity Range, north of the Arabia mining area. According to the Southern Pacific Co. (1964, p. 26), a small mine in NE¼SW¼ sec. 9, T. 29 N., R. 32 E., produced 50 sacks of silver-lead-antimony ore from an inclined shaft and an adit along a quartz vein, 6 feet wide at the surface, that contains argentiferous bindheimite emplaced along the contact between slate and a grano-

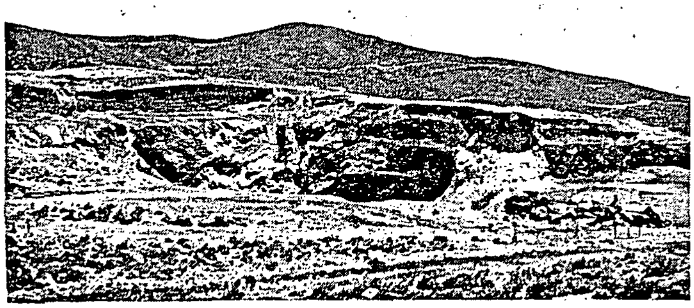


FIGURE 20. Big Mike open pit, Tobin Range.

T. 30 N., R. 40 E. The ore deposit is situated on a steep slope 3,000 feet above the valley floor. Scheelite occurs in quartz veins along the bedding planes of thin lenses of silicified limestone in shale near the contact with the granodiorite pluton. The grade of scheelite in the deposit averaged a few percent WO_3, but the amount of ore was small. The property was mined during World War II and the Korean War. Total production of scheelite is unknown but was probably about 100 tons.

Trinity District

The Trinity district, as here defined, includes a large area that extends across the northern part of the Trinity Range in Tps. 28 and 29 N., Rs. 30 and 31 E. Diverse types of ore deposits have been mined in the district. Gold-silver mines are located in the upper part of Trinity Canyon, on the east flank of the range. These mines include the Evening Star, Lucky Boy, Mazuma, Morning Star, and Steiner, of which the Evening Star was the most productive. The mines are accessible from the unimproved road that leads 10 miles north from Lovelock to Trinity Canyon. A small tungsten mine (the Esther or Black Rock mine) is located near the head of Black Rock Canyon in the central part of the range; it is accessible by a dirt road that leads up Black Rock Canyon from the eastern side of the range. U. S. Gypsum Co. operates the Pearl Hill perlite quarry on the east flank of the range about 4 miles southwest of Trinity Canyon; the mine is accessible by a mine service road that intersects Nevada State Highway 48 about 4 miles west of Lovelock, leading 6 miles north to the mine.

HISTORY

Ore was first discovered in the Trinity Range by George Lovelock in 1859. The site of the discovery is not known but may have been the gold-silver deposits in Trinity Canyon. The Evening Star was the first mine worked in the district; by 1864 it was extensively developed and had its own five-stamp mill. This mill was moved from Trinity Canyon to Oreana in 1865, when mining activity decreased at the Evening Star mine and increased at the Montezuma mine in the Arabia district. Early production from the Evening Star mine is not known, but the ore was valued at $65 per ton; the mine was worked again in 1877–78, then intermittently until 1915.

The history of the other mines in Trinity Canyon is not known, but the district produced small amounts of gold-silver ore from a few mines to 1942.

Small amounts of placer gold were recovered intermittently between 1939 and 1963 from deposits, probably in Trinity Canyon and nearby gulches that drain areas near the mines (Johnson, 1973).

One small tungsten mine, the Esther or Black Rock mine, located at the head of Black Rock Canyon, about 1 mile northwest of the Trinity Canyon mines, produced about 16 tons of tungsten ore averaging 0.96 percent WO_3 in 1943.

U. S. Gypsum Co. owns and operates a perlite quarry at Pearl Hill, in the central part of the Trinity district. The following information was given to us by U. S. Gypsum Co. and Southern Pacific Co., and we gratefully acknowledge their cooperation.

The presence of commercial-grade perlite in the Trinity Range had been known for a long time, but it was not until 1950, when U. S. Gypsum Co. purchased the deposit at Pearl Hill from the Southern Pacific Co., that the deposits were developed. U. S. Gypsum Co. mines the perlite by bench quarrying methods and trucks the ore to the crushing and sizing plant on the Southern Pacific Railroad mainline, 5 miles north of Lovelock. A sized crude perlite is produced at this plant for shipment to the Empire plant in Washoe County, where it is expanded for use as light-weight aggregate. From 1953 to 1970, 94,210 tons of perlite were produced. The product is used almost exclusively by U. S. Gypsum Co. for plaster aggregate.

GEOLOGIC SETTING AND ORE DEPOSITS

The gold-silver mines in the Trinity Canyon area are located along the southeastern margin of a large Cretaceous granodiorite stock. According to R. G. Reeves (written communication, 1971), mineralization is localized along shear zones and hornfelsic dikes that trend approximately N. 75° E. and dip 65° S., paralleling a predominant joint set in the granodiorite. This joint set offsets an earlier unmineralized joint set that trends N. 87° E., and dips 48° N., subsequently injected by mafic (diorite?) dikes. Shear-zone mineralization is characterized by a pinch-and-swell type of structure that defines pods of sheared and brecciated strongly altered granodiorite, 2 to 4 feet wide and approximately 10 feet in diameter. On the footwall side of the hornfelsic dikes, a distinct brecciated and altered zone, about 5 feet wide, exhibits blocks of highly silicified and limonite-stained granodiorite; the granodiorite forming the hanging wall of the dike is highly silicified for a distance of approximately 2 feet. Adits have been driven on both the footwall and hanging wall of this type of dike rock.

The ore in the Evening Star mine contained gold and silver, with some copper and zinc; the ore occurs in two parallel veins ranging from several inches to 3½ feet wide

(Vanderburg, 1936a, p. 45). Southern Pacific Co. (unpub. data, 1960) assayed five rocks from the dump and 14 from the mine workings; assays for the dump samples showed 0.1 to 128.1 oz silver per ton, 0.02 to 0.66 percent copper, and a trace to 0.31 oz gold, assays for the mine workings, 0.2 to 28.3 oz of silver per ton and 0.00 to 0.66 oz gold per ton. One sample assayed 1.21 percent arsenic.

Lead-silver-gold occurs in veins in a mineralized shear zone in Triassic and Jurassic slates, northwest of the main mining area in Trinity Canyon; the veins within the shear zone are highly oxidized, making recognition of ore minerals difficult (Southern Pacific Co., unpub. data, 1960). In sec. 3, T. 29 N., R. 30 E., the veins were mined by an inclined shaft, 200-foot main drift, and three stopes; assays of vein samples indicated a trace to 0.070 oz gold and 0.1 to 17.2 oz silver, 0.05 to 4.45 percent arsenic, 0.00 to 0.42 percent antimony, and 0.7 to 17.6 percent lead (Southern Pacific Co., 1964, p. 25). Similar deposits were mined in secs. 2, 10, and 13, but the history of these small mines is not known.

The Esther (or Black Rock) tungsten mine is developed on a pendant of banded garnet tactite surrounded by granodiorite. The tactite contains minor amounts of quartz, epidote, and hedenbergite. The principal ore minerals are scheelite and powellite, chalcopyrite, azurite, and malachite occur in minor amounts. In general, the grade of the ore is low, but some bands of tactite contain streaks of richer scheelite concentration averaging about several percent of WO_3. The mine development consists of trenches, pits, a 60-foot shaft, and a 350-foot adit that connects with the shaft; crosscuts extended from the adit outline the tactite area to a depth of about 50 feet below the outcrop.

Commercial perlite is volcanic glass that expands when heated to a light frothy product (Jaster, 1956, p. 376). Perlite from Pearl Hill quarry expands at a temperature of 1,400 to 1,500°F and has an expansion ratio of 10:1. Deposits of perlite in the Trinity Range are associated with Tertiary intrusive rhyolite domes. The thickness of the deposits ranges from a few feet to 90 feet at the Pearl Hill quarry, and the perlite grades into nonglassy rhyolite at some localities. The perlite is typically bluish gray, massive, and well jointed. An obsidian nodule in perlite was dated by fission track methods at 23±2 m.y. (McKee and Marvin, 1973). Three other deposits in the Trinity district are listed by Southern Pacific Co. (1964, p. 50) as meeting specifications for lightweight aggregate in plaster; these deposits are shown on the mineral resources map (pl. 2) as nos. 7, 8, and 9 in T. 28 N., R. 30 E.

Unionville District

The Unionville district, also known as the Buena Vista district, is on the east flank of the Humboldt Range; it includes mines and placers east of the crest of the range between Big Canyon and Cottonwood Canyon (Tps. 29 and 30 N., R. 34 E.). The district is served by Nevada State Highway 50, which leaves Interstate Highway 80 about 1 mile west of Mill City. The district is famous as a silver district, but gold, antimony, and lead have been produced from small mines.

HISTORY

The Unionville district was organized as the Buena Vista district in 1861 after prospectors found rich ore in Buena Vista Canyon. Between 1861 and 1873, the town of Unionville served as the first county seat in the newly formed Humboldt County (Paher, 1970, p. 136, 139). The Arizona mine, the principal silver mine in the district was discovered in 1862 and actively worked until about 1880. The mine was worked on a small scale to 1959. During the period of extensive mining, numerous silver deposits in the vicinity of the Arizona mine were extensively prospected. The Inskip (Pioneer, North Star), Millionaire, and Wheeler mines were developed at this time. The history of this period has been well described by Raymond (1869 through 1877), White (1869, 1871), and Whitehill (1873 through 1877).

The vein at the Arizona mine was developed from two locations about a quarter of a mile apart. Most of the mining in the early period was done at the northern half of the mine workings, which are credited with production estimated at between $5 and $13 million. The south half of the mine workings were explored and mined during the period 1900–1959. Scheelite is associated with silver in the southern workings and was mined intermittently from 1919 to 1959 (Cameron, 1939, p. 607; Wallace and Tatlock, 1963; Nevada Bureau of Mines and Geology, unpub. data).

Production from the Arizona and other mines in the district for the period 1862–80 is difficult to ascertain. Tonnage and value for the district and for the Arizona mine for different years during this period are given in early reports of Raymond (1869, 1870, 1872, 1873, 1875, 1877), Whitehill (1877), and Couch and Carpenter (1943), but the amounts frequently disagree. The most reliable production information, determined from a variety of sources, is listed in table 19.

Antimony was discovered in Jackson Canyon about 1870; the deposit shipped antimony worth about $6,000 to San Francisco in 1874 (Raymond, 1875, p. 259–260) and $12,000 in 1875 (Couch and Carpenter, 1943). The deposit now known as the Black Warrior mine was worked during the periods 1916–18 and 1940–41, producing about 83 tons of antimony metal (Lawrence, 1963, p. 186).

Minor gold lode and placer deposits in Buena Vista Canyon have been worked on a small scale since the 1860's. The lode mines have been operated under several names, principally as the Marigold group described by Cameron (1939, p. 615–616). The Pfluger (Manoa) mine in Cottonwood Canyon for many years was worked on a small scale for silver and lead.

GEOLOGIC SETTING

Triassic rocks of the Koipato Group and the Prida Formation are the only rock units exposed in the Unionville district. The ore deposits in the district are associated with three distinct geologic settings controlled by the rock units exposed (Wallace and Tatlock, 1962; Silberling and Wallace, 1969).

surface cuts in several places for 400 feet along strike and underground; in the Green mine, for 120 feet along strike and 55 feet down dip. Antimony minerals are most abundant in the northeast part of the fault zone at the main workings of the Green mine, but some good ore was found on the southwest part of the same fault zone. Jamesonite is the principal ore mineral, but much of it has been oxidized to bindheimite and other antimony oxides. Some of the richest ore was found near the intersection of the main fault zone and small cross faults that offset the fault zone 1 to 2 feet (Lawrence, 1963, p. 195). The Green mine is developed by four adits, totaling approximately 410 feet, from which some stopes were driven.

Tungsten deposits are developed in tactite at the contact between Cretaceous quartz monzonite and marble of the Jurassic sedimentary sequence and at the contact between marble and overlying hornfels, a few tens of feet east of the intrusive contact. The sedimentary rocks are folded into an asymmetric syncline that plunges gently northeast. The west limb is invaded by quartz monzonite. Tactite is found along most of the contact between marble and hornfels in widths of a few inches to 10 feet, but only a part of this tactite contains enough scheelite to be ore. The Long mine was developed on two ore bodies along the marble-hornfels contact. The south ore body, in the trough of the syncline, was mined along both limbs of the fold, but scheelite mineralization decreased after 130 feet on the west limb and 125 feet on the east limb. The north ore body, on the west limb of the syncline, was mined for about 200 feet. Most of the tungsten produced by the Long mine came from these two ore bodies. The scheelite-bearing tactite along the marble-monzonite contact contained sufficient scheelite in two small irregularly shaped pods to yield 150 to 200 tons of ore.

Magnetite and pyrite deposits are exposed in the northern and central part of the Wild Horse district near the contact of gabbro (diorite of Southern Pacific Co., 1964, and Moore, 1971) and limestone and hornfels of the Jurassic sedimentary sequence. Subsequent weathering has developed prominent gossans of hematite and limonite over these iron- and sulfur-rich areas; trenching and core drilling at the Tule iron prospects has demonstrated the presence of disseminated magnetite and pyrite below the gossans in the ratio 5:4 (Southern Pacific Co., 1964). The iron and sulfur content of the gossans ranged from 17.9 percent iron and 12.6 percent sulfur to 60.0 percent iron and 0.62 percent sulfur (Moore, 1971, p. 204).

Iron deposits in the southern Wild Horse district have been encountered at depths greater than 800 feet in Buena Vista Valley. Investigations by the U. S. Bureau of Mines (Moore, 1971) show that the Piute iron deposits are in a zone of heavy brecciation in metamorphosed sedimentary and volcanic rocks; much of the breccia in drill cores has been replaced by magnetite that occurs as solid massive replacements, and as irregular stringers, blebs, and disseminated grains. Information obtained from two drill holes indicates "an enormous quantity of material containing more than 20 percent iron, a very large quantity averaging more than 30 percent iron, and a substantial quantity containing more than 50 percent iron (Moore, 1971, p. 165)." These deposits have not been mined because the depth of the ore bodies makes open-pit mining economically unfeasible at the present time. According to Moore (1971, p. 165), selective underground mining would allow production of 1 ton of pellets from mining and treating approximately 2 tons of ore.

Minor prospects for silver and fluorite explore quartz veins and barite veins in the sedimentary sequence, but no ore has been developed, and the prospects are considered uneconomic. Limestone beds in the West Humboldt Range have a limited potential for use in building or other construction, but no deposits have been mined.

Willard District

The Willard district (formerly known as Loring or Lovelock) is at the north end of the West Humboldt Range in south-central Pershing County. The district includes antimony and gold mines on the west side of the range (T. 28 N., Rs. 32 and 33 E.), and clay deposits and a copper prospect in tributaries of Coal Canyon that cross the range (T. 27 N., Rs. 32 and 33 E.). The mines and prospects in the district are readily accessible by dirt roads leading from Interstate Highway 80 between Lovelock and Oreana and by dirt roads leading from the Coal Canyon road.

HISTORY

Mining activity in the Willard district has been pursued on a small scale since about 1905. Antimony has been the most productive commodity; gold and some clay have been mined. The most recent activity is renewed exploration of the antimony and clay deposits.

Gold in the Willard district was first discovered at the Sheepherder claims in 1915; some silver and copper were produced, apparently from the same area between 1905 and 1912. A small boom ensued and a tent city was built, but the lodes were not of sufficient size and value to sustain a permanent camp. Until 1951, gold and subordinate silver were mined in small quantities from claims in the Willard group of mines at the western edge of the district.

Antimony deposits were found in 1916 northwest of the gold mining area. The northernmost and most productive deposit, the Johnson–Heizer mine, consists of two ore bodies mined at different times. The southern ore body was the first mined in 1916; it produced 70 tons of 45 percent antimony ore (Southern Pacific Co., 1964). The northern ore body was not mined until 1946; it produced about 52 tons of antimony metal from 157 tons of 30 percent ore and about 300 tons of 5 to 10 percent ore (Lawrence, 1963, p. 180). Plans to reopen the Johnson–Heizer mine were made in 1970, when National Lead Co. constructed an antimony mill at Oreana to treat these ores and ores from the Sutherland mine (Black Knob district, p. 55) (Eng. Mining Jour., 1970); the plans were abandoned when the price of antimony dropped and the mill coverted to treat tungsten ores.

Development and production from the Rosal (Antimony King) and the Adriene (Louis Lay) mines, south and southeast of the Johnson–Heizer mine has not been as extensive as at the Johnson–Heizer mine. Lawrence (1963, p. 179–183) credits the Adriene mine with production of 15 tons of antimony metal during the period 1940–41, the Rosal mine with no production.

Montmorillonite deposits have been explored at five localities in tributaries of Coal Canyon. A small tonnage of montmorillonite was removed from the deposit in a tributary on the north side of Coal Canyon in sec. 6, T. 27 N., R. 38 E., and from the deposit at the west end of Coal Canyon in sec. 11, T. 27 N., R. 32 E. (Papke, 1970, p. 36).

GEOLOGIC SETTING

Most of the Willard district is underlain by sedimentary rocks of Triassic and Jurassic age. The predominant lithologies at the antimony and gold mines are shale, sandstone, quartzites, and limestone units that in general strike northwest and dip southwest. Tertiary volcanic and pyroclastic rocks overlie the sedimentary rocks throughout the district. Numerous quartz veinlets or silicified zones striking northeast and northwest occur within the metasedimentary rocks and at places within the volcanic rocks near contacts with metasedimentary rocks. The antimony, gold, and copper deposits are developed along certain of these veinlets and mineralized zones. Montmorillonite clay is developed in some units of the Tertiary volcanic series where hydrothermal alteration of vitric and tuffaceous rocks has been intense.

ORE DEPOSITS

The network of quartz veinlets at the Willard group of mines was developed by numerous tunnels, shafts, and adits, and scattered workings totaling about 1,300 feet. In 1915, high-grade gold ore, much of it valued at more than $20 per ton, was mined from surface exposures of quartz veins; further development, which included several shafts more than 100 feet deep and a 700-foot tunnel, failed to reveal continuations of the high-grade ore. From the sparse information available (Lincoln, 1923; Southern Pacific Co., 1964; Vanderburg, 1936a; Eng. Mining Jour., 1915), the ore apparently consisted of free-milling gold and silver in copper-stained quartz veins containing galena, sphalerite, and garnet. The copper prospect on the south side of Coal Canyon explores an apparently similar vein where chalcopyrite and tetrahedrite were observed (Southern Pacific Co., 1964, p. 13–14).

The antimony deposits have been described in detail by Lawrence (1963, p. 179–183). The mines are developed on quartz-stibnite veins, a few inches to 2 feet wide, that strike roughly parallel to the sedimentary rocks. Stibnite occurs as pods and individual crystals in the quartz veins and in some calcite veins but is commonly oxidized to multicolored antimony oxides. Stibnite occurs in fractures and cracks in bedrock, and antimony oxides have in places been redeposited in sandstone. Assays of vein material show antimony, silver, and a trace of gold.

The most extensive developments were at the northern ore body of the Johnson–Heizer mine. Here a 264-foot inclined shaft was sunk on a vein that strikes N. 45° W. and dips 60° SW.; about 440 feet of drifting and considerable stoping were done from the shaft to mine the antimony ore. At other places, the antimony deposits are explored by shallow shafts, short adits, and numerous pits and trenches.

The clay deposits have been described by Papke (1970, p. 34–39). All but one of the five deposits are in tuffaceous or perlitic units in the Tertiary volcanic series. The sec. 11 deposit is in a clay bed conformable to shales of the Triassic and Jurassic sedimentary sequence. The montmorillonite is developed in hydrothermally altered beds a few feet thick. The true extent of potentially economic clay deposits is unknown as most of the exposures are limited to prospect pits and trenches. The swelling qualities of the clay vary but the deposits in sec. 6 and sec. 11 exhibit better than average swelling abilities. Impurities include cristobalite, quartz, feldspars, calcite, and at places zeolite and gypsum.

Willow Creek District

The Willow Creek district is near the center of the East Range and includes gold mines and placers along Willow Creek on the west flank of the range and in Spaulding Canyon on the east flank of the range (T. 31 N., Rs. 36 and 37 E.). The Spaulding Canyon area has formerly been considered a part of the Sierra district but is included here in the Willow Creek district because it is geographically associated and geologically similar. The mines and placers are accessible from a dirt road that leads up Willow Creek from Nevada State Highway 50 in Buena Vista Valley and traverses the range to Spaulding Canyon and Grass Valley.

HISTORY

Early mining history of the Willow Creek district is not well known. The area was probably explored during the 1860's when mining was active in the Sierra district on the north. In all probability, the Willow Creek placers and lode mines were known at that time, and the Spaulding Canyon placers worked. Production from this district has frequently been listed by the U. S. Bureau of Mines with that of the Sierra and Imlay districts.

The Willow Creek placers, located along the north-flowing part of Willow Creek (NE¼ T. 31 N., R. 36 E.), were the most productive mines. The deposits were actively worked during the period 1938–64 with small earth-moving equipment used to deliver the gravels to a central washing plant. Dragline operations were carried on in 1959–60. Actual production from the Willow Creek placers is probably higher than the recorded production of 2,823 oz; it is estimated at about 4,000 oz (Johnson, 1973). The Spaulding Canyon placers were worked during the early 1930's by small-scale hand methods, in 1940 by bulldozers and carryalls. Production figures for these deposits are unknown, but are probably considerably less than those for the Willow Creek placers.

Narrow gold-quartz veins exposed at the headwaters of the west fork of Willow Creek were apparently mined, but no production records can be directly attributed to these deposits. According to Southern Pacific Co. (unpub. data,

Humboldt
Valley Siding
SOUTHERN PACIFIC
Rye Patch
Bloody Canyon
Harrison Spring
Ranches
Oreana
Windmill
Ranch
Packard Wash
Black Knob
Colado Siding
Rodak Siding
Lovelock
Radio station
Granite Point
Derby
3903
Humboldt River
CHOCOLATE BUTTE
CARSON SINK
Beacon
PERSHING CO
CHURCHILL CO