Geologic Report

RYAN CANYON PORPHYRY COPPER PROSPECT

Gillis Range, Mineral County, Nevada

by

Anthony L. Payne

July, 1966

Geologic Report

RYAN CANYON PORPHYRY COPPER PROSPECT

Gillis Range, Mineral County, Nevada

by

Anthony L. Payne

July, 1966

INTRODUCTION

The Ryan Canyon porphyry copper prospect was originally brought to the attention of Quintana Minerals Corporation by Mr. Kenneth Palosky of Hawthorne, Nevada. Mr. Palosky had staked a number of claims in the altered area comprising the prospect, and when a number of the major mining companies began showing interest in the area Mr. Grant H. Huntley of Quintana Minerals Corporation was informed.

On January 15th and 16th, 1966, Mr. Huntley conducted the writer over the ground, and a proposal for further study was made in a memorandum to Mr. Ron Thompson dated January 17, 1966. This report summarizes the results of the work outlined in the memorandum.

Mr. Huntley has attended to all aspects of property acquisition, and has reported separately upon the status of this work.

By the end of March, the area was clear of snow, and the sun was high enough during the middle of the day to avoid deep shadows in the canyon bottoms. On April 1st, vertical aerial photography was flown under contract by Western Aerial Photo, Inc., of Redwood City, California. Black and white photographs were taken at an approximate scale of 1 inch equals 500 feet, and colored exktachrome transparancies were flown at a higher elevation, on an approximate flight scale of 1 inch equals 1000 feet. The photography was done with a recent model Swiss Wild camera. The black and white photographs were used in the field for plotting geologic contacts, and for the preparation of the base for the geologic map accompanying this report. The colored transparancies were used as an aid in photogeologic interpretation of details such as the pattern of hydrothermal alteration. The map base was prepared during April by Kail Radial Plotter, using found monuments of the public land surveys for horizontal scale control and for meridian. Spot vertical elevations were taken from the Hawthorne 15-minute U.S.G.S. topographic quadrangle.

Field mapping and geochemical sampling was done during May and June, 1966.

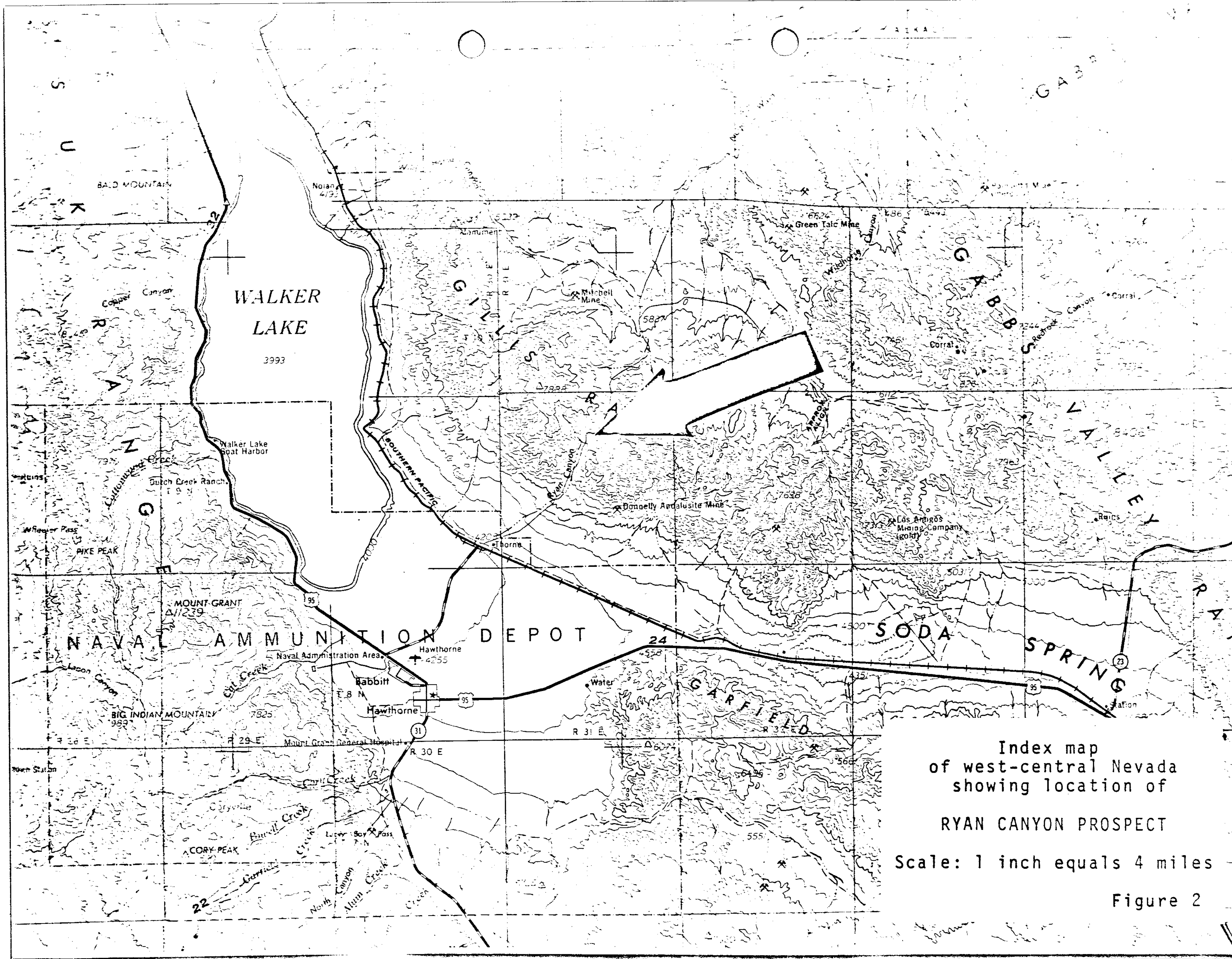
LOCATION

The altered zone comprising the Ryan Canyon prospect crosses Ryan Canyon near the corner common to Sections 9, 10, 15, and 16, T. 9 N., R. 31 E., about eight miles northeast of Hawthorne and 4 miles northeast of Thorne, Mineral County, Nevada. A paved road from Hawthorne leads to Thorne (a rail siding on the Southern Pacific Railroad). An excellent graded gravel road up Ryan Canyon from Thorne crosses the center of the prospect.

SITUATION

The arid climate of the area is that typical of much of the western Great Basin. At Hawthorne (4300 ft. elev.), temperatures range from a minimum of -6° (F°) below zero to a maximum of 107°. Average annual precipitation is just under four inches, less than half of which is in the form of winter snow. Most of the remainder is in downpours during late summer thundershowers, particularly in August and September when cloudbursts are likely to locally disrupt activity because of flashflood wash-outs.

The 1500-2000 ft. difference in elevation between Hawthorne and the Ryan Canyon area results in a slightly lower average temperature, perhaps a range of -15° to 100° (F°), with slightly higher rainfall. At this latitude in the Gillis Range, only scattered juniper and pinyon pine are found at the very highest elevations. Salt brush and sage brush are the common shrubs found in the area, and grass is sufficient for spring sheep grazing only along the crest of the mountains above 7,000 feet.



Index map
of west-central Nevada
showing location of

RYAN CANYON PROSPECT

Scale: 1 inch equals 4 miles

Figure 2

Water has been developed in a well at Thorne, and it is presumed that the valley, occupied as it is by Walker Lake, would provide ample water for future mine development.

HISTORY OF THE AREA

The harsh conditions in the area favor no activity save for attempts at mining. There are only brief references to prospecting and mining prior to the 1900's. A variety of small deposits in the Fitting (Acme) district to the south were worked for silver, gold, lead, and copper where replacements and quartz veining occur in the siliceous sedimentary-volcanic rocks near the contact of quartz monzonite igneous intrusives. The Fitting district is shown on the index map where the quarry symbol appears in south-central T. 9 N., R. 32 E., on the 1:250,000 index map on the following page. These mines shipped a few hundred thousand dollars of mineral in the period 1905-1909.

At the Donnelly Andalusite mine, aluminous minerals replace volcanic rocks of the Excelsior formation 2 miles south of the Ryan Canyon altered zone. Champion Spark Plug of Detroit explored these properties during World War II as a possible source of refractory for spark plug cores and other electrical porcelains.

Around the margins of the quartz monzonite intrusions, small contact metasomatic scheelite occurrences were sporadically prospected in the tungsten boom of the early 1950's.

Several hydrothermally altered zones along fractures in the quartz monzonite pluton southeast of Ryan Canyon have been prospected for uranium and thorium-bearing minerals.

At the mine symbol in central T. 10 N., R. 31 E., marked "Mitchell Mine" on the index map, small quantities of silver, lead, and copper have been mined.

Within the past two years many of the major mining companies have focused attention on a belt of ground extending from Tonopah to Yerington. Recently geologists have begun to refer to this as the "Walker Lane" area, and most probably this name will gain popular acceptance (even though it is a misnomer, for the area of interest represents only a small portion of the true Walker Lane, and lies at an angle to it). Banner, Hecla, Bear Creek, Anaconda, A.S. & R. Co., Occidental Petroleum, and a number of other exploration groups are active in the area, and geologists representing most of the major mining companies are seen passing through Hawthorne, Luning, and Tonopah. Most emphasis is in exploration of porphyry copper-molybdenum prospects. Drilling is actively underway in at least three areas at the present time. From an exploration standpoint, little has yet been learned from the area, and it may safely be presumed that encouragement at any of the areas being drilled will trigger a period of really intense property acquisition and physical exploration.

GEOLOGY

General

The Gillis Range trends southeast from the eastern shore of Walker Lake for approximately 25 miles where it joins the Gabbs Valley Range at a low pass just north of Luning. The range is about 4 miles in width, with an abrupt southwestern front that probably represents a basin and range fault blocked out along the "Walker Lane", the peculiar structural-topographic trough that parallels the eastern front of the Sierra Nevada.

The southwestern foot of the range lies at an elevation of 5,000 feet, and several irregular peaks along the crest of the range are 7,500 to 8,000 ft. above sea level.

Permian (?) and Triassic

Excelsior formation.--The oldest rocks exposed in the Ryan Canyon area are the volcanic-sedimentary assemblage named the Excelsior formation because of the excellent exposures in the mountains of this name just southwest of Mina. Regionally, the Excelsior unconformably overlies a thin Permian sandstone and grit called the Diablo formation. However, for a distance of at least 25 miles in every direction from Ryan Canyon, the base of the Excelsior is not exposed, and it is by no means certain the Diablo would be found beneath the Excelsior in the project area. The problem is somewhat academic, for the Excelsior is apparently thrust into the Ryan Canyon area from the west, and the normal stratigraphic sequence is disrupted by the thrust fault. The rocks underlying the thrust are actually younger than the Excelsior formation.

The Excelsior formation is a typical eugeosynclinal 1/

Note: 1/ Eugeosyncline, the sea-ward portion of the Geosynclinal trough adjoining a continent, rich in volcanic rocks.

sequence of volcanic rocks interbedded with impure sediments. It is comprised of flows, flow breccias, and tuffs ranging in composition from andesite to rhyolite, along with tuffaceous siltstones and sandstones. Limestone units are locally found in the Excelsior and are completely recrystallized to marble. Hydrothermal alteration in the central portion of the project area has completely obscured the primary features of the rocks. In the un-altered peripheral area, widespread epidotic alteration may be taken as evidence of an underlying intrusive. As is commonly the case in Triassic volcanic assemblages of the region, the over-all dark color of the rhyolites leads to an under-estimation of the amount of felsic material present in the formation. Thin sections indicate a far greater amount of rhyolite than one would estimate in visual estimates of outcroppings.

Regional studies by Ross 1/ indicate that:

> ".....the Excelsior can be divided lithologically into four types: (1) rhyolitic rocks, including soda rhyolite and quartz latite, (2) intermediate rocks of the rhyodacite and dacite groups, (3) andesitic rocks, and (4) fine-grained clastic rocks.
>
> ".....The rhyolitic rocks include both flows with prominent flow structure and tuffs; some of the tuffs are probably welded tuffs (ignimbrite). Some of the felsic rocks are white to light gray, but others are dark gray and resemble andesite. In the fresher rocks scattered quartz, sodic plagioclase, and potassic feldspar (hereafter referred to as K-feldspar) phenocrysts or fragments are set in a fine-grained groundmass of quartz and feldspar. In some specimens a relict shard texture is remarkably well preserved. Sericitic material is

Note: 1/ Ross, D. C., 1961, Geology and Mineral Deposits of Mineral County, Nevada, Nevada Bureau of Mines Bulletin 58.

common in the rhyolites, and in the more altered rocks permeates phenocrysts as well as the groundmass. In areas of more intense alteration, particularly in some of the mining districts, rocks of rhyolitic appearance and apparent rhyolitic composition may have been produced from more mafic material by the addition of silica and other materials.

".....The intermediate rocks include those which have either insufficient dark minerals or plagioclase too sodic to be considered andesitic, as well as those which lack significant amounts of quartz. This category may include some trachyte and latite. Most of the rocks and dark colored and superficially resemble andesite. Tuffs and flows, or hypabyssal intrusives, are present. Some of the tuffs are possibly welded. In the hypabyssal intrusives plagioclase and less commonly biotite or hornblende phenocrysts are set in a fine-grained matrix of quartz and feldspar. The intermediate rocks are widely distributed in the Excelsior formation, and locally make up a large part of the formation.

".....The andesitic rocks are dark gray to green and include both tuffs and flows or hypabyssal intrusives. Some specimens contain abundant augite which is in part altered to hornblende but more commonly hornblende and biotite aggregates are pseudomorphic after the original pyroxene phenocrysts. Andesine to labradorite phenocrysts are locally fresh, but more commonly extensively sericitized. Although the dark color of outcrops suggests that andesitic rocks make up a large proportion of the Excelsior formation in the Wassuk and Gillis Ranges, thin sections indicate that felsic rocks are no less abundant, particularly in the Gillis Range. Some mafic intrusives shown on the geologic map may be genetically related to the andesitic rocks. The mafic intrusives are commonly associated with outcrops of the Excelsior formation, and are similar in composition to some of the andesites.

".....The fine-grained tuffaceous clastic rocks found locally in various parts of the country are exposed most extensively on the south flank of the Pilot Mountains. These rocks are varicolored, commonly in shades of gray, brown and red. Most of the rocks are well bedded and contain clastic fragments of coarse to fine sand size. Also common are dense, siliceous rocks that resemble

> chert. Thin sections of these rocks, however, exhibit a clastic texture with angular silt- to fine-sand-sized quartz fragments scattered in a finer grained mosaic of quartz, feldspar, and mica. In one of the siltstone specimens small, rounded areas suggestive of Radiolaria are visible in thin section. Particles in some of the sandy layers have textures that suggest they are fragments of groundmass material of volcanic rocks. This, plus the association with volcanic layers, suggest that the clastic rocks are in general tuffaceous, although in some places there is no direct evidence of a volcanic parentage.........."

In the project area, thin section study of selected specimens indicates a particular abundance of fine-grained metagranodioritic textured rocks that may represent shallow intrusives in the Excelsior formation. In this area, as elsewhere in the surrounding region, these metagranodiorites are so intimately related to the andesitic portions of the Excelsior, that the intrusive probably is genetically related and the dark color and peculiar texture are caused by contamination by the Excelsior.

Because of the various effects of hydrothermal alteration (see below) it was not possible to distinguish between rock types within the Excelsior formation, and the entire unit is shown on the map in green color. It may prove desirable, if preliminary exploration is successful, to break the Excelsior formation down into more refined map units by detailed mapping. This work would require extensive petrographic study under the microscope, but would unquestionably be worth while, for the various rock types can be expected to behave quite differently during alteration and mineralization. One or more units will most probably be found to be most receptive to ore deposition.

Triassic

Luning formation.--The type locality of the Luning formation is taken from the small town of this name, near the north slope of the Pilot Mountains, where the unit is typically developed and well exposed. A complete section is not known, but Ferguson and Muller* estimate about 5,000 feet in the Garfield Hills just southeast of the Gillis Range. The Luning rests unconformably on the Excelsior formation wherever the contact is exposed elsewhere in the region, and abundant fauna indicate an Upper Triassic Age for the sediments. The formation consists of limestone, shale, argillite, conglomerate, and dolomite. The Gillis Range exposures are probably the uppermost portion of the formation, consisting of alternating units of well-bedded limestone and shale.

The Luning formation is conformably overlain in this region by the Gabbs formation, a 400 ft. thick unit of interbedded dark-colored shale and limestone in thin beds. The Gabbs formation is uppermost Triassic in age.

Cretaceous-Tertiary

The entire southeast end of the altered area shown on the geologic map consists of a granitic-textured rock, at the northwest end of a large intrusive pluton that extends for ten miles down the length of the Gillis Range to the southeast. The intru-

Note* Ferguson, H. G., and Muller, S. W., 1949, Structural Geology of the Howthorne and Tonopah Quadrangles, U. S. Geol. Surv. Prof. Paper 216.

sive is predominately quartz monzonite, although the composition ranges to granodiorite and albite granite. This intrusive is quite similar in texture and composition to the great batholith of the Sierra Nevada, and it is possible that they represent the same general period of late Cretaceous-early Tertiary magmatism. Similar intrusives are found cutting Jurassic sediments nearby. No contact relationships have been found with Cretaceous rocks. The Miocene volcanics of the area are erupted over an erosion surface cut into the granitic rock, further suggesting a "Laramide" age for the intrusion. Recent regional radioactive age dating supports an early Tertiary Age for the granitic intrusives.

It is quite possible that the Ryan Canyon altered zone is intruded by irregular small stocks, or by dikes and sills of porphyritic igneous rocks related to the larger granitic pluton.

Tertiary

The Tertiary rocks mapped along the northern margin of the Ryan Canyon area are porphyritic hornblende andesite volcanic flows. They are completely fresh, and are underlain by a thin sheet of gravel that was deposited on the deeply eroded older sedimentary and igneous rocks prior to the volcanism. These andesite flows are probably Miocene in age. There is no way of estimating the total thickness of the eruptives, but they represent scattered remnants of a once extensive volcanic assemblage that covered much of the region prior to Pliocene block faulting, uplift, and erosion.

In latest Pliocene or perhaps Pleistocene time, local basalt volcanism was related to the mountain-front basin-and-range faulting. Particularly common are cones and irregular flows erupted through structures along the uptilted side of the ranges, where faulting presumably tapped the molted simatic layer beneath the solid crust. At the mouth of Ryan Canyon, just south of the mapped area, a typical basalt flow is found, presumably having been erupted through the fault that borders the southwestern front of the Gillis Range. The rocks are gray vesicular olive basalt.

Three types of alluvial gravel are present in the Ryan Canyon area. One very old gravel, mapped separately in NE¼NW¼ Section 4, contains many cobbles and boulders that are derived from outside the project area. The deposit lies on an old erosion surface that may be older than the present Gillis Range. It is likely that this high gravel lies immediately beneath the Tertiary hornblende andesite volcanics, shown on the map as "Tv". This deposit would therefore be much older than some of the more recent "older gravels" shown by the same symbol on the map. More will be said of this old erosion surface below, for it has considerable exploration significance.

More recently, another type of older gravel was deposited, it has been mapped along the sides of the modern arroyos and canyons draining the area. These gravels were laid down upon poorly developed terraces which exhibit a crude relation to the gradients of present stream courses. These gravels are locally derived, and represent remnant alluvium from a topographically h... r series of erosion patterns that existed earlier in the down-cutting cycle of the Gillis Range.

Structure

Regional setting.--The Gillis Range is situated near the middle of what was once a great marine seaway extending through western Nevada from north to south; the eugeosynclinal portion of the Paleozoic Cordilleran trough. During Jurassic time, the land mass to the west of the Hawthorne area was uplifted, and much of the Paleozoic sediment slid out to the east over the younger sediments on the floor of the ocean basin. The result is that older Triassic Rocks of the Excelsior formation were "thrust" over the younger Luning formation in the Gillis Range. This flat structure has been named the "Gillis Thrust" by Ferguson and Muller, and it is well exposed immediately north and east of the Ryan Canyon area, along the northeastern front of the Gillis Range.

At a much later date Laramide folding, faulting, and magmatism deformed the rocks, including the Gillis thrust itself, and culminated in intrusive igneous activity, hydrothermal alteration, and metallization.

During or closely following the period of granitic igneous intrusion to the southeast of Ryan Canyon, pervasive hydrothermal alteration and metallization took place over an irregular area several thousand feet wide and about 3 miles long. It is possible that intrusive rocks underly much of the altered zone, as it is parallel to the trend of the intrusive, and occurs at one of it. Furthermore the altered zone may contain porphyry dikes or other small, irregular intrusives. Many times during mapping, strongly altered rocks were seen that are suggestive of hypabyssal igneous differentiates from the main granitic body.

In a rude en echelon pattern, several N 15° W faults with an over-all trend of N 30° W dip steeply to the west, abruptly limiting this side of the altered zone. At a number of places along these structures, notably in NE¼NE¼ 16, SE¼SE¼ 9, and NE¼SE¼ 9, the fault is sufficiently broken and mineralized to have been superficially prospected.

A long period of uplift and erosion followed intrusive activity and mineralization, and it is likely that the upper portion of the Ryan Canyon altered zone was exposed to erosion and oxidation, for the older gravels and Miocene volcanics rest directly upon an old erosion surface cut on Excelsior formation not far from the edge of the altered area.

Following this extended period of early Tertiary erosion, widespread eruptions completely buried the area with intermediate to acid volcanic eruptions. The upper portion of the early Tertiary flows was interbedded with a sequence of diatomaceous sediments, which in turn was overlain by a rhyolitic volcanic sequence, probably in late Miocene time. These younger Tertiary sediments and rhyolites, if they actually were deposited over the Ryan Canyon area, have been completely removed by post-Miocene erosion.

Late in the Pliocene the Gillis Range was block faulted upward along basin-and-range faults which mark the base of the range on either side, and basaltic eruptions issued from vents along the frontal faults. A less intensive period of erosion followed, modifying much of the surface to its present topographic form, and filling the bed of Walker Lake to the west and Nugent Flat to the east.

Periodic movement along the frontal fault continues to raise the Gillis Range upward, and consequent downcutting of the streams has left terrace-like gravel deposits a few tens to a hundred or more feet above the floor of the present drainage system.

At the present time, oxidized and decomposed rock at the surface is being swept into the arroyo bottoms during the cloudbursts. In excessive flooding conditions, this material is carried completely out of the area, and the water scours down into the stream floor bed rock. Ryan Canyon is presently undergoing active degradation.

Hydrothermal Alteration

Only one type of rock in the Ryan Canyon area has been subjected to intense hydrothermal alteration. The Excelsior formation is prominently altered in a zone several thousand feet wide extending more than three miles to the northwest from the northwestern edge of the elongate granitic intrusive mass forming the bulk of the Gillis Range.

Alteration ranges in strength from chloritic and argillic alteration to intense sericitization, along with biotitic, albitic, and K-feldspathic alteration. Silificiation is locally prominent. It was not possible to separate alteration facies during the time alloted to mapping. There is such a wide variety of rock types present in the Excelsior formation that only the most painstaking detailed work would delineate the exact nature and extent of hydrothermal effects in all areas. One of the principle difficulties is that, without being sure of what the rock was to begin with, one cannot be confident of the cause of the effects observed in the altered specimens.

Locally, particularly in areas where the Excelsior is suspected to have formerly been calcareous, epidote-garnet-quartz intergrowths are found, and this type of alteration is thought to represent a most intense modification of the original rock.

Metallization

There is abundant evidence of widespread introduction of pyrite into the rocks of the altered zone. In most places, fracture control of sulphide minerals seems to be more important than actual dissemination. Thorough oxidation has obscured relationships, for much of the limonite has not precipitated in exactly the site of derivation of the iron.

At a number of places, weak copper mineralization is observed in the form of secondary copper sulphate stains along fractures, and local slight evidence of molybdenum mineralization is obscured by the pervasive occurrence of bright yellowish-orange jarosite, an intermediate product resulting from the oxidation of pyrite.

From place to place along the more prominent steep faults, there is enough mineralization to have attracted the attention of early prospectors. A number of channel samples of such material were cut for comparative purposes, and the results are appended to this report. Several of the samples represent typical mineralization out in the wall rock away from obvious fracturing.

Sample 1393 is particularly deserving of comment, for it was taken from a bulldozer cut made by Quintana Minerals Corporation in the obviously mineralized fault zone in NE¼SE¼ 9. The trench cut down into the bed rock several feet below outcrop, and the improvement of copper showings is taken as an encouraging sign that surface croppings may similarly be leached relatively clean of copper over much of the project area.

Oxidation

Chemistry.--The extensive alteration has resulted in large areas that are relatively non-reactive, that is, unable to re-precipitate secondary copper in and near the surface. Furthermore, evidence that the metallization accompanying hydrothermal alteration is quite pyritic, resulting in "pyrite:chalcopyrite" ratios far too high to permit good development of limonites in the croppings. A good share of the limonite seen is of the dark, botryoidal type characteristic of pyritic mineralization. There is little "relief" limonite of the sort indicating secondary chalcocite enrichment at or near the base of oxidation.

A further difficulty is that the hornblende andesite, contaminated diorite, etc., of the Excelsior formation, contain a variety of iron-rich minerals, some of which have been partially oxidized and have produced peculiar limonites that confuse interpretation. The altered rock is so pyritic that the resulting acid conditions prevailing in outcrop during oxidation have further modified the rocks during supergene alteration. At many places, particularly in the arroyo bottoms where patches of partially oxidized pyritic rock are seen, jarositic staining is prominent. This jarosite appears to be an intermediate oxidation product between the primary sulphides and secondary oxides, and is usually found along fractures or moderately mobile in some other fashion such as foggy staining around the site of a former pyrite crystal.

It can be seen that a good deal depends upon a rather obvious possible relationship. If the croppings in the altered zone at Ryan Canyon are in the leached portion of a porphyry copper deposit, the copper must have preferentially been leached from the surface croppings. Of course, if this were not the case any deposit present would have long ago been discovered by conventional surface prospectors. There are a number of porphyry copper occurrences where pyrite survives copper sulphides in leached cappings.

As will be discussed below, stream sediment reconnaissance geochemical sampling for copper and molybdenum indicates that several slightly anomalous situations exist, particularly in S½NE¼ 15. Here several small unaltered zones lie within the main altered belt. They appear to be the locus of uncommonly [illegible] copper and molybdenum values at the surface. It is quite possible that metals are concentrated at the surface here because these unaltered (hence reactive) zones serve to hold a copper and molybdenum in the outcrop, whereas the metal in nearby more strongly altered rocks would have been completely flushed clean from the cap rock.

<u>Physiography</u>.--The presence of several old terrace gravel deposits and at least one very old Miocene volcanic flow unit and underlying gravel lend support to the idea that the Ryan Canyon area may have been subject to a number of cycles of oxidation. Perhaps one or more of these earlier erosional phases may have taken place under climatic conditions more favorable to oxidation and supergene enrichment than the existing situation. Hopefully, a mid-Miocene period of accelerated weathering may have taken place, for such older surfaces usually result in important leaching and enrichment.

There is over a thousand feet difference in elevation between the outcrops of Tertiary volcanics in NE¼ 4 and the bottom of Ryan Canyon where it cuts through the altered zone in E½ SE¼ 9. Without making any allowance for old topographic surfaces or subsequent faulting, it is difficult to imagine a differential leaching of copper sulphides from this entire vertical interval without some evidence seen in the form of secondary staining, limonite, or other intermediate oxidation products. The answer to this problem is that then, perhaps even more than now, the Ryan Canyon altered zone was a deeply oxidized, relatively soft, easily eroded zone that expressed itself as an elongate basin or trough, much as it looks today, but perhaps less rugged. It is possible therefore, that such an old topographic surface might project far less than 1000 ft. over the present bottom of Ryan Canyon, and that the entire altered area represents a few hundred feet of old leached capping that has partially been dissected by more recent erosional downcutting.

There is no way of estimating at what depth the present water table will be encountered, and absolutely no way of knowing where older static water levels may have occurred in relation to early erosion cycles. Exploratory drilling is the only practical method of answering this question.

GEOCHEMISTRY

General

A program of geochemical sampling of stream sediments was undertaken by collecting about 20 grams of the "fresh" from the stream beds of the drainage of the area. The samples were allowed to dry thoroughly, then screened to minus 80 mesh in stainless steel wire screen.

It was felt that such a pattern of samples might reveal broad patterns to the relative intensity of mineralization. Molybdenum was of particular interest, for it is often not mobile in surface acid conditions, and might therefore accurately delineate zones of most intense primary mineralization. Copper was determined because the fine fraction of stream sediments, (particularly clayey material), often adsorb, precipitate, or otherwise act as a locus for deposition of secondary copper compounds from aqueous solutions. Mercury was determined because of the widespread use of trace amounts of the element as a pathfinder for base metal occurrences.

Molybdenum

The map on the following page portrays the distribution of molybdenum in stream sediments in the project area. It is apparent that regional values are less than 5 ppm Mo, and averaging of the results, as tabulated in Appendix B at the end of this report, indicates 2.5 ppm to be an approximate background outside the altered zone. This corresponds well with regional and world averages for molybdenum content of such surface material.

The most impressive showings of molybdenum in stream sediments are found in the southeast central portion of the altered zone in the north half of Section 15. This anomalous area corresponds well with a general clustering of higher copper values (see below) in the stream sediments. This area is visually more impressive with regard to intensity of alteration and strength of mineralization, as will be discussed below in more detail.

Copper

Copper content of the stream sediment samples clearly reveals an anomalous pattern coincident with the molybdenum anomaly in north central Section 15. Background for copper is less than

100 ppm, which is in accordance with regional data.

Perhaps deserving of comment is the clearly defined pattern of higher, anomalous values occurring only in streams of very short "fetch". None of the samples from streams more than a thousand feet long is seen to contain anomalous copper. This results partly, of course, from dilution by the greater volume of sediment moving in the larger streams, but there is some sort of chemical "decay" of values involved. The normal sequence of unstable secondary copper minerals, and the loosely held copper adsorbed and exchanged on clays is not forming well. The copper is going into ionic aqueous solution. This most probably is due to the fact that acid conditions exist right at the surface, and the secondary copper (hydromorphic copper) is stable in the acid aqueous phase. This can be interpreted as good indirect evidence that the modern topographic surface is being cut down into a partially oxidized zone that contains some remnant sulphide copper. In other words modern erosion is cutting down into the area so rapidly that the physical processes remove oxidized material at the surface slightly faster than chemical processes oxidize the sulphide minerals in the sub-outcrop.

For these reasons, the distribution of copper in stream sediments may be taken as a more reliable guide to metallization than is normally the case in a thoroughly oxidized porphyry capping. A certain amount of interpretation is necessary in using the geochemical map, and it would probably be advisable to ignore all of the samples collected from streams more than a quarter of a mile in length.

Mercury

Because of the intense interest in mercury as a trace pathfinder for base metal ores, particularly in Russia, the samples were run for mercury. The map on the following page illustrates the general coincidence of high mercury values with the altered zone. There are a few discrepancies, but in general one would know that he was in background at 0-100 parts per billion (ppb) Hg, in a threshold situation at 100-150 ppb, or clearly anomalous over 150 ppb. These values correspond well with regionally derived figures.

The primary sulphide of mercury (cinnabar) is stable, and survives the physical abrasion and chemical corrosion of the stream bed. Much less is known of the nature of the secondary compounds of mercury, but much recent work indicates that such minerals survive stream cycle conditions, and that anomalous mercury values might persist far enough downstream to provide an effective reconnaissance evaluation method for base metal mineralization.

MINERALIZATION

Past prospecting activity has concentrated on four general types of mineralization in the project area: (1) sheared contacts between granite and Triassic sediments; (2) steep quartz veins that are most commonly observed at the margins of the zone of alteration; (3) the large crushed silicified zone that borders the southwestern margin of the altered zone; and (4) where limonite in fractures and disseminated into the wall rock was so obvious that superficial exploration was done.

There is a distinct connection between the larger silicified zones and the pattern of hydrothermal alteration and disseminated sulphides. It is likely that the silicification represents a phase of alteration that is quite closely related to the metallization. Re-current post-ore movement along the zones has broken them, relatively thorough oxidation has leached the croppings free of metal.

The bulk of the altered zone itself was subjected to pervasive dissemination of iron sulphide, and to a lesser extent copper mineralization. The primary sulphides were formed at the expense of primary iron-rich minerals in the rock. Partial oxidation has obscured the original primary relationships, but the limonites that have formed indicate that pyrite was probably in excess of chalcopyrite, and that the sulphides were more commonly deposited along small faults and along irregular fractures, rather than disseminated into the walls.

EXPLORATION POSSIBILITIES

Exploration possibilities at Ryan Canyon hinge upon two alternatives: (1) the present outcrop may represent a partially leached capping of a porphyry copper deposit in the Excelsior formation; or (2) the present altered croppings overly a more favorable host rock situation at depth, and a blind deposit might be disclosed by exploration drilling.

If a mineable ore deposit is to be found in the Excelsior formation beneath outcrops, one fundamental relationship must exist. The copper sulphides present in the cap rock must be leached preferentially over pyrite, and the rocks must be so non-reactive and the supergene solutions so acid that diagnostic secondary copper and limonites are not well developed. This possibility in itself is good enough to merit a preliminary drilling program to test the downward behavior of copper values in relation to pyrite.

The Excelsior formation is made up of rocks that probably vary greatly in their capacity as host to primary mineralization, and also in the manner in which they undergo supergene oxidation, leaching, and possible enrichment.

At other "porphyry" deposits in eugeosynclinal sediments, some rock types are more receptive to ore, and are much more apt to enrich appreciably under supergene conditions. At Copper Canyon near Battle Mountain, for example, one Pennsylvanian unit that outcrops very poorly at the surface is found to be much more receptive to ore, and furthermore porous enough to enhance supergene movement and re-deposition of copper. A common situation has occurred in diamond drilling of the deposit, where more or less indifferent rocks at the surface were found to be underlain by tight, weakly oxidized pyritic mineralization. As drilling progressed, however, the bit passed through this less receptive sedimentary unit and entered strongly oxidized porous formation that was in turn underlain by good ore. At a number of localities, oxidation and enrichment of good ore has gone back downdip along receptive horizons, overlain at the surface by very unfavorable looking croppings. The drilling at Ryan Canyon should be carefully interpreted with such possibilities in mind.

A completely separate possibility exists, that the Gillis thrust may lie at shallow enough depth to be reached by drill within reasonable mining limit. The Gillis thrust, if present, should be underlain by the Luning formation. Although the Luning outcrops in relatively small areas in the surrounding region, this formation acts as host to virtually all of the important copper mineralization. It is possible that hydrothermal alteration and mineralization might be much stronger in this unit, and possibilities are further enhanced by a general tendency for thrust faults to act as a "barrier" to ascending mineralizing solutions. It should be emphasized that the Gillis thrust more than likely will not consist of a single fault plane, but will probably be broken along a number of "imbricate" fault surfaces.

RECOMMENDATIONS

The size of the Ryan Canyon altered zone is permissive of one or more porphyry copper deposits, and the general character of the alteration and mineralization invites further exploration. The principal weak-point of the prospect is that the present erosion pattern is cutting into cap rock that shows partially oxidized pyrite with scant evidence of bulk copper mineralization. There is very little "relief" limonite indicative of supergene chalcocite, much of the secondary iron oxide is dense dark material resulting from an extremely high pyrite-chalcopyrite ratio. It is probable that the altered zone consists principally of pyritic mineralization, and that copper mineralization will be too weak and/or limited in size to constitute an important mineable ore deposit. Geochemistry has not been as helpful as might be desired in delineating drilling areas, and geophysics at this time would probably do nothing more than indicate the zones of most intense pyritization.

Five drill holes are recommended as a preliminary test for mineralization. For these first holes, rotary drilling is indicated because of low cost, rapid progress, and suitable sample for accurate analysis for copper and molybdenum. Each of the five holes has been designated on the geologic map by letter: A, B, C, D. and E. These location designations do not indicate drilling order of priority, and it is presumed that the holes will be numbered 1, 2, 3, etc., in the order they are drilled. The objectives of the drill hole at each location are summarized as follows. All of the holes will be drilled vertically to a depth of 500 ft. except for one to be selected when in good condition at 500 ft. depth. This hole will be drilled as deep as can economically be done with the drill rig in use, and it will be a test for the "Gillis Thrust" and underlying Luning formation.

<u>Location A</u>.--The hole to be drilled here will be a test of an area of well developed disseminated sulphides. The croppings appear to be quite pyritic, but the better-than-average dissemination here should make it possible to check the pyrite:chalcopyrite

ratio in depth away from surface leaching, while at the same time testing for ore.

Location B.--The hole at this location is a test of the downward and lateral behavior of the rock with the best surface showings of copper anywhere in the project area. This hole might be considered for the deep probe for the Gillis thrust, as outlined above.

Location C.--The drill hole here will test beneath a typical segment of the mineralized fault zone that borders the southwest margin of the altered area.

Location D.--This drill hole will test the strength of mineralization under a typical tract of well-altered Excelsior formation exhibiting sporadic, weak copper staining at the surface.

Location E.--This drill hole will check one of the stronger altered zones, near a remnant mass of unaltered Excelsior formation, near the center of a zone geochemically anomalous for copper, molybdenum, and mercury.

There is no order of preference for any of the work, although it would be advisable to make the deep test for the Gillis thrust as quickly as possible, and location B is indicated as the most logical place, inasmuch as it is at the lowest topographic spot anywhere in the project area. Drill Hole No. 1 then might be drilled at location "B".

If a 100-ft. drill hole intercept is found of 0.25% Cu or 0.10% Mo (or any combination of the two metals) further detailed ation work will be indicated.

A detailed memorandum will be prepared outlining sampling procedures, engineering record keeping, geologic methods of logging, after the drill has arrived and the necessary discussions have been made.

Respectfully submitted,

Anthony L. Payne

Anthony L. Payne
Mining Geologist

July, 1966
Reno, Nevada

APPENDIX A.

Rock samples, description, and analytical results

Sample No.	Location	Description	% Cu	% Mo	oz. Au	oz. Ag	% W	% Hg
1384	NW¼SE¼ 4	6" quartz vein.	0.28	0.02				
1385	SW¼SW¼ 10	9" quartz vein.	0.10	tr.				
1386	NW¼SW¼ 14	Manganese stained sheared vein at Tgr TRe contact.	0.03	0.01	0.01	tr.	0.02	
1387	SE¼NE¼ 15	Bulk rock sample	0.01	tr.				
1388	SW¼NE¼ 15	Selected fragments of vein material on dump.	0.03	0.01				
1389	SW¼NE¼ 15	Chip sample of bull-dozer trench.	0.03	0.01				
1390	SE¼NW¼ 15	Bulk rock sample.	0.02	0.01				
1391	SE¼SW¼ 10	Bulk rock sample.	tr.	tr.				
1392	NE¼NE¼ 16	24" quartz vein.	0.04	tr.				
1393	NW¼SE¼ 9	Chip sample of bull-dozer trench.	0.43	tr.				
1394	NW¼SE¼ 9	6" quartz vein.	0.04	tr.				
1395	NW¼SE¼ 9	Selected chips of red siliceous vein material in spoil from bulldozer trench.	0.63	tr.				0.038

APPENDIX B.

Geochemical stream sediment samples

(Refer to geologic map for exact location of sample sites, and to geochemical maps for generalized portrayal of analytical results.)

Copper analyses by atomic absorption, Rocky Mountain Geochemical Laboratories.

Molybdenum determined colorimetrically, Rocky Mountain Geochemical Laboratories.

Mercury determined spectrophotometrically, Lemaire Instruments.

Sample No.	Copper	Molybdenum	Mercury
001	20 ppm1/	3 ppm1/	110 ppb2/
002	20	4	140
003	10	3	70
004	25	3	90
005	35	3	80
006	35	3	120
007	30	3	120
008	20	2	130
009	40	3	110
010	25	4	90
011	20	2	80
012	20	2	100
013	25	4	90
014	25	3	100
015	35	4	160
016	30	2	90
017	50	3	100
018	45	3	110
019	30	3	90
020	30	2	70
021	25	4	130
022	20	2	50
023	30	2	130

Note: 1/ ppm = parts per million (microgram per gram)

2/ ppb = parts per billion (micrograms per kilogram)

APPENDIX B. (cont.)

Sample No.	Copper	Molybdenum	Mercury
024	30 ppm	2 ppm	170 ppb
025	30	4	150
026	45	5	110
027	35	4	60
028	40	3	110
029	25	3	80
030	30	4	110
031	30	4	190
032	25	3	130
033	20	3	110
034	40	4	120
035	105	4	210
036	40	4	130
037	30	3	110
038	20	3	50
039	20	4	60
040	40	3	90
041	35	4	230
042	30	5	140
043	35	3	190
044	35	4	160
045	50	3	150
046	30	3	140
047	30	3	100
048	30	5	70
049	30	4	90
050	35	4	100
051	145	5	200
052	60	5	170
053	470	3	130
054	75	3	110
055	25	2	140
056	30	2	80
057	40	2	80
058	55	2	200
059	30	3	90
060	30	2	80
061	25	2	60
062	25	4	90
063	15	2	70
064	25	2	60
065	25	4	50
066	35	3	60
067	30	4	60
068	25	3	60
069	45	3	400+
070	45	3	90
071	35	3	140
072	40	4	100
073	85	6	50

APPENDIX B. (cont.)

Sample No.	Copper	Molybdenum	Mercury
074	50 ppm	5 ppm	130 ppb
075	40	6	90
076	45	4	130
077	35	5	120
078	40	4	60
079	25	3	80
080	45	5	100
081	25	4	80
082	90	5	110
083	35	4	90
084	40	4	240
085	95	5	140
086	25	4	40
087	30	3	100
088	50	3	60
089	45	4	70
090	30	4	90
091	35	3	40
092	35	2	110
093	30	2	60
094	15	3	30
095	20	3	30
096	40	4	40
097	25	5	70
098	20	3	50
099	20	5	60
100	20	4	60
101	25	5	150
102	30	6	150
103	30	4	70
104	30	3	50
105	40	5	60
106	35	3	70
107	45	4	80
108	35	4	120
109	370	14	60
110	260	14	100
111	305	11	90
112	160	9	90
113	380	44	60
114	500	11	100
115	130	9	110
116	75	5	130
117	255	11	140
118	40	5	90
119	40	6	80
120	30	5	120
121	40	5	200
122	40	4	180
123	40	4	220
124	60	6	160

APPENDIX B. (cont.)

Sample No.	Copper	Molybdenum	Mercury
125	120 ppm	17 ppm	200 ppb
126	100	11	170
127	50	5	120
128	250	10	180
129	245	8	170
130	440	17	110
131	250	11	140
131	125	10	180
133	75	5	200
134	125	5	220
135	45	5	130
136	60	8	170
137	75	5	200
138	70	4	170
139	100	4	170
140	50	6	130
141	60	4	130
142	200	9	180
143	100	8	160
144	60	7	200
145	395	13	210
146	185	7	200
147	190	10	150
148	125	9	120
149	100	7	110
150	30	6	170
151	40	3	200
152	30	5	180
153	35	5	180
154	60	7	170
155	40	4	190
156	35	4	180
157	40	6	170
158	55	14	240
159	190	11	190
160	45	6	180
161	30	5	280
162	20	4	90
163	30	7	160
164	30	6	120
165	20	6	100
166	60	5	130
167	30	5	120
168	65	5	130
169	140	6	180
170	50	6	160
171	60	6	160
172	30	5	150
173	40	5	120
174	50	6	100
175	50	4	140