# GEOLOGY OF THE ADELAIDE DISTRICT
# HUMBOLDT COUNTY, NEVADA

March 10, 1971



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## SUMMARY

Geologic work coupled with geochemical prospecting and drilling in the Gregg Canyon-Granite Canyon sector of the Adelaide district has delineated an area of several square miles underlain by low grade copper and molybdenum mineralization. Silver and tungsten also exist in more restricted areas. The mineralization is associated with a group of igneous rocks of intermediate to acid composition which began intrusive activity in Cretaceous time and continued intermittently into late Tertiary. These plutons invaded metamorphic rocks of early and late Paleozoic age which have had a complex structural history of overthrusting and faulting. Part of the mineralized area is obscured by late Tertiary volcanics.

Eight diamond drill holes ranging in depth from 581 to 1,173 ft. and totalling 7,818 ft. were put down into the mineralized area. All show a widely persistent average copper content of .04 to .05 per cent in altered quartz monzonite and in a breccia zone that is associated with the intrusive. Also, three of the holes intersected a thick section - more than 1,000 ft. - of molybdenite mineralization averaging about 0.075% $MoS_2$ and 0.05% Cu. The molybdenite appears to occur in a halo or hood-like deposit on the north side of a slightly altered but nearly barren quartz porphyry plug which is later than the quartz monzonite, and as the molybdenite is spacially related to the quartz porphyry, it is likely genetically related also. The copper, on the other hand, overlaps the molybdenum mineralization and the quartz porphyry, and is therefore later. It is thought to be genetically related to one or several of a group of Tertiary intrusives in the district. One such intrusive in the south can account for low grade copper there, but in the north, a possible source for the copper in the quartz monzonite as well as in the metamorphic rocks at and near the Adelaide mine has not been identified. It might underlie the cover of Tertiary volcanics.

## CONCLUSIONS AND RECOMMENDATIONS

The widespread and at places rather interesting amounts of copper mineralization in the Adelaide district suggests that there could be a viable copper deposit somewhere here if the right geological environment can be found. There are two possibilities: (1) A source of copper coupled with a good structural condition night exist under obscuring Tertiary volcanics north of Granite Canyon and (2) a plumbing system of fracturing and faulting might lead from the Granite Canyon mineralization area northeastward into the Adelaide mine area, and thus contact or replacement type deposits could occur along the zone in some of the limey units of the Preble formation.

To test the first possibility for a large mineralized area under the volcanics will require a simple program of rotary drilling through about 700 ft. or less of ash beds and quartz latite into basement rock. A site at about N 19,600, E 14,600 is proposed for the first hole; a second, if required, should be spotted after reviewing the first. No further property acquisition is required, but I would suggest retaining the lease on the Southern Pacific ground just northeast. Also, one should be poised to stake additional ground in section 36 to the north if a find is made. The program will cost an estimated $12,000 for two rotary holes, and require 6 to 10 weeks to complete.

The second possibility, to pinpoint targets for a replacement type deposit in the Adelaide zone, is essentially a continuation of the district study. It will require property acquisition, detailed geology mapping, trenching and geophysical work leading to a drilling program. Initial field work would require about 4 to 6 months work for a geologist and assistant after which a few drilling targets will have been selected. Ore deposits in this environment are likely to be of modest size - say, in the one to several hundred thousand ton potential, but with a fairly good grade of copper with by-product silver, lead and zinc. I think the chances for success are reasonably good, but the potential ore might be somewhat small for a major mining company.

As indicated by aeromagnetic data, the Gregg Canyon-Granite Canyon intrusive probably extends northwestward to Stony Basin under a relative shallow cover of Paleozoic rocks. This trend is crossed in Cumberland Creek by a series of fractures and faults, and as the intrusives are mineralized,this "crossing" offers a possible target.

A test of this could be done on a strictly wildcat basis by putting a hole down to about 2,000 ft. by rotary and/or hammer for a cost of $15,000 to $20,000. However, such a program could probably be better considered along with the longer range study mentioned in (2) above.

The molybdenite at the Adelaide is a sequence of mineralization separate from the copper, and therefore any further exploration for molybdenite should be considered for that metal alone. As the molybdenite that we have so far found appears to lie as a half-halo around a quartz porphyry stock, further drilling around this intrusive might find additional thick zones of Mo mineralization, but the chances are considered to be nil that any better grade will be found near the surface. A better grade, viable deposit if existent at all will have to underlie the area at some depth and it would likely be related to another intrusive or igneous pulsation not now recognized.

This possibility could exist, but there are no firm clues that it does. I suggest that a thin section study be made of the rocks associated with the molybdenite to see if any firm positive features can be discerned, and then a decision can be made whether or not to drill.

Several little irregular veins in the Vet group have contained shoots of high grade silver plus a little tungsten and copper. Our drilling and sampling indicates that no large tonnage with a viable grade can be developed here, but there is a good chance that a few more of the small shoots could be found by diligent prospecting. This potential might be of interest to a leaser or small mine operator, but it holds no opportunity for a large mining company.

## INTRODUCTION

The study of the Adelaide district for Cerro Corporation was begun in May, 1969, and has since continued fairly steadily except for a 4-1/4 month shutdown during the 1969-1970 winter. The first year's work was described by the writer in the following reports:

1. Geologic investigation of Adelaide mining district, October 8, 1969.

2. Gomes-Vetter property, drilling results, December 31, 1969.

3. Adelaide project, progress report, January 2, 1970.

The report of January 2, 1970, was chiefly concerned with the Granite Canyon copper-molybdenum anomaly and the Vet group silver-tungsten prospects, and a proposal was made for further geologic work leading to a drilling program.

This expanded work was begun in late April, 1970; several more claims were staked to cover adjacent open ground, and geochemical sampling and ground magnetic surveys were made over the claims as well as on a grid over adjacent leased ground. Several miles of bulldozer road and cuts were made for access and for geologic information, and about 8,000 ft. of air-trac drilling was done in 149 holes ranging from 30 to 80 ft. in depth.

The diamond drilling program began on August 3, 1970, and was halted on January 30, 1971, after completing 7,818 feet in 8 holes. A truck-mounted Longyear 44 with two crews was employed during the entire period and completed six of the holes; a Joy 22, also with two crews, worked from early November, 1970, until mid-January, 1971, and completed two holes.

A two-month's reconnaissance job of geologic mapping and geochemical sampling was done by W. E. Spurk in August and September. Areas of intrusives were covered in Stony Basin and Spanish Basin. Spurk's data is incorporated with mine in this report which is to summarize all of the information we have on hand and to show the possibilities that may still exist in the Adelaide district for an ore deposit.

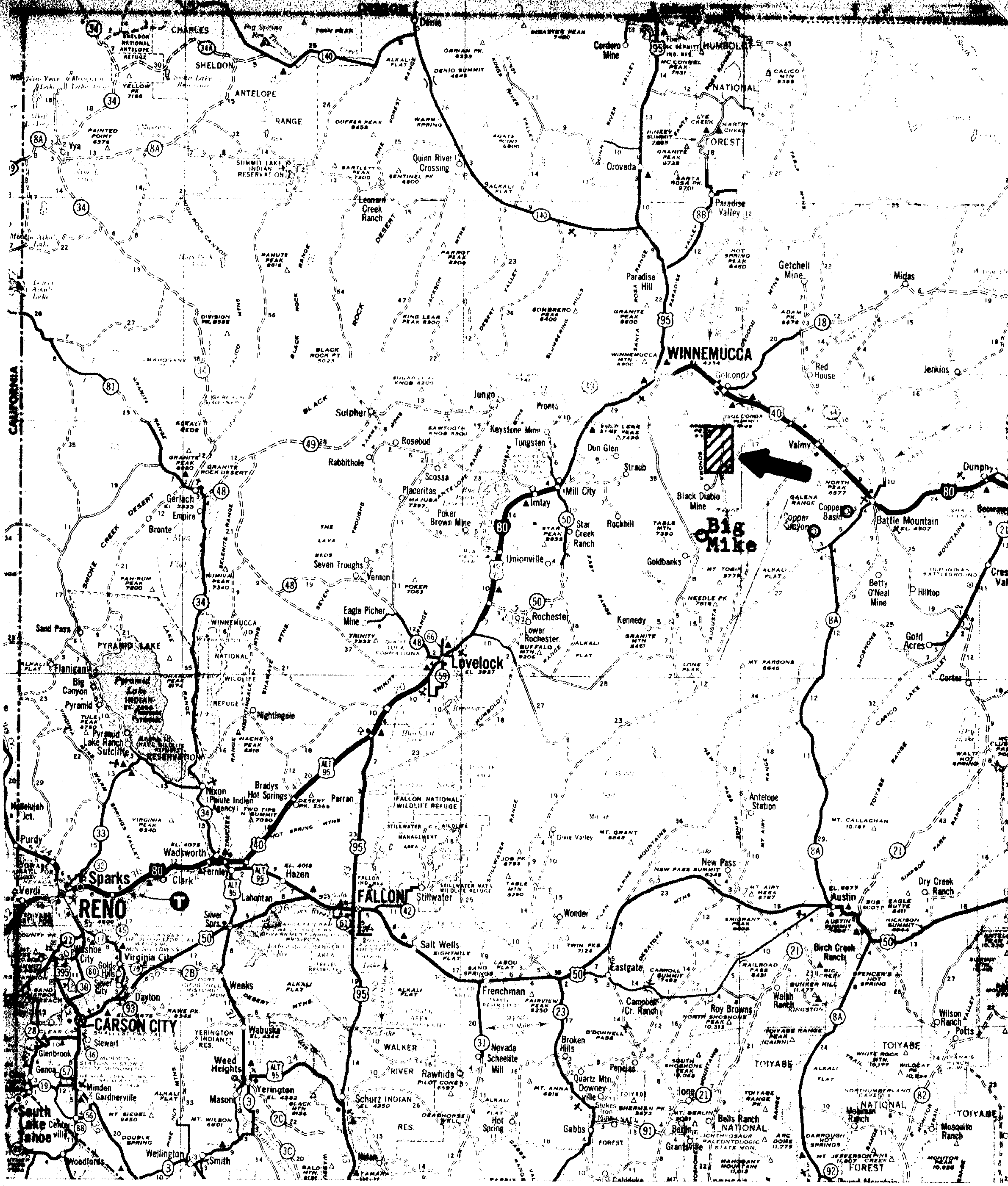


Figure 1. Map of northwest Nevada showing location of Adelaide District.
Scale: 1 in = 25 mi.

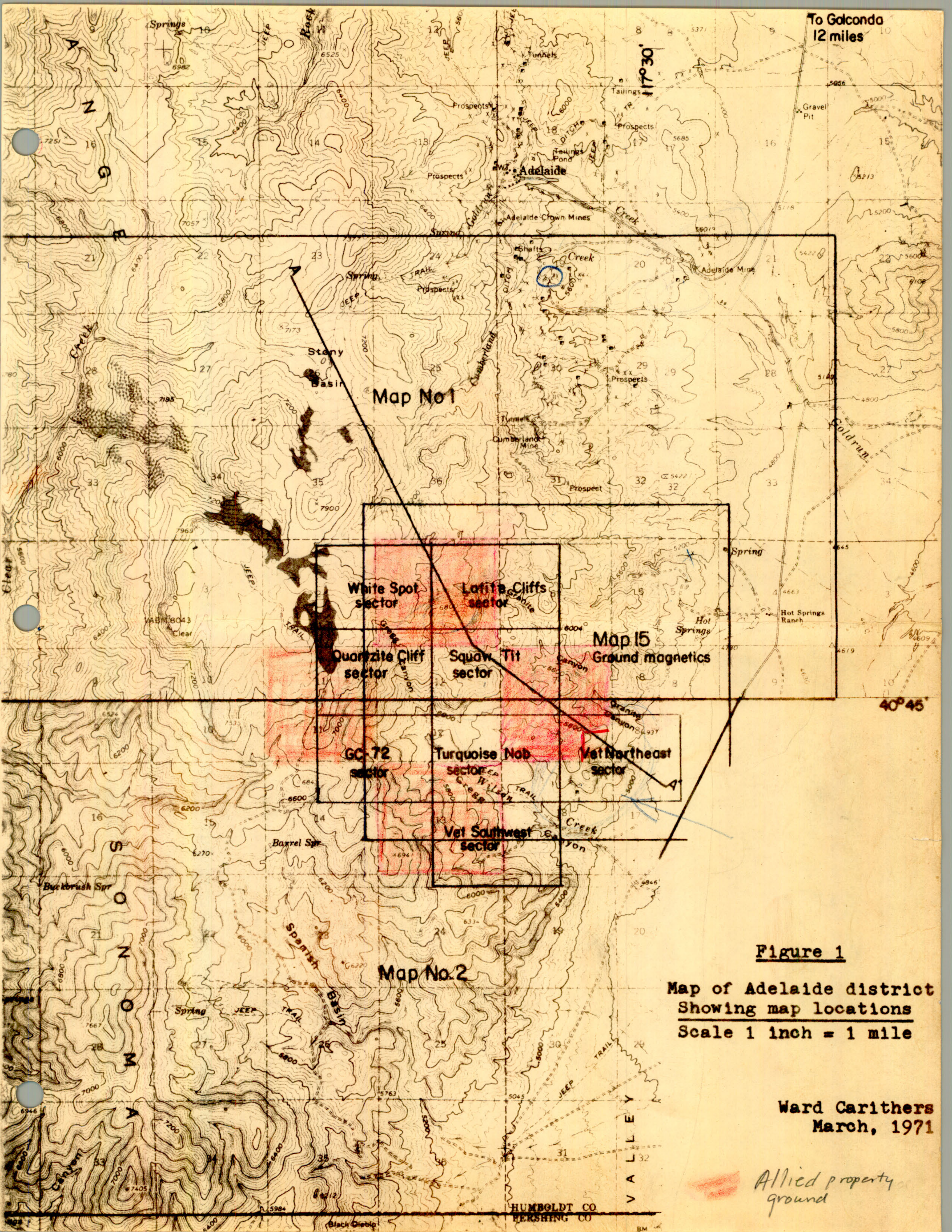


**Figure 1**

Map of Adelaide district
Showing map locations
Scale 1 inch = 1 mile

Ward Carithers
March, 1971

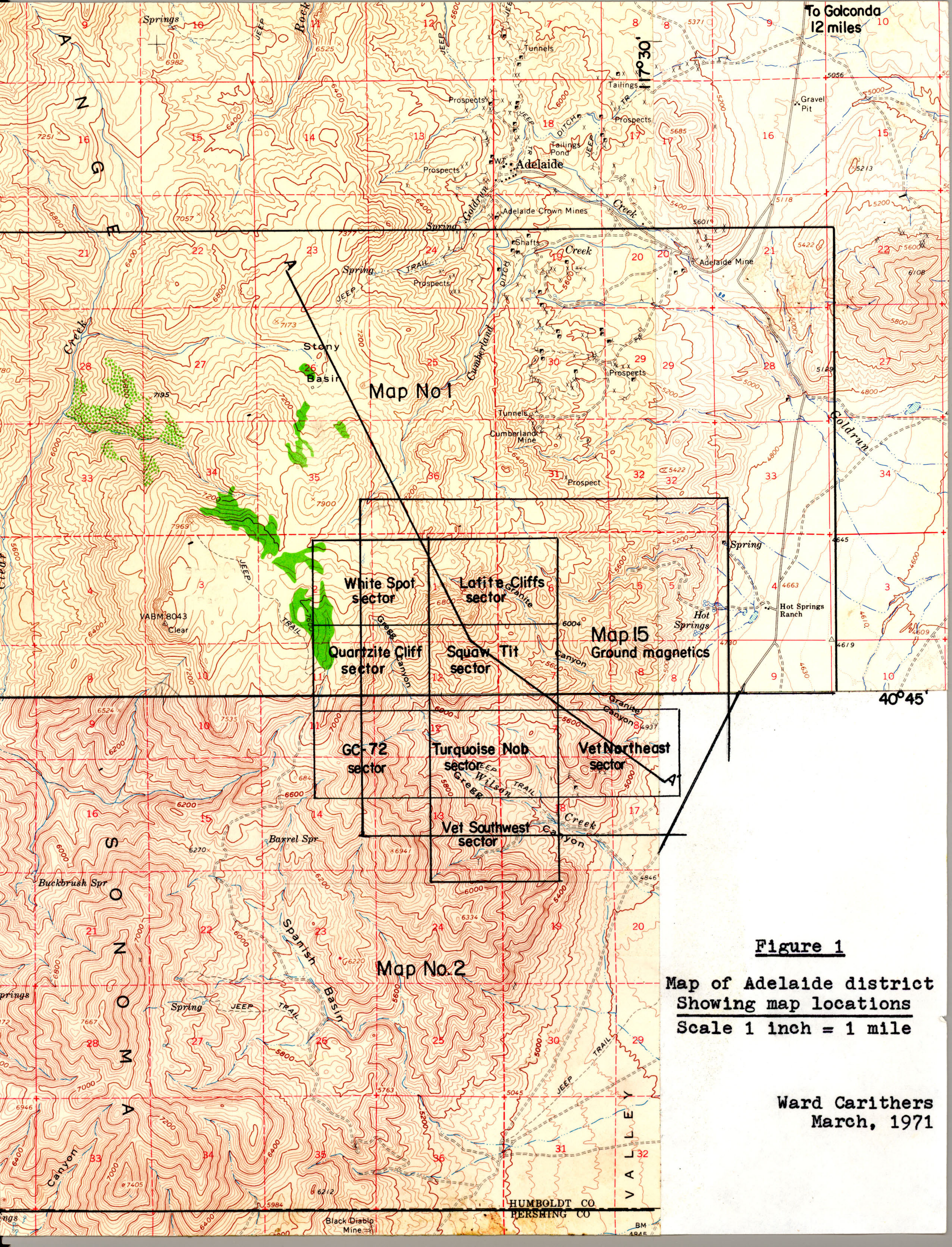


**Figure 1**

Map of Adelaide district
Showing map locations
Scale 1 inch = 1 mile

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## MAPS

Fifteen maps and sections that accompany the report are presented in a separate folio for convenience in handling; Figure 1 herewith shows the location of each. The two base maps (Nos. 1 and 2) are 1000-scale areal plans enlarged from the U.S.G.S. Winnemucca quadrangle on the north and the Leach Hot Springs quadrangle on the south, with the dividing line between being 40° 45' north latitude. Map No. 1 on the north is of Stony Basin and the northern part of the Adelaide district including the Granite Canyon breccia pipe and all of our diamond drill holes except AD-4. Map No. 2 is of Spanish Basin and the southern part of the district including the Vet group of claims and the southern part of the Gregg Canyon intrusive; AD-4 is on this map.

The main area of interest where most detailed work and the diamond drilling was done is covered by a group of eight 200-scale maps, each given a "sector" name from a prominent feature within the block. The block number of each is the north and east coordinates of the southwest corner; the coordinate system was arbitrarily established by calling the southwest corner of the GC-9 claim N 15,000, E 15,000.

Four 100-scale sections were prepared through the diamond drill holes, each showing analyses of samples and interpretations. Another over-all section on 1000-scale from the Vet prospect through the Granite Canyon and Stony Basin areas is shown on Map No. 1 as A-A'.

A 500-scale map of the Vet and Granite Canyon areas includes a plotting of our ground magnetic survey and contoured results. Aerial magnetic data developed by the Geological Survey and released in mid-1970 is shown in general on Map No. 1; this survey extends farther east, west and north, but not southward onto Map No. 2.

## PROPERTY

An additional 31 lode mining claims were staked during 1970 making a total of 105 claims and two mineral leases being held by Cerro as follows:

### Claims

| | |
|---|---|
| Vet 1 through Vet 33 | 33 claims |
| GC-1 through GC-72 | 72 claims |
| | 105 claims |

### Leases

Allied Properties (expires Dec. 1, 1971)
Sec. 1, T 33 N, R 39 E
Sec. 7, T 33 N, R 40 E (except a portion of the SE-1/4)

2120 0017
between 4 and 5

# TABLE OF FORMATIONS IN ADELAIDE AREA

| AGE | FORMATION | SYMBOL | DESCRIPTION |
|---|---|---|---|
| Quaternary | landslides | Qls | Large blocks and deposits of debres. |
| " | alluvium | Qal | Stream and slope wash, includes talus. |
| Faulting and unconformity | | | |
| Quaternary | older gravels | Qoal | Older alluvium and gravels |
| Late Tertiary (?) | basalt | QTb | Flow of basalt along Rock Creek, north of Adelaide. |
| Faulting and unconformity | | | |
| Miocene | volcanics | Tvl | Quartz latite flows, domes and welded ash flow tuffs (?). |
| " | tuff and gravel | Tvt | Ash beds and gravels associated with Tvl. |
| " | dikes and plugs | Ti | Quartz latite and rhyolite intrusives. Some are probably feeders for Tvl and Tvt. |
| Faulting and angular unconformity | | | |
| Early Tertiary (?) | porphyry | TKi | Porphyritic intrusive of about quartz monzonite composition, probably later than Ki. |
| Sequence unknown | | | |
| Cretaceous | granitic rocks | Ki | Quartz monzonite and granodiorite (?) as stocks and plugs. |
| Intrusive contact | | | |
| Permian or early Triassic | Koipato formation | Pk | Mostly rhyolite and trachitic lavas: flow banded or spherulitic; breccia and tuff. Andesitic lava near base at places. |
| Major angular unconformity | | | |
| Permian | Havallah fm. | Ph | Mostly dark chert and brownish quartzite, but with smaller amounts of limestone and slate; minor conglomerate. |
| Gradational contact | | | |
| Carboniferous (Pennsylvanian) | Pumpernickel formation | Cp | Greenstone, dark chert and dark argillite with interbedded limestone and clastic sediments in variable proportions. Upper plate |
| Sonoma orogeny; Golconda thrust zone | | | Lower plate |
| Permian | Edna Mtn. | Pem | Mostly fine-grained sandstone; some slate, both somewhat calcarious; few thin limestone beds. |
| Erosional unconformity | | | |
| Carboniferous (Pennsylvanian) | Antler Peak limestone | Cap | Dark grey limestone with some shaly and sandy beds. |
| " | Highway limestone | Chy | Massive light-grey limestone. Cherty near base at places; thin sandy and pebbly layers throughout. |
| " | Battle fm. | Cb | Interbedded conglomerate, sandstone, shale, calcareous shale and limestone; lower 150 ft. is coarse conglomerate. |
| Major angular unconformity<br>Antler orogeny; Adelaide and Roberts Mtns. thrusts | | | |
| Ordovician | Valmy fm. | Ov | Interbedded chert, quartzite, greenstone with minor argillite and sandstone. Little serpentine. Some quartzite units (Ovq) are on upper plate of the Adelaide thrust. Includes former Comus and Sonoma Range formations |
| Sequence unknown | | | |
| Cambrian | Harmony fm. | Єh | Yellow- and brown-weathering arkosic sandstone with interbedded greenish-brown shale and small amounts of gritty conglomerate and limestone. |
| Sequence unknown | | | |
| Cambrian | Preble fm. | Єp | Greenish-grey phyllitic shale and slate with intercalated bluish-grey, well-bedded limestone. |
| Gradational contact | | | |
| Cambrian | Osgood Mtn. | Єom | Medium-bedded, massive, pure quartzite, well sorted and fine- to medium-grained; local micaceous partings, abundant toward top where phyllite partings are transitional into Preble formation. Base not exposed. |

Leases (cont.)

Southern Pacific Company (expires March 15, 1971)
Sec. 5, T 33 N, R 40 E
The following portions of Sec. 31, T 34 N, R 40 E:
The SW-1/4
The SW-1/4 of the NW-1/4
The S-1/2 of the SE-1/4

These properties total about 6-1/2 square miles; their border is outlined on Map No. 1 and Map No. 2. An adequate amount of assessment work has been done on the claims to satisfy work requirements for the current year. An affidavit of this work will be filed with the County Recorder, after which the claims can be held without further work until September 1, 1972.

An adverse claim, the Bad Moon, was found to be within the GC group, and as has been reported in several memoranda, Cerro attempted to clear the title by making an offer to the locator, Galen Edgar. He accepted the offer informally at one time but did not sign the contract offered to him. I last saw Edgar in mid-August, 1970, at which time I advised that Cerro had withdrawn the offer. There are no plans for further work in the area of the Bad Moon claim, and I see no reason to be concerned any longer with Edgar.

## GENERAL GEOLOGY

### Paleozoic stratigraphy and structure

The rocks of the Adelaide area include Paleozoic sedimentary and volcanic rocks, Cretaceous and Tertiary igneous intrusives and Tertiary volcanic and sedimentary rocks. A few intermontaine valleys as well as the main drainages and the Pumpernickel Valley are occupied by both early and late Quaternary alluvium. The rocks of the general Adelaide area are shown on the accompanying table of formations and the reader is referred to this as well as the references cited for more detailed descriptions.

The Paleozoic rocks include strata of two distinct sequences, one of early Paleozoic age and the other, late. As shown on Map Nos. 1 and 2 the early Paleozoic Preble and Valmy formations crop out extensively in the Adelaide district, and both are involved with mineralization. The Cambrian Harmony formation occurs only in the southwest corner of the map area where it overlies younger Valmy rocks on a thrust fault.

No upper Ordovician through Mississippian rocks are recognized in the Adelaide district - nor in all of Humboldt County, for that matter, except for a couple of minor occurrences of questionable Mississippian age. During this period Adelaide was apparently on the eastward side of a major uplift called the Antler Orogeny (Roberts, et al., 1958) and was overridden by thrust faulting from west to east and eroded. The chief structure of this period was the Adelaide thrust fault thought by some to be part of the better-known Roberts Mountain thrust to the east (Silberling and Roberts, 1962, and Roberts, 1964). The thrust is shown on the accompanying maps as sheets and klippes of Valmy quartzite resting here and there with a marked structural discordance over shales, cherts and volcanics of the lower Valmy formation along the west side of the district, and over phyllite of the Preble in the Vet area.

Most U.S.G.S. maps (Ferguson, et al., 1951; Willden, 1964) show the entire lower Valmy sequence (sometimes called the Sonoma Range formation) to have moved over the Preble along the Adelaide thrust, but I have not been able to substantiate this. No place was found where the contact could actually be observed between the Preble and lower, non-siliceous Valmy, but where they are in close proximity, as along ridges in secs. 30 and 31, T 34 N, R 40 E, and sec. 25, T 34 N, R 39 E, shales, greenstone and chert of the Valmy appear to be in contact with the Preble on a high angle fault occupied by a dike. With this interpretation, siliceous facies of the Valmy may have been thrust from west to east across lower Valmy and Preble along the Adelaide and Roberts Mountain thrust in accordance with the thinking of Roberts and others (1958), and later high angle faulting may have down-dropped the sequence on the west side of the district in accordance with Gilluly (1967). As the quartzite is more resistant to erosion than other constituents of the Valmy, these units stand out in relief and give an impression that entire units have moved; but I think our observations in the Granite Canyon sector show this not to be the case.

Late Paleozoic rocks of the Adelaide district include the Edna Mountain formation which was deposited as a near-shore sediment with other members of a group called the Antler sequence to the north and east, and the Pumpernickel and Havallah formations (Havallah sequence) which were chiefly deep water sediments and submarine volcanics to the west and south. Both sequences were uplifted and eroded probably in mid-Permian time, and the Havallah sequence was thrust eastward along the Golconda thrust. This structure is clearly shown in gullies a mile southeast of the Adelaide mine (sec. 28, T 34 N, R 40 E) where Pumpernickel and/or Havallah overlie the Edna Mountain formation along a shear zone. Farther south, in the Vet and Gregg Canyon areas, the Edna Mountain and other members of the Antler sequence are missing and the Havallah sequence overlie the Preble and Valmy formations on the thrust plane.

Following the Golconda thrust, the older rocks of the Adelaide area were overlain with a marked unconformity by the late Permian Koipato rhyolitic formation and by subsequent Triassic sediments which are well shown on China Mountain, 10 miles southeast. Except for a thin sliver of the Koipato in the Vet area, these early Mesozoic rocks were removed from the Adelaide area following a long period of erosion beginning in middle or late Mesozoic.

Mesozoic and Cenozoic igneous rocks

The intrusion of granitic rocks into north-central Nevada - and tectonic activity as well - began in Jurassic time and has apparently continued more or less intermittently until the present. Five major epochs of intrusive activity have been recognized by Silberman and McKee (Roberts, et al., 1971) by potassium-argon dating of thirty-one plutons of the region. The oldest group of dates is Jurassic (168 to 143 m.y. old), then follow two Cretaceous groups (105 to 87 and 71 to 68 m.y. old respectively); the next group is early Tertiary (40 to 30 m.y. old) and the youngest is late Tertiary (16 to 10 m.y. old).

At least three and possibly four periods of intrusive activity are recognized in the Adelaide district beginning with the Gregg Canyon intrusive which is dated 104 m.y. by the Geological Survey. This exposure of quartz monzonite is one of several in the general area, the others being in Stony Basin, 3 miles northwest, Spanish Basin, 3 miles southwest; and in Washoke and near Clear Creek Canyons 6 to 8 miles to the west and southwest, on the western side of the Sonoma Range. The altitudes of the tops of these exposures are nearly conformable suggesting that they may all be apophyses of a single, rather flat-topped stock which has been partially de-roofed of overlying intruded Paleozoic rocks. Aeromagnetic contours over the northern part of the Adelaide (Map No. 1) strongly suggest this to be the case between the Gregg Canyon and the Stony Basin exposures, and the age date of the pluton in Stony Basin is 105 m.y. (Roberts, et al., 1971), essentially the same as the Gregg Canyon. This relatively flat top of the pluton is shown in section A-A' on Map No. 1, but obviously its continuity might be broken here and there by post-intrusive faulting. Another intrusive crops out and is well indicated by aeromagnetics 3 to 5 miles northeast of the Adelaide mine. It does not appear to be part of the Gregg Canyon group, and its composition appears to be a granodiorite type rather than a quartz monzonite.

The Gregg Canyon granitic rock is a medium- to coarse-grained quartz monzonite which is everywhere more or less altered hydrothermally by later igneous activity. Typically the least altered rock is medium gray in color and consists of plagioclase, quartz and less commonly orthoclase. Hornblende is rare probably because of alteration; biotite is common and is partly altered to chlorite and a little epidote.

Much of the border of the Gregg Canyon intrusive consists of a porphyritic facies of quartz monzonite with crowded quartz euhedrons and a few large feldspars in a finer groundmass. This rock also occurs here and there within the Gregg Canyon exposure where it is thought to be erosional remnants of the former top or roof-border of the intrusive. The origin of this quartz porphyry is in question; I have been unable to determine whether it is simply a border phase of the Gregg Canyon intrusive or part of another, later intrusive. I suspect it is the latter. This quartz porphyry was observed at Stony Basin - also on the border of the intrusive - but not at the Spanish Basin exposure.

A zone or pipe of brecciation occurs on the northwest edge of the Gregg Canyon exposure where it appears to be in an embayment or in a depression in the quartz monzonite. It is 1,500 to 2,000 ft. wide and about a mile long, and is elongated in a northwest-southeast direction. The breccia is composed of sub-rounded to sub-angular abundant fragments of schist, chert, quartzite, quartz monzonite and rarely quartz porphyry in a fine-grained grey interstitial matrix containing altered feldspars and biotite. The metamorphic rock fragments are of the nearby Paleozoic rocks; in the north part of the pipe they are from the Valmy and in the south they are from the Preble. These fragments are generally not much changed by the igneous activity, but the fragments of quartz monzonite are considerably argillized and at some places they are silicified.

Petrographic work will be required to identify the fine interstitial material; I think it might be finely ground (gouge) material made by attrition in the pipe that has been hydrothermally altered. This material is completely silicified at a few places; at some others it is replaced by a pastey-looking igneous rock.

The fragment content of the breccia diminishes downward and the rock gradually merges into the "normal" altered quartz monzonite which contains a few xenolithic clusters of fragments, usually schist. The bottom of the breccia was penetrated in holes AD-1, 2, 6 and 8; but not in 7, which bottomed at 1127 ft., nor in 3, which bottomed at 814 ft. The Adelaide pipe is similar in many respects to the pipes of the Shoshone Range, 45 miles southeast, the origin of which Gilluly and Gates (1965, p. 66-75) ascribe to a sequence of pulsating intrusions and volcanic activity.

The altered quartz monzonite and the Adelaide breccia are both intruded by a quartz porphyry rock consisting of quartz phenocrysts together with feldspars to 1/2 inch or so in a finer grained ground mass, some of which is a salmon-colored matrix, probably potassium silicate. The main mass of this rock appears to be a stock or plug-like body of coarse grained material of about granite or quartz monzonite composition just southwest of the breccia zone, but irregular dikes and sill-like masses of finer quartz porphyry also occur and suggest an onion-peel structure around or over a central core. Also, as mentioned above, this quartz porphyry might have intruded along the borders and over the top of the earlier quartz monzonite. This "onion-peel" structure is not uncommon. It is known to occur in a stock at the Hall molybdenite deposit in Nye County and in a similar stock 25 miles west.

The Adelaide quartz porphyry is much like the quartz monzonite porphyry stocks at Copper Canyon and at Buckingham at Battle Mountain, and it may well have a similar age date of 38 m.y. as reported for the Copper Canyon intrusive (Roberts, et al., 1971). We have, however, shown this rock on our maps as TKi as well as several other dikes and possible apophyses of unknown age relationships scattered in the Preble formation to the northeast.

Four plugs of a grey, pastey-looking igneous rock, possibly rhyolite composition, occur in the Vet area near the east edge of the Gregg Canyon quartz monzonite, and each is associated with brecciation or a breccia pipe. One of the plugs cuts the quartz monzonite, and so is later, and another cuts a fault thought to be a spur from a range-front fault; so it could be quite young - say late Tertiary. A similar light gray dike and a possible plug occur on the contact of the Preble and the Valmy in the center of Map No. 1, and related dikes follow fracture zones also occupied by narrow veins in the same area. These intrusives might be genetically related to the mid-Tertiary latite porphyry sequence described below, but they are deeper eroded and hence are thought to be older.

A swarm of quartz latite plugs and stubby dikes punctuate the Granite Canyon sector and they seem especially abundant in the most altered phases of the quartz monzonite and the breccia. This might be because of the softness of the rock in these areas, but on the other hand, the dikes and plugs themselves may have effected some of the alteration, particularly argillization. The rock consists of a gray glassy matrix which weathers brown, crowded with crystals of orthoclase and plagioclase, some of which are embayed and saussuritized. The crystals are as much as 1 or 2 inches long in the center of masses, but they are progressively smaller toward borders. A 2- to 4-foot zone of black glass is common on the walls.

These quartz latite intrusives were the feeders for the massive cliffs of porphyritic rock that crop out and obscure the earlier rocks in the area north of the Adelaide breccia pipe, and one can actually follow several of the dikes upward through pre-Tertiary rock and observe where it broke out into domes or flows. These "flows" however were probably sill-like intrusives into a formation of volcanic ash beds and gravels which covered much of the surface at the time of the extrusion, and tuff beds can be found both below and above the quartz latite which have chilled borders of black glass on both upper and lower walls. Gilluly (1967) called these "flows" welded ash flow tuffs and gave a radiometric age of 15.3 $\pm$ .8 m.y., which corresponds to Silberman and McKee's youngest intrusive epoch (Roberts, et al., 1971).

The thickness of the quartz latite and associated ash beds and gravels was reported by Gilluly (1967) to be on the order of several thousand feet, but I can account for only 1,200 to 1,500 ft. in the Adelaide area. I think they may be only 500 to 700 ft. thick in the area just north of the breccia pipe.

The youngest igneous rock in the Adelaide area is a basalt flow probably of Pleistocene age. This occupies part of Rock Creek Valley a few miles north, but it might be represented at Adelaide by two narrow outcrops of scoriaceous basalt a half a mile and a mile south of the Adelaide mine. They are probably connected under alluvium, but I cannot determine whether they are a dike or a narrow gully-fill. A steep angle basalt dike was intersected at 1,100 ft. in hole AD-2.

Late Structure

Tectonic activity has, of course, been going on in the Adelaide area since Cretaceous time and some faults may have first controlled the emplacement of the quartz monzonite and quartz porphyry intrusives. A later group of faults trend north to N 25 E and several of these are followed by the quartz latite intrusives which, in turn, appear to be cut or followed by still later faults trending in about the same direction. One of these is a mile west of the breccia pipe; the west side is down-dropped, probably as the western block was tilted eastward bringing the Tertiary quartz latite down on the west in contact with Valmy on the east. A parallel fault bounds the Pumpernickel Valley on the east and this block also was probably tilted in that direction as late as Pleistocene as evidenced by the displacement of older Quaternary alluvium.

## MINERALIZATION AND DRILLING

Four areas of large-scale but low-grade mineralization are recognized in the Adelaide district: (1) the copper and molybdenum in and around the Gregg Canyon and associated intrusives; (2) copper in Stony Basin; (3) copper in and around the old Adelaide copper mine; and (4) silver-tungsten veins with minor amounts of other metals along the range-front fault on the west edge of the Pumpernickel Valley. The first three of these are thought to be related to the Gregg Canyon plutons, but the fourth, though superposed over the Gregg Canyon, is likely a younger, lower temperature development, possibly related to a group of plugs and breccias in the Wet area.

Gregg-Granite Canyon anomalies

Essentially all of the Gregg Canyon quartz monzonite is anomalous in copper and molybdenum, and the source of this mineralization is considered to be the later intrusives at the northwest edge of the quartz monzonite and also around its borders and in the middle where a little quartz porphyry exists as possible remnants of a former roof. However, only the molybdenum values are consistently higher in association with the quartz porphyry and can thus be shown to have a spacial and possible genetic relation to it. The copper, on the other hand, is quite ubiquitous without regard to the quartz porphyry and so probably has another source.

Eight diamond drill holes have been put down into this mineralized area and are summarized:

| Hole No. | Total depth | Mineralized Interval | Footage | % Cu | % $MoS_2$ |
|---|---|---|---|---|---|
| AD-1 | 985 | 20-948 | 928 | .042 | .008 |
| AD-2 | 1,131 | 20-1,020 | 1,000 | .040 | .088 |
| AD-3 | 814 | 214-814 | 600 | .051 | .038 |
| AD-4 | 898 | 20-898 | 878 | .031 | .008 |
| AD-5 | 1,104 | 80-382 | 302 | .073 | .078 |
| AD-6 | 1,173 | 16-1,173 | 1,157 | .042 | .042 |
| AD-7 | 1,127 | 58-1,127 | 1,069 | .048 | .066 |
| AD-8 | 581 | 15-581 | 566 | .046 | .022 |
| Total | 7,818 | | | | |

Except for hole AD-4, all of the holes were collared in the Adelaide breccia zone, and as mentioned before, AD-1, 2, 6 and 8 extended through the breccia. Both AD-3 and 7 intersected dikes of quartz porphyry cutting the breccia but when stopped, both were running into rock which was predominantly quartz monzonite with clusters of breccia fragments; so both holes might be close to the bottom of the zone. Hole AD-5 ran in fairly well mineralized brecciated and silicified schist to 382 ft., then in a quartz latite dike or plug to 696 ft. From there to 740 ft. a fault in quartz monzonite was intersected, and below to the bottom the hole continued in coarse-grained, poorly mineralized quartz porphyry, the same as on the surface 250 ft. to the south. Similar rock was found in the bottoms of holes AD-1 and 2. Hole AD-4 was collared in and remained in altered quartz monzonite to the bottom.

The consistency of the copper content in all the drill holes is somewhat remarkable and as shown on the sections, .03 to .05% Cu is essentially a "background". A few intervals assay .1 to .2% Cu, but most of these are at the water table where each hole found a thin blanket of secondary enrichment. Below, the copper occurs as chalcopyrite in tiny veinlets or in discrete disseminated grains commonly with pyrite and partly chloritized biotite. These occur in breccia, schist and quartz monzonite alike, but only rarely in the coarse quartz porphyry. This is well shown in hole AD-5 which below 740 ft. ran in coarse quartz porphyry averaging only 70 ppm Cu and 14 ppm Mo.

The best molybdenite on the average was found in holes AD-2, 5 and 7, and these three average .077% $MoS_2$ and .05% Cu including a 310 ft. section in AD-2 from 590 to 900 ft. averaging 0.15% $MoS_2$. As the holes are 800 to 900 ft. apart, a sizeable tonnage potential from the surface downward is indicated. The molybdenite occurs partly with quartz and partly without in random veinlets from a knife blade to 1/8 inch or so thick. There does not appear to be any greater amount of silicification, sericitization nor other alteration accompanying the molybdenum mineralization nor any particular rock change. Like the copper, it occurs in schist, breccia and quartz monzonite, but only rarely in the coarse quartz porphyry.

In surface plan, as outlined by holes AD-2, 5 and 7 and the surface geochemical anomaly, the molybdenite deposit occurs in a more or less arcuate pattern around the northeastern and northern edges of the quartz porphyry intrusive. This suggests part of a halo around a central core, which is a common pattern of many other low-grade molybdenite deposits. Outside of the anomalous area there is no apparent increase in copper content, but the pyrite found in breccia and quartz monzonite in holes AD-6, 8 and surrounding air-trac holes is considerably higher than the average elsewhere - up to 5 to 8 per cent in several thick sections vs. a usual content of .5 to 1.5 per cent pyrite. Hence a zonal pattern related to the quartz porphyry and molybdenite is suggested.

The molybdenite deposit probably dips northward and northeastward away from the quartz porphyry and this is suggested by an increase of $MoS_2$ downward in hole AD-6, where 80 ft. near the bottom (1,040 to 1,120 ft.)averages 0.133% $MoS_2$. Presumably if hole AD-8 were drilled to 1,000 or 1,500 ft., it also might find a downward extension of the moly deposit. But there is no suggestion that it will necessarily be of better grade. In fact, in most of the halo or hood type deposits, the molybdenite commonly diminishes in grade downward toward the lower parts of the hood.

Stony Basin anomaly

The quartz monzonite intrusive at Stony Basin is much obscured by alluvium, but rock and soil samples indicate that it is slightly anomalous in copper - but not in molybdenum - in the southeast part of the exposure and in a few smaller areas elsewhere. As the Stony Basin intrusive is probably an outlier of the Gregg Canyon pluton and is connected to it at no great depth, the anomaly is likely minor leakage from Gregg Canyon. It is reflecting an even lower grade of copper than the Gregg Canyon rock, and no further work is desirable.

Adelaide mine area

The Adelaide mine, the chief past producer of the district, was operated mostly in the early part of this century. Production records are lacking, but it is estimated that a few hundred tons of copper was produced from a modest amount of ore, and specimens that remain suggest that it was of good grade.

The ore consisted of shoots of nearly massive and disseminated sulfides erratically distributed along a zone or series of lenses of altered limestone. Ore minerals were chalcopyrite, sphalerite and galena together with pyrrhotite and pyrite. The gangue included calcite, garnet, epidote, wollastonite and other lime silicates. The mineralization occurs here and there along strike for about 1,000 ft., and it was reportedly mined down a steep dip for 300 ft. The country rock is dark gray to black calcareous phyllite and interbedded limestone of the upper Preble formation which strikes northward and dips steeply east.

As shown on Map No. 1, a fairly "sharp" geochemical copper anomaly occurs in soil over the Adelaide mine, and a probable continuation of the anomaly extends southwest for about two miles. This roughly follows a trend of several narrow silver-lead veins, but a relationship to these is no certainty for these veins rarely have copper and other, similar veins in the area with different structures have no similar copper pattern. Instead, I suspect that the anomaly is reflecting a deep seated copper pattern that follows a fracture zone toward the southwest. It might be leakage outward from the Gregg and Granite canyon mineralization in which case reactive rocks, like those at the Adelaide mine, might be the locus of mineralization.

Two groups of narrow quartz veins occur here and there between the Adelaide copper mine to the northeast and the Cumberland mine to the southwest, and these were described in the Carithers report of October 8, 1969. The veins occupy fractures or fault zones in phyllite, commonly with a latite dike, and they contain little shoots of argentiferous galena, sphalerite, arsenopyrite and probably lead-antimony minerals. They are of modest grade, and the tonnage potential of each is small.

Range-front fault (Vet) area

A fault zone extends from the Gregg Canyon area northward along the west edge of the Pumpernickel Valley nearly to the Adelaide mine. It is well marked in the Vet claim area and along the Hot Springs just west of the Tipton Ranch. Although there has been fairly late activity along this fault, it is probably an ancestral one.

In the eastern part of the Vet group the fault has created a rather complex geological situation. There, the Pumpernickel formation overlies the Preble on the Golconda thrust, and both are cut by the fault, bringing the Kolpato formation down on the east side to be in contact with the Pumpernickel and also to be intruded by quartz monzonite or quartz porphyry of the Gregg Canyon plutons. Later intrusive and breccia pipe activity added to the complex. The fault is en echelon in the east Vet area, and it as well as several subordinate fractures extending into the Pumpernickel and quartz monzonite are irregularly mineralized by hubnerite, a black, dusty manganese mineral and minor sulfides including pyrite, chalcopyrite and galena. No silver mineral was recognized, but some of the vein material contains several ounces per ton; it is thought to be with the black material. Most of the veins are in the Pumpernickel; a few are in the quartz monzonite, but they are rare in the Kolpato.

The small, narrow and irregular veins were mined at one time, but all of the old underground work is caved. So in order to test the area for any large tonnage potential, nine air-trac holes were put down to a depth of 80 ft. as shown on the Vet Northeast sector map. All holes show anomalously high silver, copper and tungsten in the rock with an average analyses of .5 to 5 ppm Ag, 200 to 600 ppm Cu, and 10 to 100 ppm W. No sample of commercial grade was drilled.

A spur vein leads from the east side to the west side of the Vet group where several old time workings explore little irregular veins in fractured quartz monzonite. Very little of the veins can be observed because the workings are all now caved but they were apparently about the same as on the east side except they have less tungsten. The veins must have been a good grade for material on the dump assays as much as 20 ounces silver per ton, plus minor copper, lead and tungsten. Quartz monzonite wall rock is considerably altered and fractured and at places it is laced by a stockworks of thin quartz pyrite veining. However, analyses of samples of this material found no commercial grade mineralization.

Twenty-one air-trac holes were put down in and around the old workings in the west Vet area and as shown on the 200-scale sector maps these were more or less in three "fences" across the trend of the southwestern-trending zone. One hole intersected a ten-foot section assaying 65 ppm Ag (1.9 oz. per ton), and another found a 20 foot section assaying 43 ppm Ag (1.3 oz. per ton). Other holes showed anomalous silver here and there, but not as consistently as on the eastern side of the Vet. The rock is also slightly anomalous in copper.

Other small veins and vein groups were recognized to the north of the Vet on spurs extending southwest from the range-front fault. One is in the north part of section 8 and another is in the northeast quarter of section 5, T 33 N, R 40 E, where an ounce or two of silver per ton and minor copper was found over narrow widths in siliceous zones in the Preble. An alteration zone along the range-front fault and around the Hot Springs is also slightly anomalous in tungsten and silver.

<u>Outlying areas</u>

Several little outlying areas with slightly anomalous copper occur here and there in Spanish Basin and the rest of the area that was reconnoitered. The largest is an area containing a few low grade copper analyses (50-85 ppm) near the mouth of Spanish Basin Creek. This low grade anomaly might be a reflection of nearby mineralization in the range-front fault, but the values are so lean that follow up work is not encouraged.

Another, smaller area is near Clear Creek in the northwest corner of Map No. 2. This place and also a dike trending southeastward across section 16, T 33 N, R 39 E, was explored for gold a few years ago by U. S. Smelting Company and by Homestake. No commercial grade of mineralization was found.

## POSSIBILITIES

<u>Target area I</u>

The low grade copper mineralization is so consistent throughout the quartz monzonite, even at depth, that I see no possibility of finding a major increase in grade within the areas of basement rock now exposed. The quantity of copper does suggest a potential for an ore body in the area, but if one is there, it will likely be in a rock type, or alteration environment or structural situation different from that which we see now in the Gregg Canyon-Granite Canyon area.

The two rock changes experienced in the drilling so far were non-productive: No appreciable difference in the copper content was observed between the breccia and the quartz monzonite, and the coarse quartz porphyry was found to be very poorly mineralized. However, these features provide a few clues. As the copper mineralization overlaps both the quartz monzonite and the breccia (which contains quartz monzonite fragments) it must be younger than both. Unlike the molybdenite, the copper appears to also overlap the quartz porphyry for it has no spacial relationship and although the coarse quartz porphyry is poorly mineralized, it does have a few hairline veinlets of rich chalcopyrite. Several thin zones of sericitization and potassic silicate alteration occur along an east-west trend between the Vet and the Turquois Nob, and at places this zone has slightly more than the average copper content. This zone is also followed by a set of irregular dark-colored dikes, and a similar dike cuts coarse quartz porphyry near the bottom of hole AD-2. So a late stage of alteration and copper mineralization is documented and it might be related to one or more late intrusives.

There are only two places where a possible copper source might occur close to the surface: (1) The late stock and hydrothermal activity in the Vet area might have spread alteration and hydrothermal activity westward, but this was weak, and I doubt that it could account for the copper being spread throughout the quartz monzonite. (2) Another intrusive and/or alteration zone might be hidden beneath the two square miles of late Tertiary volcanic rocks and sediments north of the breccia zone. Several good-looking showings of copper are on the south side of this cover, and there are veins and a copper anomaly on the north, but there is no particular reason to expect a change in the environment. Nevertheless, the obscured area is probably mineralized and consequently offers a reasonable target for another hole or two.

Target area I is shown on both Map No. 1 and the Latite Cliffs sector maps, and a test hole about half way between the north and south edges of the volcanics and slightly to the west to favor for a schist contact would be a good location for the first test hole; this is about at coordinates N 19,600, E 14,600. Access can be made by extending an existing road in the area. A rotary hole should be drilled using mud through the gravels and ash beds and I think a rotary bit will also cut the quartz latite. After reaching the basement, samples will be required of the cuttings, and if these are not satisfactory, coreing might be required. The hole should continue through a probable leached zone and into unweathered rock. This will probably be about 750 ft. deep, but 1,000 ft. of rods should be on the job to be on the safe side.

A second hole might be required, but its location should be decided after the first is drilled. If, say, a total of 1,500 ft. is drilled in two holes, the job can probably be done for about $12,000:

| | |
|---|---|
| Rotary drilling @ $4.50 | $ 6,750.00 |
| 3-1/2 days bulldozer work | 1,000.00 |
| Supervision and geology | 2,500.00 |
| Assaying | 250.00 |
| Travel expense | 1,500.00 |
| | $12,000.00 |

Adelaide anomaly

The low grade geochemical copper anomaly extending southwesterly from the Adelaide mine is an intriguing feature. As mentioned above, it is aligned with a fracture or fault system which projects northeast from upper Cumberland Creek and which probably crosses the Gregg Canyon mineralization. The Adelaide mine anomaly, then, might be reflecting an underlying plumbing system that brought hydrothermal solutions into the mine area from Gregg Canyon. The granodiorite pluton to the north of the Adelaide is closer, but it is dry.

The rocks underlying the anomaly are limey phyllites and limestone, good reactive rocks for contact or replacement type deposits. So if any ore deposits exist in the area at depth, they are likely to be similar to the Adelaide deposit: of modest size but of good grade in copper with subordinate lead, zinc and silver.

The possible targets in the Adelaide mine area are blind and hence difficult to pinpoint. A project here will require the acquisition of old claims, the staking (and restaking) of claims, detailed mapping of the geology and probable geophysical work, hopefully leading to a drilling program.

Target area II

This target area is encircled on Map No. 1 as a rather far-out possibility for exploration. It is an area considerably obscured by alluvium where the northwest trend of the Gregg Canyon-Stony Basin intrusive is crossed by a set of faults or fractures trending northeast down Cumberland Creek. This trend also aligns with the low grade copper anomaly at the Adelaide mine.

There is a little alteration and staining in Valmy rocks in the area but the rock and soil is not anomalous in either copper or molybdenum. The target horizon for a drill hole would be to see if the underlying intrusive contact is mineralized any better than it is in Stony Basin or in Gregg Canyon. The aeromagnetic contours show an embayment here which could be due to alteration or, on the other hand, to a greater depth to the intrusive. If tested, a hole at least 2,000 ft. deep should be planned, but only on a wildcat basis. It would cost about $20,000 for drilling, road building and supervision.

Molybdenite

The molybdenite in the Granite Canyon sector is believed to be of a mineralization stage separate from the copper, so any additional exploration for molybdenite should be considered for that mineral alone and not in relation to the copper. This overlapping situation may not be unusual; in the Battle Mountain district, the Buckingham molybdenite deposit, also associated with a quartz porphyry, is overlapped by copper mineralization from the nearby Copper Basin deposit.

As the molybdenite deposit that has been delineated so far at Adelaide by drilling appears to lie as a half halo around the northern side of the coarse quartz porphyry, chances are reasonably good that additional mineralization can be found around other sides. However, chances are very slim that any better grade can be found near the surface. In fact, the best surface showings and geochemical molybdenum anomaly are also on the north side, so drilling elsewhere may find less. Consequently the only way to look for any improvement in grade is down.

There are two possibilities for a grade improvement at depth, both weak: (1) If the relation of the molybdenite to the coarse quartz porphyry is only a coincidence, or if the quartz porphyry intruded later and cut out the molybdenite, then the mineralization we see now might be the top of something better. (2) As molybdenite deposits are sometimes the result of multiple igneous intrusions or of igneous pulsations and have onion-peel structures, another deposit might exist under this one and hopefully be of better grade.

We have very few favorable clues for either possibility. Hole AD-7 was still in rock averaging .066% $MoS_2$ when stopped at 1,127 ft., and hole AD-2 was still in .077% $MoS_2$ at 1,020 ft., below which the mineralization was masked by dikes. Both holes cut thin dikes of a pink felsitic porphyry which might be related to a deeper, high potash rock.

Perhaps a petrographic study of the dikes as well as of the quartz monzonite country rock will be useful to determine if there is any change in alteration downward or if there is any increase in silica or potassium silicate.

Vet prospects

The possibilities in the Vet area are limited to a few small veins containing silver ore shoots. A little higher than average copper was found in a few thin limey units in the Preble, but otherwise the copper seems weakly disseminated through the rock much as in the quartz monzonite to the west. Molybdenite, also, occurs rather weakly and erratically. Some tungsten mineralization as hubnerite and scheelite was found on a few of the dumps in the eastern Vet area; it occurs with quartz and manganese in a few of the thin veins mined in the past. Elsewhere it occurs only in anomalous amounts of 20 to 50 ppm, probably as leakage from the veins.

The known veins in which the fairly high silver was found were apparently all mined out by the old timers and any new ore will have to be found and developed. The two air-trac holes in which we found a little silver (10 ft. of 1.9 oz. per ton in No. 1131 and 20 ft. of 1.3 oz. per ton in No. 1133) made the intercepts from 40 to 50 ft. and 20 to 40 ft. respectively. This mineralization might be in one or more thin high grade veins which were diluted in the 10-ft. samples penetrating them. Not much effort would be required to dig into the showings and see if they could be followed and mined, and one might expect that other, similar showings might be found in the area if a diligent search were made. This kind of work might be profitable to a small mine operator or an individual leasor or prospector, but it is not, of course, an opportunity for Cerro Corporation.

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WC/nd

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