University of Nevada
Reno

Geology and Mineralization of the Marietta Area, Mineral County, Nevada

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Geology

by

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ABSTRACT

Pre-Tertiary layered rocks dominate the study area at Marietta, Nevada, in the central Excelsior Mountains. In stratigraphic order these include andesite volcanics and volcaniclastic sediments, calcareous siltstone, conglomerate with interbedded arkosic wacke and siltstone with interbedded conglomerate. They range from Permian through Lower Jurassic in age and are about 2,900 meters thick. Tertiary volcanics cap the range to the north, with a quartz monzonite intrusion bordering the area to the southwest.

The rocks strike northeast and dip to the southeast. This has been complicated in the southern portion of the area by northwest trending faults and a fold resulting from the forceful quartz monzonite intrusion.

Mineralization consists of argentiferous galena veins which are hosted by conglomerate. The veins have a preferred strike of $N60^\circ$ to $80^\circ W$ with steep dips. They can be divided into coarse grained galena veins and veins of more varied sulfide mixtures. Other mineralization includes occurrences of copper and gold.
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1. Geologic map of the Marietta Area, Mineral County, Nevada ................................................ in pocket

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INTRODUCTION

PURPOSE AND SCOPE

The purpose of this study is to map the geology of the Marietta area at a larger scale than previous investigations, paying particular attention to local petrologic and structural relationships, and to study the mineralization to determine its type, extent and origin.

LOCATION AND ACCESSIBILITY

Marietta is on the south side of the central Excelsior Mountains in southern Mineral County, Nevada, approximately 40 air kilometers southeast of Hawthorne. The study area is centered on the main canyon north of Marietta and includes the townsite in the southeastern corner (figure 1). It is in T. 4, 5 N., R. 32, 33 E. on the Moho Mountain, Teels Marsh, Rattlesnake Flat and Little Huntoon Valley 7 1/2 minute quadrangles.

The study area may be approached via State Route 10, which is a 37 kilometer paved highway that connects U. S. Highway 95 with U. S. Highway 6 (figure 2). At Belleville, along State Route 10, an improved gravel road leads 16 kilometers westward to Marietta. A two-wheel drive gravel road leads north from Marietta into the main canyon providing access to the central portion of the study area. A four-wheel drive vehicle will provide greater access; however, foot travel is necessary in many of the side canyons as they are steep and narrow. When visiting, it is advisable to inquire with one of the Marietta residents, as there is patented land and a limited amount of current mining activity in the study area.
Figure 1 - Study area from the south with Marietta in the foreground and the main canyon north of Marietta to the left of center.
Figure 2 - Location of study area
CLIMATE AND VEGETATION

The climate of the area is semiarid, hence, it is characterized by cold, windy winters and hot, dry summers with large daily temperature ranges. The nearest location for which climatic data was obtainable is Mina, which lies at an elevation of 1384 meters along U. S. Highway 95 to the northeast. These records show an average temperature of 0.2° Centigrade in January and 25.6° Centigrade in July (Ross, 1961, table 2, p. 6).

Precipitation occurs largely as snow during the winter months and as occasional summer thunderstorms which may result in flash floods. Snow melts quickly in Marietta at the foot of the range, but remains for some time in canyons and on north facing slopes at high elevations. The average annual precipitation in Mina is 8.9 centimeters (Ross, 1961, table 2, p. 6).

There are no springs in the study area, however, the water table is only 7 meters below the surface in Marietta where several wells have been drilled.

Vegetation consists primarily of Sagebrush and several varieties of grasses at lower elevations and gives way to Píñon Pine and Utah Juniper trees at higher elevations. Gentle slopes near the crest of the range are heavily forested.

PREVIOUS INVESTIGATIONS

Initial interest in the area derived from the early mining activity. Publications by Hill (1915), Lincoln (1923) and Vanderburg (1937) include brief accounts of the geology, ore deposits and mining activity.
Muller and Ferguson (1936) were the first to describe and name the Triassic and Lower Jurassic formations in west central Nevada. Later publications by these noted geologists focus on the Mesozoic stratigraphy and structural geology (1949) of the Hawthorne and Tonopah quadrangles. A geologic map of the more restricted Mina quadrangle by Ferguson, Muller and Cathcart was published in 1954. Nevada Bureau of Mines Bulletin No. 58 by Ross (1961) summarizes the geology and mineral deposits of Mineral County. A Ph.D. thesis by Nielsen (1963) focuses on the geology of the Pilot Mountains and vicinity and includes a 1:25,000 scale geologic map of the Marietta area. A 1977 publication by Speed covers the pre-Tertiary layered rocks in southeastern Mineral County.

**METHOD OF INVESTIGATION**

The geology of the 31 square kilometer study area was mapped on 1:12,000 scale black and white enlargements of 1:24,000 scale color aerial photographs. The color aerial photographs, when viewed stereoscopically, were quite useful in locating geologic contacts and structural features which were later ground checked. This information was transferred to a topographic base map of the same scale, made by enlarging the 1:24,000 scale U. S. Geological Survey topographic maps of the area.

Forty five days were spent in the field, five of which were devoted to studying the underground workings. Over 200 hand samples were collected from which 53 thin sections were made to assist in rock identification. Staining was done to aid in the differentiation of plagioclase and alkali feldspar. X-ray diffraction techniques were utilized
to assist in the identification of certain minerals. Eleven polished sections were made from ore samples to aid in mineral identification and paragenetic interpretation. Two of these sections were examined on a scanning electron microscope to locate concentrations of silver. Several samples of vein material were assayed for silver, gold, lead, zinc and copper.

Rock names used are as defined by Compton (1962), except the words conglomerate and breccia. Conglomerate, when used in this paper, refers to a sedimentary rock composed of clasts greater than 2 millimeters in diameter, while breccia refers to a texturally similar rock with a volcanic origin.
ROCK UNITS

REGIONAL SETTING

The Excelsior Mountains are composed of pre-Tertiary volcanic and sedimentary rocks which have been subjected to greenschist facies metamorphism. They were intruded by Mesozoic granitic rocks which are widely exposed in the western half of the range. These older rocks have been capped by Tertiary volcanics with Quaternary deposits filling washes.

PRE-TERTIARY LAYERED ROCKS

Four pre-Tertiary units are exposed in the study area. They include, from oldest to youngest, andesite volcanics and volcaniclastic sediments, calcareous siltstone, conglomerate with interbedded arkosic wacke and siltstone with interbedded conglomerate.

Andesite Volcanics and Volcaniclastic Sediments

Andesite volcanics and their epiclastic derivatives form the basal unit and are widespread in the study area. To the east of the main canyon north of Marietta andesite breccia is interbedded with, but generally underlain by, subordinate andesite flows (plate 1, rock unit Pv). These units are interbedded with lenses of locally derived arkosic wacke and siltstone, which form the bulk of the volcanic material to the west (plate 1, rock unit Ps). Outcrops are dark greenish-gray due to chlorite, actinolite and epidote associated with greenschist facies metamorphism. They are also generally magnetic due to minor amounts of contained magnetite.
The thickness of the andesite breccia and flows has been estimated as 1200 meters, however, this is questionable due to the lack of reliable attitudes. Individual units are up to 10 meters thick, but are difficult to differentiate due to the lack of continuous outcrop.

Porphyritic andesite flows contain subhedral phenocrysts of clinopyroxene and plagioclase in a fine grain groundmass (figure 3). Clinopyroxene, up to 9 millimeters in length, comprises 10 to 40 percent of the rock. It is completely or partially replaced by actinolite, biotite, chlorite, epidote, calcite, quartz and magnetite. Laths of albitized and partially sericitized plagioclase are up to 1.5 centimeters in length and form up to 25 percent of the rock. The remainder of the rock is groundmass, which may contain plagioclase microlites in a fine grain mixture of chlorite, actinolite, and devitrified glass. Minor amounts of epidote, biotite, calcite, quartz and magnetite, which may be skeletal, are also present.

In some flows, plagioclase phenocrysts are absent and there is an increase in the amount of clinopyroxene, giving the rock a basaltic composition. Occasionally, outcrops of this rock appear scoriaceous due to the weathering of abundant clinopyroxene.

Andesite breccia units are composed primarily of andesite flow fragments up to 0.6 meters in diameter, with lesser amounts of fine grain sediments and devitrified glassy volcanics (figure 4). In one locale, calcareous siltstone clasts were found. These angular to sub-rounded fragments are contained in a chlorite and devitrified glass matrix, which contains smaller lithic fragments, as well as plagioclase and alkali feldspar grains up to 2 millimeters in length. Lesser
Figure 3 - Porphyritic andesite flow containing phenocrysts of plagioclase (white) and clinopyroxene (dark green). Note pen for scale.

Figure 4 - Andesite breccia composed of andesite flow fragments. Note pen for scale.
amounts of biotite, actinolite, epidote, calcite and magnetite are also present.

Medium grained volcaniclastic sediments occur in beds of arkosic wacke which contain mainly plagioclase, with lesser amounts of lithic fragments, alkali feldspar and quartz (figure 5). These angular to subrounded grains comprise 50 to 80 percent of the total rock and range up to 2 millimeters in diameter, with occasional lithic fragments to 1.5 centimeters. The clasts are contained in a matrix which is dominated by feldspar and quartz with minor amounts of magnetite, but may contain considerable epidote, biotite, calcite, actinolite or chlorite.

The arkosic wacke is poorly to moderately sorted as to size, with some in graded beds up to 4 centimeters thick. Locally the larger lithic fragments dominate and form conglomerate lenses.

Fine grained volcaniclastic sediments occur in beds of siltstone which contain a few recognizable grains of feldspar, quartz and lithic fragments. The silt size matrix, believed to be similar in composition to the larger fragments, comprises most of the rock and contains variable amounts of epidote and chlorite.

The siltstone is usually massive, however, in one instance graded laminations up to 1.5 millimeters thick were observed.

Occasionally epidote-actinolite veins, up to 7 millimeters thick, cut the volcaniclastic sediments for a few meters. They are usually seen along fractures developed by jointing.

Calcareous Siltstone

Calcareous siltstone lies above volcaniclastic sediments and is dominant in the northwest corner of the study area (plate 1, rock unit
Figure 5 - Photomicrograph of volcaniclastic arkosic wacke. It is composed of mainly plagioclase feldspar (pl) in an epidote (ep) and calcite (ca) matrix. Cross nicols.
Jcs), where it achieves a thickness of 810 meters. It thins to the south, partially due to faulting.

The generally massive light greenish-gray siltstone (figure 6) contains a lense of buff weathering, dark gray siltstone (plate 1, rock unit Jgcs). The unit has been subjected to varying degrees of metamorphism, with the more intensely metamorphosed rocks taking on a lighter color. In some localized areas the rock is very hard and brittle and could be classified as calc-silicate hornfels.

In general the unit is composed of 20 to 50 percent quartz and feldspar grains. These angular to subrounded grains average 0.05 millimeters in diameter, but in some specimens range up to 0.4 millimeters. They are held in a fine grain, silt size matrix that is believed to be similar in composition to the larger grains, but contains variable amounts of calcite and tremolite. Larger grains of tremolite, up to 0.15 millimeters in length, and clinozoisite dominate in more intensely metamorphosed rocks. Minor amounts of pyrite and epidote may be present.

The light greenish-gray, slightly metamorphosed rocks occasionally contain dark gray silty laminations, which are up to 1.5 centimeters in width and extend over a distance of a few meters.

Conglomerate with interbedded Arkosic Wacke

Conglomerate with subordinate interbedded arkosic wacke dominates the center of the study area where it lies conformably above calcareous siltstone (plate 1, rock unit Jc). It achieves a maximum thickness of 1815 meters. The maroon conglomerate and light to medium gray arkosic wacke contains a few beds of dark maroon siltstone. Locally chlorite,
Figure 6 - Light greenish-gray calcareous siltstone. Note hammer for scale.
actinolite, and epidote associated with greenschist facies metamorphism and iron staining, has given the rocks a green and reddish-brown color, respectively.

Conglomerate beds are often several meters thick; however, some are as thin as 5 centimeters where interbedded with beds of arkosic wacke, which range from 5 centimeters to 5 meters in width. Sedimentary features such as graded bedding, cross bedding and cut and fills are common. Shaly cleavage which parallels bedding is seen in the siltstone.

Conglomerate is composed of angular to subrounded lithic clasts which comprise 30 to 60 percent of the total rock (figure 7). They are 2 millimeters to 5 centimeters in diameter and are primarily chert fragments with minor volcanics. The clasts are contained in a matrix which is dominated by quartz and feldspar grains and may contain considerable dolomite. Minor amounts of magnetite are also present, with epidote, actinolite and chlorite occasionally found.

Arkosic wacke is dominated by grains of quartz, feldspar and lithic fragments which comprise 50 to 70 percent of the total rock. These angular to subrounded grains average 0.1 millimeters in diameter, with a few grains up to 0.4 millimeters. They are held in a fine grained silt-size matrix believed to be similar in composition to the larger grains. Calcite occasionally constitutes a large portion of the matrix. Minor amounts of magnetite are also present, with epidote, actinolite, chlorite and biotite occasionally found.

In a few units fine grained matrix comprises a majority of the rock and it can be classified as siltstone.
Figure 7 - Graded interbeds of chert pebble conglomerate and arkosic wacke. Note quarter for scale.
Siltstone with interbedded Conglomerate

Patches of siltstone up to 60 meters thick lie unconformably on volcaniclastic sediments in the western portion of the study area (plate 1, rock unit Js). This poorly sorted maroon to purple siltstone is generally massive, but occasionally exhibits shaly cleavage. It contains a few angular to subrounded grains of feldspar, quartz and lithic fragments in a fine grained, silt-size matrix. The matrix is thought to be of similar composition to the larger grains and may contain minor amounts of actinolite, epidote, calcite and chlorite.

Lithic clasts, which include chert and volcanics up to 2 centimeters in diameter, may concentrate locally and form conglomerate lenses (figure 8). These are generally found near the base of the unit.

Correlation and Age

The pre-Tertiary layered rocks have been divided into various formations over the years (figure 9). Muller and Ferguson (1939) originally lumped them into the Dunlap Formation (Muller and Ferguson, 1939, plate 1). Although no fossils are noted from this location, similar rocks are exposed to the west of the study area in the western Excelsior Mountains and to the north of the study area in the Garfield Hills, where Lower Jurassic fossils were found (Muller and Ferguson, 1939, p. 1621).

Nielsen (1963) reduced the size of the Dunlap Formation and created the Gold Range Formation. The study area includes a portion of the type Gold Range (Nielsen, 1963, plate 5). He found poorly preserved pelecypod remains in the calcareous siltstone, which were
Figure 8 - Graded chert and volcanic pebble conglomerate lense in maroon siltstone. Note pen for scale.
Figure 9 - Maximum thickness of pre-Tertiary units exposed in study area with assigned formational names.
tentatively identified as Weyla sp. indicating an Early Jurassic age (Nielsen, 1963, p. 57-59).

Speed (1977) names the andesite breccia and flows Black Dyke Formation and correlates it with a similar unit exposed at Black Dyke Mountain 25 kilometers to the northeast. Radiometric dates of hornblende crystals from breccia fragments at both locations are nearly identical and indicate a minimum age of 252 m.y. (Speed, 1977a, p. 334). He refers to the remainder of the pre-Tertiary rocks in the study area as Upper Triassic and Jurassic shelf strata (Speed, 1977b, p. 354).

Due to Speed's recent work, the pre-Tertiary layered rocks have not been given formational names. His date of the andesite breccia is used; however, the author believes that the volcaniclastic sediments in the western portion of the study area are of similar age since they are analogous to volcaniclastic lenses in the andesite breccia and flows. Nielsen's, and Muller and Ferguson's ages for the remainder of the pre-Tertiary rocks have been adopted.

**MESOZOIC INTRUSIVES**

Quartz monzonite intrudes pre-Tertiary layered rocks and is exposed at the surface in the western portion of the study area (plate 1, rock unit Kqm). The large intrusion in the southwest corner consists of undifferentiated quartz monzonite and quartz monzonite porphyry. Quartz monzonite porphyry also occurs in small intrusions and dikes marginal to the main intrusive contact. The intrusion is thought to underlie the entire study area at depth and to be responsible for the greenschist facies metamorphism and mineralization.
Light pinkish-gray inequigranular quartz monzonite forms the main intrusion (figure 10). It contains 40 to 50 percent alkali feldspar, 25 to 30 percent plagioclase and 25 to 30 percent quartz in grains up to 5 millimeters in diameter. Minor amounts of biotite and magnetite are also present. Secondary effects include sericitization of feldspar and chloritization of biotite.

The quartz monzonite porphyry found in the main intrusion is similar in color and composition to the quartz monzonite. Euhedral to anhedral phenocrysts of quartz, alkali feldspar and plagioclase, up to 4 millimeters in diameter, comprise 40 to 50 percent of the rock. They are held in a fine grained matrix of alkali feldspar, quartz and plagioclase.

Quartz monzonite also occurs marginal to the main intrusion in small intrusions and dikes which range from 10 to 230 meters in width and 30 to 1000 meters in length. It is more variable in composition than the quartz monzonite porphyry found in the main intrusion and contains granite porphyry phases (figure 10). It is light pinkish-gray to medium gray, depending on composition, which varies from 30 to 60 percent alkali feldspar, 10 to 55 percent plagioclase and 10 to 35 percent quartz. Twenty five to sixty percent of these grains occur as euhedral to anhedral phenocrysts up to 4 millimeters in diameter. The matrix consists mainly of a fine grained mixture of quartz and alkali feldspar, some of which occurs as graphic intergrowths. Minor amounts of hornblende, biotite, muscovite and magnetite may be present, with one finer grained medium gray porphyry containing 3 to 5 percent pyrite. Secondary minerals include sericite, chlorite and epidote.
Figure 10 - Mesozoic intrusive rocks; upper left - quartz monzonite porphyry from a marginal dike; lower left - granite porphyry from a marginal dike; right - inequigranular quartz monzonite from the main intrusion.
One of the small intrusions is composed of medium gray hypidimorphic-granular diorite (plate 1, rock unit Kd). It consists of 55 to 60 percent plagioclase, 20 to 25 percent alkali feldspar and 5 to 7 percent quartz, with 7 to 10 percent hornblende. Grains average 0.6 millimeters in diameter with some hornblende to 7 millimeters in length. Minor constituents include chloritized biotite and magnetite. A 0.3 meter wide aplite dike zone, with dikes 1 to 8 centimeters thick, cuts this intrusion for a few meters.

Age

The main quartz monzonite intrusion is part of a granitic stock which covers much of the western Excelsior Mountains. Radiometric dates from the stock ran 101 and 102 m.y. (hornblende) and 86 m.y. (biotite) (Evernden and Kistler, 1970, plates 1 and 2). Granite and granite porphyry, similar to the intrusive rocks found in the study area, are exposed in the eastern Excelsior Mountains and have been dated 92.8 and 89.5 m.y. (biotite) respectively (Garside and Silberman, 1978, pp. 31-32).

These intrusions are satellites of the Sierra Nevada batholith to the west. The quartz monzonite porphyry is believed to be a slightly younger phase of the quartz monzonite.

TERTIARY VOLCANICS

Tertiary volcanic rocks cap pre-Tertiary layered rocks in the northern portion of the study area. They consist mainly of interlayered andesite flow and andesite tuff breccia (plate 1, rock unit Tv).
Andesite flows are light to medium gray and consist of subhedral phenocrysts of hornblende and plagioclase in a fine grain groundmass. Hornblende comprises 7 to 10 percent of the rock and is up to 4 millimeters in length. Laths of plagioclase are up to 5 millimeters in length and form up to 35 percent of the rock. Feldspar microlites, which sometimes show preferred orientation, comprise most of the groundmass along with minor amounts of magnetite and occasionally clinopyroxene.

Andesite tuff breccia consists of angular to subangular fragments of andesite flow and vitric tuff up to 3 meters in diameter, which are held in a vitric tuffaceous matrix. The tuff fragments and tuffaceous matrix contain crystals of plagioclase and clinopyroxene. Some tuff breccias are bedded in alternating light and dark layers which are up to 15 meters thick (figure 11). The lighter layers contain more tuffaceous material while the darker layers contain mainly andesite fragments. It is possible that portions of the tuff breccia may be lahatic.

A small patch of reddish-brown weathering, dark gray basalt is exposed in the north central portion of the study area (plate 1, rock unit Tb). It consists of 7 to 10 percent olivine phenocrysts up to 1.2 millimeters in diameter. They are held in a matrix dominated by plagioclase microlites and clinopyroxene, with minor amounts of calcite and magnetite.

Since there is no olivine in the groundmass and the olivine phenocrysts are embayed, indicating resorption by the melt, this basalt can be classified as an olivine tholeiite.
Figure 11 - Interbedded light and dark layers of tuff breccia. The lighter layers contain more tuffaceous material, while the darker layers contain mainly andesite fragments.
One small outcrop of welded rhyolite tuff was found in the north-west corner of the study area (plate 1, rock unit Tr).

**Age**

A sequence of similar andesite flows to the east of the study area in the eastern Excelsior Mountains, has been radiometrically dated from 15.7 m.y. (biotite) (Silberman, Bonham, Garside and Osborne, 1975, p. 17) to older than 18.9 m.y. (plagioclase) (Garside and Silberman, 1978, p. 29). The latter date is of a latite hypabyssal intrusive which intrudes older andesite flows.

The olivine basalt appears to underlie the andesite volcanics and, hence, would be older.

**QUATERNARY ALLUVIUM**

Recent boulders and gravels fill the larger canyons in the study area and form alluvial fans at their mouths. In the main canyon north of Marietta, flood banks are up to 5 meters high. These poorly sorted sediments are eventually deposited in Teels Marsh, the basin to the south of the range.
STRUCTURE

REGIONAL SETTING

The pre-Tertiary structure of the Excelsior Mountains has not been studied in detail. Nielson's Gold Range Formation and the overlying discordant Dunlap Formation are believed to have been deposited in a tectonically active environment (Nielsen, 1963, p. 76). Strong folding and faulting is thought to have accompanied and followed the deposition of these Upper Triassic and Lower Jurassic units, although some of the deformation could be the result of granitic intrusions (Ross, 1961, p. 57).

Speed, however, believes the Black Dyke Formation is the uppermost thrust nappe in an extensive pile of nappes which consist of Upper Triassic and Jurassic shelf strata (Speed, 1977b, p. 354). These rocks have been thrust in from the west on the Luning thrust, which he dates between post-late Early Jurassic and 65 m.y. (Speed, 1977a, p. 328).

Cenozoic faulting in the Excelsior Mountains generally follows the trend of old folded structures and the trend of the range. Two north-northwest trending mineralized Tertiary fault systems are present 15 kilometers northeast of the study area, in the eastern part of the range, at Camp Douglas and Silver Dyke Canyon. Other faults, which cut rocks as young as Pleistocene, parallel the range front east of Marietta and west of Teels Marsh (Ross, 1961, p. 57).

According to Sales the majority of the Excelsior Mountains lie within the Walker Lane subprovince. This is a 70 to 120 kilometer wide zone which extends on a N35°W trend from Las Vegas to Pyramid Lake (Sales, 1966, plate 1). The zone consists of nonlinear contorted low
sets of ranges which have resulted from oroclinal folding in combination with later gravity tectonics (Sales, 1966, p. 147). A substantial amount of right lateral offset characterizes this zone. Nielsen (1965, p. 1306) reports up to 19 kilometers of right lateral separation on faults in the Garfield Hills, Soda Spring Valley and Pilot Mountains.

NORTHEAST STRUCTURES

A northeast structural trend dominates the northern portion of the study area. Here, a conformable sequence of calcareous siltstone overlain by conglomerate, generally strikes N40° to 50°E and dips 40° to 60°SE (plate 1, portions of sections 13, 14, 17, 18, 19, 20, 23 and 24). A fault which strikes N40°E cuts off the conglomerate and exposes underlying andesite breccia and flows (plate 1, SE corners of sections 17 and 19 and section 20). The actual displacement of the high angle fault is unknown; however, the overlying calcareous siltstone and conglomerate units, which it cuts, total at least 2,700 meters in thickness (figure 9).

This outcrop of andesite breccia and flows, which borders the eastern boundary of the study area is, according to Speed (1977a, p. 334), a thrust nappe. However, it has not been mapped as such due to its linearity which indicates a high angle fault plane. Also, contemporaneous volcaniclastic sediments to the west appear to utilize the andesite breccia and flows as a source and, hence, a thrust would seem unlikely.

NORTHWEST STRUCTURES

A northwest structural trend dominates the southern portion of the
study area. This change in trend is thought to be due to the quartz monzonite intrusion whose contact strikes N40°W. Forceful intrusion of this pluton caused faulting and folding in the pre-Tertiary layered rocks to the east.

East of the intrusive contact an older structure, which strikes N30°W, is indicated by the alignment of numerous small quartz monzonite porphyry intrusions and dikes (plate 1, southern half of section 24, eastern half of section 25, SW corner of section 30 and NW corner of section 31). The porphyritic quartz monzonite is thought to have been intruded along a fault which separates andesitic volcaniclastic rocks to the west from calcareous siltstone and conglomerate to the east. The thinning or absence of calcareous siltstone along this structure can be attributed to faulting, although the unit does thin to the south. Several faults which parallel this structure to the east are indicated by quartz-sericite alteration and iron staining in the conglomerate. Other faults which trend east-west cut this older structure.

Andesitic volcaniclastic rocks are folded into an anticline near the mouth of the main canyon north of Marietta (plate 1, southern half of section 30 and NE corner of section 31). The trend of the axis, which plunges to the north, is N25°W. Overturned bedding occurs on the west limb of the anticline; however, its significance is uncertain.

To the east of the anticline several essentially parallel faults, which strike N40° to 50°W, have formed a geologic graben (plate 1, SW corner of section 29, SE corner of section 30, NE corner of section 31 and NW corner of section 32). The graben fill consists of
conglomerate, with andesitic volcaniclastic rocks to the west and andesite breccia and flows to the east. The easternmost fault has the greatest displacement, probably at least several hundred meters. Iron stained fault breccia is present at various locations along the faults. They are, for the most part, high angle faults due to the linearity of their outcrop pattern; the only exception being the western branch of the westernmost fault which has a low angle of dip to the east.

RECENT FAULTING

The earthquake of January 30, 1934, which originated in the vicinity of the Excelsior Mountains, was studied by Callaghan and Gianella. Associated with the earthquake was a break in the surface of the ground, along the trace of an old fault, just west of the Endowment mine (plate 1, southern half of section 13). This now largely eroded rupture was traceable for 1.4 kilometers on a trend of N65°E. The scarp dipped 73 degrees to the north, with the north side up to 13 centimeters lower than the south side. The pattern of en echelon fissures seen at many places along the fault indicated slight left lateral movement (Callaghan and Gianella, 1935, p. 166-167).

The epicenter of the earthquake was estimated to lie 24 kilometers west-southwest of the surface fault and may indicate its subsurface continuation (Shawe, 1965, p. 1364). Shawe has named this the Excelsior fault and believes it to be related to movement along the Walker Lane (Shawe, 1965, p. 1372).
The Marietta area has been known separately as the Marietta, or Black Mountain Mining District. However, officially it is included in the Silver Star Mining District, which covers the central and eastern Excelsior Mountains (Lincoln, 1923, p. 154).

The Silver Star Mining District includes several mines with considerable past production. Sixteen kilometers northeast of Marietta, in the eastern Excelsior Mountains, quartz veins bearing gold and silver were discovered at Camp Douglas in 1893. Just south of Camp Douglas massive quartz veins were first worked for silver in 1916. This vein system, called the Silver Dyke due to the early silver production, was subsequently found to contain abundant scheelite (Ross, 1961, p. 85). The Silver Dyke is the largest producer in the district with a recorded production of $1,200,000 in tungsten during and after World War I (Ross, 1961, table 6.7). Silver and gold veins at the Moho mine had a small production. These mines, in addition to those at Marietta, account for essentially all of the districts recorded $1,810,000 worth of production (Ross, 1961, table 7, p. 71).

Silver-lead ore was discovered in the Marietta area in the early 1860's. Available production figures range from $130,000 to $1,577,000; the former is probably more accurate (Ross, 1961, table 6.7). Most of the mining was done prior to the 1930's with intermittent activity continuing into recent years.

In addition to silver-lead mineralization there are occurrences of gold and copper in the study area.
Description of the Veins

Silver-lead mineralization occurs in veins which were emplaced along fractures. These fractures acted as ore solution passageways and sites of ore mineral deposition. Premineral movement along the fractures is indicated by fragments of host rock which occur as inclusions in the veins.

The veins range in strike from east-west to N75°E, and dip 69°N to 35°S. However, they display a preferred strike of N60° to 80°W (figure 12), with a steep dip. Most of the veins cut the bedding, which strikes N40° to 50°E, at an obtuse angle. This local fracture pattern may be due to en echelon fractures between two larger faults. Faults which strike N30° to 40°W are seen in the west fork of the main canyon north of Marietta (plate 1, western half of section 19, eastern half of section 24, NE corner of section 25 and NW corner of section 30), and could be related to a fault system which is responsible for en echelon fractures as displayed by the veins.

Vein width ranges from 1 centimeter to 2 meters, but most are narrow and range in thickness from 2 to 10 centimeters. They pinch and swell, and a given vein might change an order of magnitude in width over a few meters. Many veins can be followed for more than 30 meters, with one traced by the author for about 60 meters. It is possible that some veins may be 300 meters or longer; however, due to the lack of outcrops they cannot be traced continuously on the surface.

Cross faults offset and brecciate vein fillings. Brecciated ore consists of angular fragments of sulfides and gangue, which, if not
Figure 12 - Rose diagram of 18 silver-lead veins showing N60° to 80°W trend. The number equals the number of veins of a particular orientation.
subsequently silicified, are easily oxidized (figure 13).

Host rock for most of the mineralization is the conglomerate; however, a limited amount is seen in the andesite breccia and flows on the eastern border of the study area (plate 1, section 20).

Mineralogy of the Veins

The veins consist of sulfide (the term sulfide when used in this paper includes the sulfosalt group) and gangue minerals which have been subjected to varying degrees of oxidation. These are discussed under primary and secondary minerals.

Primary Minerals

Primary minerals include galena, pyrite, tetrahedrite, sphalerite, chalcopyrite and boulangerite in a quartz and barite gangue. These are seen in more prevalent massive galena veins, as well as in veins of sulfide mixtures.

Massive lead-gray galena (PbS) veins are typically coarse grained and argentiferous (figure 14). Some cleavage fragments are up to 2 centimeters in diameter with veins of galena reaching a maximum width of 5 centimeters. Galena comprises 95 to 98 percent of the total sulfides in the vein system.

Pyrite (FeS$_2$) is the only sulfide seen included in galena when viewed megascopically. It has a maximum diameter of 1 to 9 millimeters and ranges down to 0.02 millimeters. Grains vary in shape from rounded to cubic and in some cases form multicrystal aggregates. Pyrite occasionally contains inclusions of galena, chalcopyrite, tetrahedrite or quartz. Pyrite comprises 1 to 5 percent of the total sulfides in the
Figure 13 – Photomicrograph of brecciated galena fragments (light gray) cemented with quartz (dark gray). Plane light.

Figure 14 – Vein of massive galena in iron stained conglomerate. Note inclusions of pyrite (py) and relict outlines of former pyrite grains (rl).
In a few veins pyrite is concentrated along one side. This seems to indicate that it was early formed.

Other primary sulfides which are observed microscopically as inclusions in galena are tetrahedrite, sphalerite and chalcopyrite. Tetrahedrite \((\text{Cu,Fe,Zn,Ag})_\text{12} \text{Sb}_\text{4} \text{S}_\text{13})\) grains range in diameter from 0.01 to 0.03 millimeters. They are angular to rounded in outline and almost always fractured. Sphalerite \((\text{Zn,Fe})\text{S})\) forms rounded grains ranging in diameter from 0.05 to 0.4 millimeters. It commonly contains randomly oriented blebs of chalcopyrite. Rounded grains of chalcopyrite \((\text{CuFeS}_\text{2})\), which range in diameter from 0.1 to 0.4 millimeters, also occur separately. These three primary sulfides generally comprise less than 1 percent of the total sulfides in the vein system.

No separate primary silver minerals are recognized. The silver is thought to be due to acanthite which is in solid solution in galena. According to Ramdohr (1969, p. 634), galena can carry up to 0.1 percent acanthite in solid solution, which is equivalent to 28.9 oz/ton silver. Two samples of hand sorted galena grains from the Rip Van Winkle and Badger mines ran 59.2 and 4.1 oz/ton silver, respectively.

Also included in the vein system are the gangue minerals quartz \((\text{SiO}_\text{2})\) and barite \((\text{BaSO}_\text{4})\). They are seen as both massive fine grained aggregates and as coarse crystals. Quartz forms subhedral milky crystals up to 15 millimeters in length and 5 millimeters in width. Barite forms white platy crystals up to 3 centimeters in length and 3 millimeters in width. They are commonly concentrated along one or both sides of the vein, with a few grains occurring as inclusions in galena.
In one case, a 10 centimeter wide seam of quartz and barite is concentrated along the footwall of the vein. This, again, is thought to indicate they are early formed.

Massive galena veins which occur in andesite breccia and flows were not studied in detail. However, they seem to contain less pyrite than veins in conglomerate. They also have epidote and calcite included as gangue minerals, which is no doubt due to the different chemistry of the host rock.

Veins which contain a more varied mixture of sulfides are also seen. Two occurrences are found in the lower unoxidized levels of the Endowment mine.

An ore shoot of the main vein in the Endowment mine consists of pyrite, boulangerite and sphalerite in quartz gangue. Pitted subhedral grains of pyrite, up to 1.5 millimeters in diameter, comprise 40 to 50 percent of the total sulfides. Boulangerite (Pb$_5$Sb$_4$S$_{11}$), which forms grains up to 6 millimeters in diameter, composes 25 to 30 percent of total sulfides. It contains inclusions of pyrite and sphalerite and fills in between other sulfides and gangue indicating a late stage of deposition (figure 15). Pitted grains of honey-brown sphalerite, up to 6 millimeters in diameter, form 25 to 30 percent of the total sulfides. Sphalerite contains inclusions of pyrite and quartz and frequently forms multicrystal aggregates. The sulfides are homogeneously distributed in a quartz matrix.

A fine grained offshoot of the main vein in the Endowment mine contains primarily tetrahedrite and galena in quartz gangue (figure 16). Anhedral grains of tetrahedrite comprise 50 to 60 percent of the
Figure 15 - Photomicrograph of boulangerite (bo) containing sphalerite (sp) inclusions and pyrite (py) in quartz gangue. Note how boulangerite fills in fractures in quartz indicating a late stage of deposition. Plane light.

Figure 16 - Photomicrograph of intergrowth of mainly tetrahedrite (td) and galena (gn) with minor sphalerite (sp) and pyrite (py) in quartz gangue. Note oxidation of galena (gray spots). Plane light.
total sulfides and are up to 1 millimeter in diameter. They surround and include grains of galena indicating simultaneous or later deposition. Anhedral grains of galena, up to 0.5 millimeters in diameter, compose 30 to 40 percent of the total sulfides. Other sulfides present in lesser amounts are pyrite and sphalerite. A few grains of free gold, up to 0.03 millimeters in diameter, are also present. Quartz grains, up to 1 millimeter in diameter, are found with the sulfides; however, most quartz is fine grained and concentrated along vein margins with pyrite.

A scanning electron microscope, filled with an energy dispersive X-ray spectrometer for element detection, was used on a polished section in an attempt to determine where silver is concentrated. The section was from the previously discussed fine grained offshoot of the main vein in the Endowment mine. Detection limits of the instrument vary from 0.1 to 1 percent. Silver was not detected in galena or tetrahedrite; however, it was found concentrated in an oxidation product of galena (figure 16). This lead oxide contains two phases. The lighter colored phase consists essentially of lead and is thought to be cerussite. A darker phase contains mainly silver and sulfur with some lead and copper. It appears that a silver sulfide is concentrating in the zone of oxidation. This may be an aggregation of acanthite, which was held in solid solution in galena, or a silver sulfide, which is being precipitated in the oxide zone. However, the latter conclusion would be a geochemical oddity.
Secondary Minerals

Secondary minerals include cerussite, anglesite, limonite, malachite, azurite, chalcanthite, covellite and smithsonite. All result from the oxidation of primary sulfides. Although the presence of silver is indicated by assay, no secondary silver minerals are seen.

Oxidized ore consists predominately of silver enriched iron stained cerussite \((\text{PbCO}_3)\). In polished section, oxidation is seen taking place along the jagged borders of galena (figure 17). Anglesite \((\text{PbSO}_4)\) is more closely associated with galena than cerussite. It is seen along cleavage cracks and is directly adjacent to the borders of galena. Cerussite replaces anglesite and is generally found further removed from galena. These lead oxides, which are sometimes difficult to distinguish, frequently form bands parallel to the oxidation front.

The heavy amount of iron staining in the oxidized ore results from the oxidation of pyrite. Pyrite is replaced by limonite \((\text{FeO(OH)} \cdot n\text{H}_2\text{O})\) in partially oxidized ore and is taken into solution with increasing oxidation. This is evidenced by relict outlines of former pyrite grains in galena. A limited amount of copper staining is seen in the oxidized ore. This is occasionally concentrated in the minerals malachite \((\text{Cu}_2\text{CO}_3(\text{OH})_2)\), azurite \((\text{Cu}_3\text{CO}_3(\text{OH})_2)\) or chalcanthite \((\text{CuSO}_4 \cdot 5\text{H}_2\text{O})\), which coat oxidizing sulfides or wall rock. There is also a minor amount of manganese stain, which is occasionally observed as dendrites along fractures in the host rock.

Covellite \((\text{CuS})\) is found as a film on galena. In polished section, it is seen replacing galena as well as bordering tetrahedrite and chalcopyrite. Although not seen by the author, Hill (1915, p. 180)
Figure 17 - Photomicrograph of oxidizing galena (white) and secondary cerussite (gray-brown). Plane light.
reports finding smithsonite (ZnCO$_3$) in the oxidized ore at the Endowment mine.

Paragenesis

A generalized paragenesis has been worked out (figure 18) based on ore textures. In utilizing the results one should keep in mind that only a limited number of polished sections were studied. Inclusions and positions of minerals in the vein were given the strongest weight in interpretation.

Wall Rock Alteration

Wall rock alteration includes pyritization and clay development in the conglomerate host rock. These effects are seen in the matrix of the conglomerate, a few meters on either side of the vein. Pyrite grains, which range up to 1 millimeter in diameter, are disseminated in the matrix with a few grains along borders or fractures of lithic fragments. White clay results from the alteration of matrix feldspar grains of the arkosic fraction. The clay was not X-rayed due to the small amount of available material.

Classification and Origin

The mineralization is classified, using Lindgren's classification of ore deposits (Lindgren, 1933, p. 565-566), as a mesothermal silver-lead vein deposit of the quartz-tetrahedrite-galena type. As seen at Marietta, they typically carry tetrahedrite, galena, sphalerite and pyrite in a milky quartz gangue. Also characteristic is the massive appearance of the vein filling, which formed by the introduction of mineralizing fluids along a strong fracture zone. Pyritization and
Primary Minerals

quartz
barite
pyrite
tetrahedrite
chalcopyrite
sphalerite
galena
boulangerite

Secondary Minerals

anglesite
cerussite
limonite
covellite

Figure 18 - Paragenetic sequence of silver-lead mineralization.
clay development in the host rock is common.

Mesothermal deposits are commonly seen adjacent to granitic intrusive bodies throughout the Cordilleran region, which are thought to be the source of mineralizing fluids. The mineralization at Marietta is bordered by a quartz monzonite intrusion that is exposed at the surface to the west. None of the veins could be traced to the intrusive on the surface. However, small quartz monzonite porphyry intrusions and dikes in proximity to the veins, suggest the intrusion may underlie the mineralization. The Birdsong mine is only 400 meters from a small outcrop of quartz monzonite porphyry. A pyritized silicified outcrop of quartz monzonite porphyry, 900 meters southwest of the Badger mine, is evidence that mineralizing fluids were associated with the granitic rocks.

Mines

Although silver-lead mineralization occurs at numerous locations in the study area, only the more prominent workings will be discussed in detail. These include the London Lead-Silver, Endowment and Black Hawk mines.

London Lead-Silver Group

The London Lead-Silver group of mines is located in the west canyon (plate 1, NW corner of section 19 and NE corner of section 24) and includes the Badger, Birdsong, Rip Van Winkle and Silver Gulch mines. They consist of adits and shafts with approximately 1000 meters of workings that reveal 13 veins.

In general, the veins are similar in attitude but vary somewhat in
dimensions. They range in strike from N30°W to east-west, however, many are parallel and strike N70°W. The dips vary between 69°N and 75°S. The veins range from a few meters to 60 meters in length and up to 15 centimeters in width, although most are 2 to 10 centimeters thick. Some of the veins are cut off by faults.

All veins have a similar mineralogy consisting of coarse grained galena which is speckled with pyrite. Gangue minerals include quartz and barite. These primary minerals are usually enclosed in iron stained oxides consisting mainly of cerussite. The zone of total oxidation is shallow, probably no more than 10 meters.

Endowment Mine

The Endowment mine is located in the upper part of the west canyon just below the Tertiary volcanics (plate 1, SW corner of section 18). It was the first property worked in the Marietta area (Hill, 1915, p. 176) and is one of the larger mines. It consists of an adit, two winzes and four lower levels with approximately 1200 meters of workings, which expose two separate veins. Certain details of the veins are taken from Whiting's map (1927) of the Endowment mine.

The first vein, which strikes N36°W and dips 46°SW, is 40 meters in length and up to 2 meters thick. It has been worked from the surface to a depth of 92 meters. A second vein, which strikes N75°E and dips 77°SE, is 43 meters in length and up to 1 meter thick. It is exposed over a vertical distance of 40 meters. A 32 meter wide fault zone, which strikes N55°E and dips 50°SE, cuts off the first vein to the east and the second vein to the west. Another fault, which
strikes N84°W and dips 73°NE, borders the second vein to the east.

Unoxidized sulfides are only exposed in the first vein at the lower levels and contain a mixture of sulfides which is not typical of other silver-lead veins in the Marietta area. A shoot of the main vein on the third level consists of boulangerite, sphalerite and pyrite in quartz gangue (see p. 36). An offshoot of the main vein on the fourth level, which strikes N72°W and dips 27°NE, is exposed for 5 meters and is up to 0.3 meters thick. It consists of a fine grained mixture of mainly tetrahedrite and galena (see pp. 36, 38) and assayed 274 oz/ton silver.

The first vein is oxidized to a depth of about 50 meters, while the second vein bottoms in oxides about 75 meters below the surface. The oxidized ore consists of mainly cerussite, which was reported to average 120 oz/ton silver in the first vein.

Black Hawk Mine

The Black Hawk mine is the only prominent working in the east canyon (plate 1, NE corner of section 19). It consists of an adit, an open stope and several shafts, and although largely inaccessible is probably similar in size to the Endowment mine, based on the size of the dumps.

The oldest workings are at the head of a box canyon, where a vein has been stoped to the surface for 30 meters along strike. Although no vein material is exposed, the stope strikes N25°W and has a vertical dip. Only the adit, with approximately 400 meters of workings, is accessible. It is driven near the bottom of the main canyon approximately 35 meters vertically below the open stope with which it connects.
Two oxidized veins are exposed in the adit. One, which strikes N40°W and dips vertically, is 50 meters in length. A second vein, which strikes N60°E and dips 35°SE, is 10 meters in length. They have a maximum width of 10 centimeters.

The veins consist of iron stained cerussite with a little fresh galena. An assay from the first vein ran 186 oz/ton silver. A dump sample of partially oxidized ore, studied microscopically, includes galena, pyrite, sphalerite, tetrahedrite, chalcopyrite, cerussite, anglesite and covellite in quartz gangue. Although the ore is heavily oxidized, the primary mineralogy is thought to be coarse grained galena due to the large proportion of galena compared with other sulfides.
OTHER MINERALIZATION

In addition to silver-lead mineralization, occurrences of copper and gold are found in the study area. These include the Marietta mines and Rutty group of mines, respectively.

Marietta Mines

The Marietta mines are developed on a copper show in the low range front hills to the east of the main canyon (plate 1, SW corner of section 29, NE corner of section 31 and NW corner of section 32). They are owned and have been worked in the past by Giroux Mines Limited. The openings consist of numerous adits and shafts with approximately 1500 meters of workings.

This area is believed to be covered by a thin layer of conglomerate which is underlain by volcaniclastic sediments. Limited mineralization occurs in both rock types.

The most extensive workings are located in a small outcrop of volcaniclastic sediments at the base of the range. The outcrop has been cut by a shear zone which strikes east-west, dips 40°N, is 10 meters thick and traceable for about 50 meters. The zone is heavily iron stained with some clay development.

Unaltered dump samples of volcaniclastic sediments contain pyrite and traces of chalcopyrite along fracture surfaces. Gangue minerals include quartz and siderite. These are seen as veinlets, up to 1 centimeter in width, bordered by pyrite and as localized concentrations, up to 5 centimeters in diameter, respectively.

Numerous secondary minerals are recognized. Dump samples of a working which penetrates the shear zone contain cuprite veinlets, up to
3 millimeters in width, in a clay host. Other secondary copper minerals, which coat fracture surfaces of dump samples, include malachite, azurite and chrysocolla. Limonite veins, up to 5 centimeters in width, which follow randomly oriented fractures, were seen in one adit. Manganese stain is found coating heavily oxidized iron stained dump samples.

Many of the workings in the conglomerate are localized around iron stained fractures, which strike N60° to 80°W. They are exposed over a distance of up to 100 meters. These fractures are on the same trend as other local structures. Some well developed gossan is exposed at the surface; however, no fresh mineralization is seen.

Although no granitic rocks are seen on the dumps, they are thought to underlie and be responsible for the alteration and limited mineralization.

The area was once thought to be a porphyry copper target. A shaft sunk in the middle 1940's penetrated the conglomerate and encountered small amounts of chalcopyrite in the underlying volcaniclastic sediments. A diamond drilling program was carried out in the early 1960's; however, the core was not available for examination. No work has been done in recent years (Roy Ladd, personal communication, 1977).

Rutty Group

The Rutty group of mines is a gold occurrence at the foot of the mountains just west of the main canyon (plate 1, NW corner of section 31). The property was located in 1910 by Joe Rutty, who made a living from it for several years. It consists of several adits with approximately 1200 meters of workings (Vanderburg, 1937, p. 43).
The gold occurs in veins which were emplaced along faults and fractures in the volcanioclastic sediments. These veins vary in strike from N35°E to N35°W and generally have steep dips. They range up to about 25 meters in length and have a maximum width of 0.3 meters. The gold is believed to have occurred with pyrite in a quartz and possibly siderite gangue. This is exposed as iron stained fault gouge due to post-mineralization movement. It consists of fragments of quartz with limonite cubes. An assay of vein material ran 0.56 oz/ton gold. A limited amount of clay is seen in the volcanioclastic sediments surrounding the veins. The adjacent quartz monzonite intrusive is thought to be the source of the mineralizing fluids.

The most productive workings, which are just above the end of the road, expose several veins. Further up the hill smaller veins were worked. A vein in the uppermost adit, which is unaffected by post-mineralization faulting, contains quartz and siderite. Below the road two adits were driven into barren volcanioclastic sediments and quartz monzonite. This was undoubtedly an attempt to intersect the veins at depth.

POTENTIAL

The overall potential of the area is limited. The best possibility is in the silver-lead veins which, although small, show some good silver values. With the current market price of silver ($5.90/oz) a two to three man operation, with careful hand sorting, could feasibly make some money.

The copper show at the Marietta mines has been looked at many times and the mineralization appears to be minimal.
The Rutty group shows decent gold values; however, the veins are generally small. The possibility of economically recoverable gold disseminated in the host rock is unlikely.

With this goal, certain particulars were not dealt with in detail. Certain units, such as the andesite volcanics and volcaniclastic sediments, Tertiary volcanics and quartz monzonite-cristo monzonite porphyry, were not internally differentiated. Some of this work would require larger scale mapping, and other projects would be more worthwhile at present. A detailed examination of the polished sections of vein material on an electron microscope would assist in a better understanding of the mineralogy and geochemistry of the primary and secondary minerals. However, such a project is beyond the scope of this study.

The tracing of the veins defined in the study area throughout the central Excalator Mountains would be helpful in understanding their stratigraphy and structure. Other mines in the Excalator Mountains, for which a similar study could be done, are the Helen mine and the Camp Douglas area. A study of the uranium occurrences in the western Excalator Mountains was done by Serba (1972), and one on the Silver Dyke mine area is in progress (Kilby).
CONCLUSIONS

This study was carried out in an attempt to tie together the overall geologic picture of the Marietta area. With this goal, certain particulars were not dealt with in detail. Certain units, such as the andesite volcanics and volcaniclastic sediments. Tertiary volcanics and quartz monzonite-quartz monzonite porphyry were not internally differentiated. Some of this work would require larger scale mapping, and other projects would be more worthwhile at present. A detailed examination of the polished sections of vein material on an electron microscope would assist in a better understanding of the mineralogy and geochemistry of the primary and secondary minerals. However, such a project is beyond the scope of this study.

The tracing of the units defined in the study area throughout the central Excelsior Mountains would be helpful in understanding their stratigraphy and structure. Other mines in the Excelsior Mountains, for which a similar study could be done, are the Moho mine and the Camp Douglas area. A thesis on the uranium occurrences in the western Excelsior Mountains was done by Borbas (1977), and one on the Silver Dyke mine area is in progress (Kilbreath).
<table>
<thead>
<tr>
<th>Location Description</th>
<th>Gold (oz/ton)</th>
<th>Silver (oz/ton)</th>
<th>Copper (%)</th>
<th>Lead (%)</th>
<th>Zinc (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endowment mine; chip sample from a 0.3 meter wide offshoot of the main vein on the 3rd level. Fine grained sulfides including pyrite, sphalerite and galena disseminated in a large amount of quartz. Secondary copper staining is also present.</td>
<td>0.030</td>
<td>29.67</td>
<td>1.87</td>
<td>2.68</td>
<td>3.12</td>
</tr>
<tr>
<td>Endowment mine; grab sample from a 2 meter wide shoot of the main vein on the 3rd level. Massive sulfide ore consisting of pyrite, boulangerite and sphalerite contained in a large amount of quartz.</td>
<td>0.010</td>
<td>0.78</td>
<td>0.18</td>
<td>3.05</td>
<td>3.42</td>
</tr>
<tr>
<td>Endowment mine; channel sample from a 2 centimeter wide offshoot of the main vein on the 3rd level. Fine grained massive sulfide ore consisting of tetrahedrite, galena, sphalerite and pyrite in addition to quartz. Malachite is also present.</td>
<td>0.200</td>
<td>274</td>
<td>11.2</td>
<td>9.32</td>
<td>2.74</td>
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<tr>
<td>Black Hawk mine; chip sample from a 10 centimeter wide vein in the lower adit. Iron and copper stained highly oxidized rock which contains appreciable amounts of cerussite.</td>
<td>0.100</td>
<td>186.59</td>
<td>1.24</td>
<td>39.3</td>
<td>1.15</td>
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<tr>
<td>Badger mine; dump sample of a 3 centimeter wide vein from the lower westernmost workings. Hand sorted galena grains from a coarse grained galena sample.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.06</td>
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<tr>
<td>Rip Van Winkle mine; channel sample from a 2 centimeter wide vein in the northernmost workings. Hand sorted galena grains from a coarse grained galena sample.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>59.2</td>
</tr>
<tr>
<td>Location</td>
<td>Description</td>
<td>Gold (oz/ton)</td>
<td>Silver (oz/ton)</td>
<td>Copper (%)</td>
<td>Lead (%)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Rutty group; grab sample from a 0.3 meter wide vein in the main workings.</td>
<td>Iron stained chips and powder which include quartz fragments with limonite cubes.</td>
<td>0.560</td>
<td>0.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
bibliography


Muller, S. W., 1939, Mesozoic stratigraphy of the Hawthorne and Tonopah quadrangles, Nevada: Geol. Soc. America Bull., v. 50, p. 1573-1624.


Whiting, L. W., 1927, Engineering map of the Endowment mine: Whiting Brother Engineer's, Mina, Nevada.