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DISCOVERY OF THE BELL GOLD MINE -- JERRITT CANYON DISTRICT, ELKO COUNTY, NEVADA

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The discovery of the Jerritt Canyon Mining District and the Enfield B. Bell Gold Mine by geologists of Freeport Exploration Company and FMC Corporation is one of the most significant exploration developments within the United States in the past 10 years. The Bell Gold Mine has announced recoverable reserves of 9.1 million metric tons grading 7.4 gms. Au/Ton for a total recoverable reserve of 67.61 million gms. of gold. Initial mill startup and production is expected to begin during the 3rd quarter of 1981 towards a designed milling rate of 2500 metric tons/day. The discovery resulted from a comprehensive program of detailed geologic surface mapping, soil and rock chip geochemical sampling, and extensive rotary, rotary percussion, and diamond core drilling.

Gold mineralization is hosted within carbonaceous dolomitic calcarenites of the Ordovician Hanson Creek and Silurian Roberts Mountains formations. The host rocks are exposed in a large, northeasterly trending, structurally controlled window of the Roberts Mountains Thrust Fault in the northern portion of the Independence Mountains in central Elko County, Nevada. The nature of the mineralization, host rock type, trace element assemblages and local structural control indicate that the deposit may be classified as of the "Carlin Type" and similar to other known occurrences of fine grained disseminated gold in central Nevada.

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The discovery of the gold deposits of the Jerritt Canyon district and the construction of the E. B. Bell Mine is one of the significant mining developments in the United States during the past ten years. This mine will exploit one of the larger deposits of disseminated gold presently known, with proven, recoverable reserves in excess of 67.6 million grams of gold. Interest generated by the success of this project has contributed greatly to the tremendous resurgence in exploration for disseminated gold deposits in Nevada and throughout the west.

The Jerritt Canyon project, including the Bell Mine, is a 70/30 joint venture between Freeport Gold Company and FMC Gold Incorporated, both of which are wholly owned affiliates of the respective parent companies, Freeport-McMoRan, Inc. and FMC Incorporated. Under the terms of the joint venture agreement, Freeport Exploration Company, another Freeport-McMoRan affiliate, manages the exploration and pre-mine development. Drilling, design, construction and management of the Bell Mine are provided by Freeport Gold Company.

The Jerritt Canyon District is located in the Independence Mountains in north-central Elko County, Nevada, approximately 48 kilometers northeast of the Carlin Gold Mine (Figure 1), and 68 kilometers north of Elko, the closest, large community. Paved highways follow the valleys on each side of the Independence Range, with numerous dirt roads providing access to the district in the heart of the mountains.

The Bell Mine is located in the northern quarter of the Jerritt Canyon Window in Sections 33, 34, and 35 of Township 41N, Range 53E (Figure 2).

The mine itself is in the center of the Independence Range; the mill is located in the foothills on the east flank of the mountains, due east of the mine. An all-weather haul road, approximately eight miles long, connects the mine to the mill.

History

The discovery of gold mineralization was the result of a grass roots exploration program initiated by FMC geologists in search of antimony. Interestingly, Bulletin 61 of the Nevada Bureau of Mines, Antimony Deposits of Nevada, helped identify the area. Work on the property began in 1971 with geologic mapping followed by sampling and geochemical analyses. Although looking for antimony, the geologists recognized the striking similarity of the area to Carlin and soon focused on the gold potential. The upsurge in the price of gold from $35.00/ounce came at this opportune time and served to stimulate interest and support for the exploration program. The samples collected then were analysed for gold and trace elements usually associated with gold. This program detected a strong gold anomaly on the North Fork of Jerritt Canyon which was called the Alchem anomaly (Figure 4). Drill testing of this anomaly in 1973 revealed significant grades and thicknesses of gold mineralization in the lower portion of the Roberts Mountain Formation. This initial discovery and subsequent drilling proved the existence of several small pods of low-grade, gold-bearing material which cropped out at their up-dip edges, causing the surface anomaly. The mineralization was very interesting, but was not, by itself, of economic importance from the standpoint of either grade or tonnage.

In the spring of 1976, Freeport Exploration Company assumed management of the program following the formation of the joint venture. During the remainder of 1976, an expanded program of detailed mapping and geochemical sampling led to new interpretations of the structural and alteration patterns. Drilling, based on this new understanding of the geology, was resumed in the fall of 1976. The fifth drill hole of that program penetrated the edge of the Marlboro Canyon orebody, which is now being exploited in the Bell Mine. Although a classic "bullseye" geochemical target was the clue which led to the initial discovery in the Alchem area (Figure 5), the bulk of the reserves that are known today lay beneath a cover of talus and soil that was geochemically barren. Discovery of these deposits was the result of geologic intuition based on careful mapping and a new structural interpretation of the data.

Drilling continued through 1977, 1978, and 1979, adding to both the reserves and the knowledge of the characteristics of the ore bodies. A decision to proceed with the construction of a mine and mill was made in 1979, based on mineable reserves of 9.1 million metric tonnes which average 7.4 grams of recoverable gold per tonne. The Bell Mine was developed and a mill constructed with a capacity sufficient to treat 2,500 metric tonnes per day. The mill was started up on a limited basis in late June and the first gold bar was poured July 4, 1981. The plant presently is being progressively brought up to its design capacity. An aggressive exploration program continues on the joint venture's properties.

Regional Geology

The geology of Jerritt Canyon (Hawkins, 1973), is similar to that of the Lynn Window (Carlin Mine) as described by Radtke, et al (1980). During

Ordovician and Silurian times, a wide marine trough lay in the area which is now Nevada. Within the trough, the conditions of sedimentation were different on the eastern and western sides. To the east, miogeosynclinal limestones, dolomites, siltstones and quartzites accumulated. To the west, eugeosynclinal siliceous sediments including interbedded cherts, argillites, quartzites and shales with minor greenstone, limestone and barite beds accumulated. At the end of the Devonian period these Paleozoic sediments were deformed in the Antler orogeny. The culminating event of that orogeny was thrusting which pushed the siliceous rocks of the western facies eastward over the carbonate rocks of the eastern facies on the Roberts Mountain thrust fault. In the Tertiary, during the formation of the Basin and Range Province, high angle, normal faults broke the terrain into blocks, lifting some, depressing others. Erosion of the uplifted blocks then locally removed the upper plate rocks to form windows which now expose the underlying lower plate sediments. The Jerritt Canyon window is such an eroded uplifted block. The lower plate rocks are bounded by high-angle, block faults in most areas; only locally is the Roberts Mountain Thrust exposed.

Stratigraphy

Lower plate stratigraphy within the Jerritt Canyon Window has been mapped and described by Kerr (1962), Hawkins (1973), Collord (1978), and Birak (1979). Exposures are sufficient to enable the identification of a continuous stratigraphic section from the middle Ordovician Eureka Quartzite through the Silurian Hanson Creek Formation and the Roberts Mountain Formation of upper Silurian age.

The Eureka Quartzite has been recognized throughout most of central Nevada where it is a prominent cliff-forming member of the eastern assemblage. The formation is well exposed in the southern portion of the Jerritt Canyon window where it forms distinctive cliffs along Burns Creek and Wheeler Mountain. It is a well-to-moderately-sorted, pure quartz sandstone composed of angular to subrounded grains cemented by a mixture of silica, carbonate and iron oxide. The rock is medium to dark grey in color on fresh surfaces but weathers yellow to red-brown on exposed surfaces. The unit is massive, composed of poorly defined beds at least three meters thick. Within the Jerritt Canyon district measured thicknesses of the Eureka Quartzite range from 165 to 185 meters with the thicker sections to the south.

The Hanson Creek formation which unconformably overlies the Eureka Quartzite is host to much of the economic gold mineralization at the Bell Mine; therefore, its lithologic characteristics have received detailed study both in outcrop and in drill core (Figure 3). By combining surface and subsurface work, complete stratigraphic sections have been determined at a number of locations within the Window. As a result of this work, the formation has been divided into five lithologic units. The basal unit consists of some 90 meters of banded, interbedded carbonaceous and shaly limestones with minor lenses and pods of chert. Above this are 33 meters of massive, light grey, cherty, bioclastic limestone and dolomite. This is overlain by an upper, banded limestone unit which typically is composed of 30-35 meters of fine grained, banded, greyish-black carbonaceous limestone. This zone is host to a major portion of the ore grade mineralization at the Bell Mine. Above the upper banded zone is an upper, massive carbonate unit.

At the mine, this unit consists of thirty meters of light grey, medium-grained, massive, dolomite which conformably overlies the upper banded limestone. This unit grades laterally into limestone and locally is totally replaced by silica to form jasperoid. The uppermost member of the Hanson Creek Formation is a banded chert carbonate horizon, 9-18 meters thick. Within the mine area, this member has been strongly silicified to form a dense chert-jasperoid which makes up most of the bold, jagged outcrops. This unit characteristically consists of thin, dark grey to black bands of chert, 1-13 centimeters thick interbedded with lighter grey carbonate layers. Depending on the degree of silicification, cherty silica may make up from 50 to 98% of the unit.

The Roberts Mountain Formation is the youngest and most widely exposed formation within the lower plate. Up to 305 meters of well laminated, moderately hard, medium-dark grey, calcareous siltstone and dolomite have been measured within the Jerritt Canyon window and the top of the unit has not been seen. Individual siltstone layers are generally less than 1.5 cm in thickness and are interbedded with thin lenses of chert less than 30 cm in length and 1 cm thick. Carbonaceous matter is present in the siltstone and is abundant locally, particularly where remobilized along fault zones. Small cubes of syngenetic or diagenetic pyrite occur throughout the formation. The Roberts Mountain Formation does not form rugged outcrops; instead, it tends to form a subdued rolling topography with the bedrock mantled by soil and float composed of platy rock fragments, less than 1.5 cm thick. The basal 60 meters of the Roberts Mountain Formation is a host to economic gold mineralization.

The upper plate, western facies, rocks of the Independence Range have been correlated with the Valmy Group as described and named by Churkin and Kay (1967) from the area immediately to the north. The Snow Canyon Formation, the basal unit of the Valmy Group, is the only upper plate unit recognized in the Jerritt Canyon District. This unit consists of interbedded layers of chert, argillite, shale and quartzite, with minor amounts of greenstone, limestone and bedded barite. The layers of the various lithologic types average 3 to 6 meters in thickness and occur in no regular sequence. The Snow Canyon Formation crops out in smooth slopes generally covered by only sparse vegetation.

Tertiary igneous activity was scarce and there is no evidence of a major intrusion in this area. Several small dikes and a plug of diorite and one small rhyodacite flow have been mapped. Travertine and hotspring deposits also have been found both in the heart of the area and along its flanks. The closest active hot spring is located in the Independence Valley some ten miles northwest of the Jerritt Canyon District.

As has been mentioned, the Roberts Mountain thrust fault lies between the lower plate, eastern facies and the upper plate, western facies rocks. The thrust faulted terrain was broken by a series of high-angle normal faults which both blocked out and broke up the range. At Jerritt Canyon, we have noted three systems of faults, an east-west, a northeast, and a northwest trending system.

The oldest, and also the youngest, faults belong to the east-west trending set. What we locally call the Snow Canyon fault is only a part of a major regional east-west break, the Wells fault, which is thought to have first moved in the Mesozoic. Movement along the Wells and its related parallel faults has continued intermittently up to recent times. Because there has been this repeated movement on east-west trending faults, faults of this system cut all other fault systems in the area.

Another important group of faults is the northeast trending system. This group includes the Marlboro Canyon, Mill Creek, and associated faults. These faults have a close association with economic mineralization as well as locally forming the edges of the window.

The third group of faults includes the northwest trending faults which apparently are post-ore, since they offset the mineralization.

Faults of all the different systems may have associated drag folds and breccia zones.

Geology of the Bell Mine

The Bell Mine is being developed to exploit five mineralized areas which have been drilled out within an area 3,300 meters long, and 1,200 meters wide, as shown in Figure 4. Mineralization within these areas is strata controlled; that is, it occurs only in the favorable horizons of the upper Hanson Creek and lower Roberts Mountain Formations. Most of the reserves have been found in the upper banded limestone unit of the Hanson Creek Formation. Smaller amounts of ore have formed in the basal 60 meters of the Roberts Mountain Formation. In plan, the individual ore bodies are elongate, apparently controlled by the intersection of normal faults with favorable stratigraphic horizons (Figure 4A). In cross-section, the deposits are thickest adjacent to faults and thin and decrease in grade away from the faults, down the dip of the host strata. This relationship is clearly shown in Figure 6, which gives a section through the Marlboro Canyon deposit. A similar situation has been observed in the newly exposed benches in the North Generator Hill deposit where higher grades and greater thicknesses are found in the deformed and fractured host rocks proximate to northeast trending faults.

There are two types of ore at Jerritt Canyon, carbonaceous and oxide. This is similar to the situation at Carlin and other finely disseminated gold deposits of Nevada. The carbonaceous ores are dark grey to black, pyritic, silty calcarenites or calcareous siltstones which may contain as much as 30 grams of gold per tonne. Pervasive silicification may be complete, partial or lacking. Free gold has not been found in the carbonaceous ores where gold is believed to be tied up with organic compounds; however, no definitive research has been done to prove this. Oxide ores are similar to the carbonaceous ores except that they are light in color as they contain less carbonaceous material. Oxide ore is believed to have formed by the oxidation of carbonaceous ore through the action of either ground water or late stage hydrothermal fluids. Recognition and separate handling of the two ore types is important because carbonaceous ore requires oxidation to inactivate the carbon present before economic recovery of the gold can be achieved. At the Bell Mine, carbonaceous and oxide ores are present in about equal amounts.

There is no visible gold at Jerritt Canyon. Where free gold has been found by electron probe analyses, most particles are less than one micron in diameter, with a few ranging up to four microns, far too small to be seen, even with optical magnification. The small particle size also makes it impossible to concentrate gold from the ore by panning and accounts for the lack of placer accumulations in the area.

Other hydrothermal minerals associated with the gold, in order of decreasing abundance, are realgar, orpiment, arsenopyrite and cinnabar. The first three, arsenic minerals, occur with calcite as fracture fillings in carbonaceous ores but have been removed from the oxide ores. Cinnabar evidently resists oxidation as it is found in both types of ore. Stibnite, barite and quartz occur as crystals in veinlets and as open space fillings in jasperoids near ore deposits. These minerals are believed to have formed during the later stages of mineralization.

Throughout the Jerritt Canyon District, pervasive silicification is the dominant alteration. The degree of silicification ranges from complete replacement, which has formed jasperoids that may be as much as 98% SiO_2, through all gradations to unaltered limestones.

Other effects of hydrothermal alteration include the remobilization of carbonaceous material and the leaching of carbonate. Greasy, black, graphitic, carbonaceous material occurs in tabular bodies along faults, where it clearly has been introduced. As the surrounding sediments contain carbonaceous matter, this concentration of carbon is thought to have resulted from remobilization and deposition of carbon by hydrothermal fluids. Remobilized carbon and a general lack of calcite in the rock are usually coincident with ore-grade mineralization, suggesting a common hydrothermal cause. Remobilized carbon frequently is extremely active chemically and may actually take gold out of a cyanide solution so its presence calls for special attention in processing.

The ore deposits of the Jerritt Canyon District appear to be similar in nature and origin to those at Carlin, which have been studied in detail. Our ideas on the genesis of the Jerritt Canyon ore deposit include the following points:

The known mineralization at Jerritt is limited to specific stratigraphic horizons of the eastern facies, lower plate rocks, which were favorable for gold deposition. Those favorable horizons typically contained abundant carbonaceous matter which reacted with the hydrothermal solution to precipitate gold. In addition, the rock had to have sufficient permeability and porosity to allow the movement of solutions necessary to bring gold into contact with the carbonaceous material.

Steeply dipping normal faults played a major role in the introduction and distribution of gold-bearing solutions as shown by the localization of ore along the fault trends. Fracturing and drag-folding associated with the faults had an important part in creating pre-ore porosity and permeability. This type of induced permeability appears to be necessary for mineralization to occur in the Hanson Creek Formation, but not in the Roberts Mountain Formation which evidently had better primary porosity and permeability.

The open vuggy nature of the silicification, the presence of travertine, arsenic sulfides and mercury, and the proximity of the ore deposits to a mid-Tertiary erosion surface, suggest a shallow, low-temperature environment of deposition. This origin has not yet been corroborated by fluid inclusion and stable isotype studies. Oxidation by the action of late-stage hydrothermal fluids or by circulating groundwater then converted about half of the originally deposited carbonaceous ore to oxide ore.

Acknowledgements

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REFERENCES

Birak, D. J., 1979, Detailed Geology and Stratigraphy of the Hanson Creek and Roberts Mountain Formation; Jerritt Canyon Project; unpublished Freeport Exploration Company report.

Churkin, M. Jr., and Kay, M., 1967, Graptolite-bearing Ordovician siliceous and volcanic rocks, northern Independence Range, Nevada; Geol. Soc. Amer. Bull., v. 78, p. 651-668.

Collord, E. J., 1979, Geology of the Marlboro Canyon area, Jerritt Canyon Project, Elko County, Nevada; unpublished Freeport Exploration Company report.

Hardie, B. S., 1966, The Carlin Gold Mine, Lynn District, Nevada; Nevada Bur. of Mines Rept. 13, part A, p. 73-83.

Hawkins, R. B. 1973, The geology and mineralization of the Jerritt Creek area, northern Independence Mountains, Nevada; unpublished Master's Thesis, Idaho State Univ., 103p.

Kerr, W., 1962, Paleozoic sequences and thrust slices of the Seetaya Mountains, Independence Range, Elko County, Nevada; Geol. Soc. Amer. Bull., v. 70, p. 539-564.

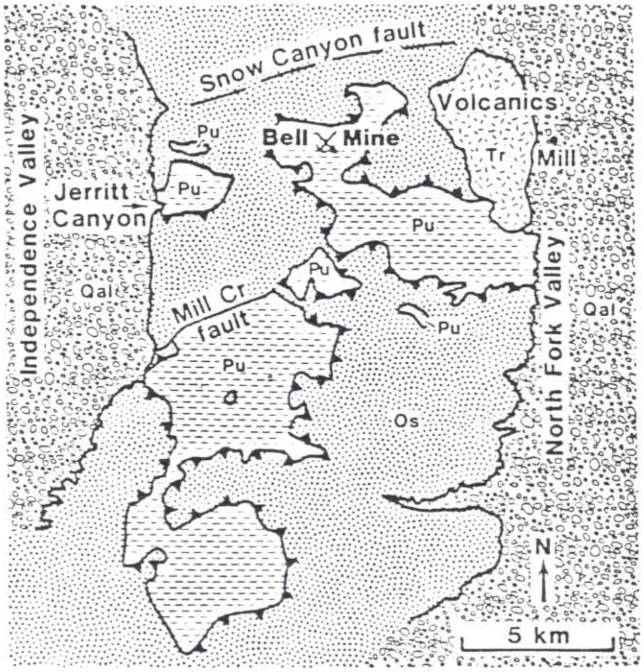
Lawrence, E. F., 1963, Antimony deposits of Nevada; Nevada Bur. of Mines Bull. 61.

Radtke, A. S., and Dickson, F. W., 1974, Genesis and vertical position of fine-grained disseminated replacement-type gold deposits in Nevada and Utah, U.S.A.; Internat'l Assoc. Genesis Ore Deposits (IAGOD), 4th Symposium, 1974, Varna, Bulgaria, Proc., v. 1, p. 71-78.

Radtke, A. S., Rye, R. O., and Dickson, F. W., 1980, Geology and stable isotope studies of the Carlin gold deposit, Nevada; Econ. Geol., v. 75, no. 5, p. 641-672.

FIGURES

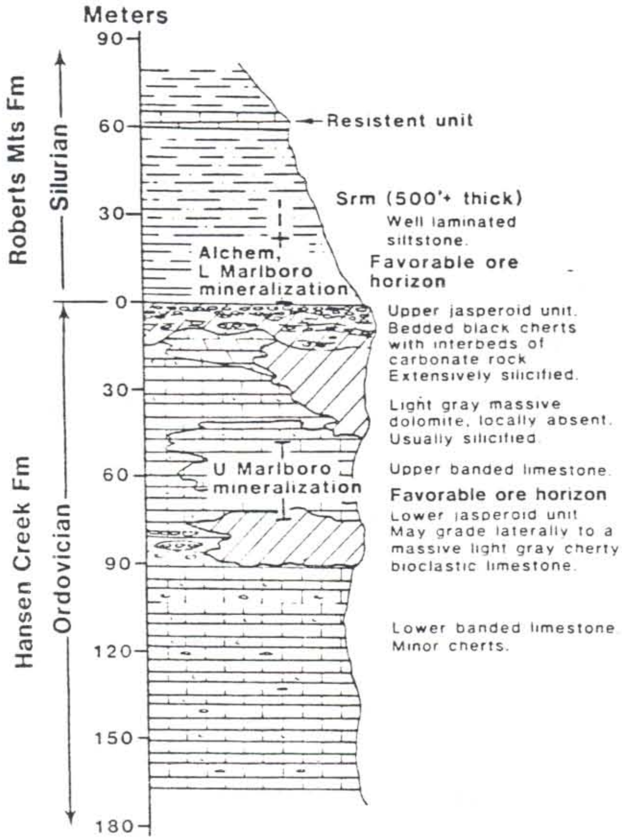
PHOTOGRAPHS

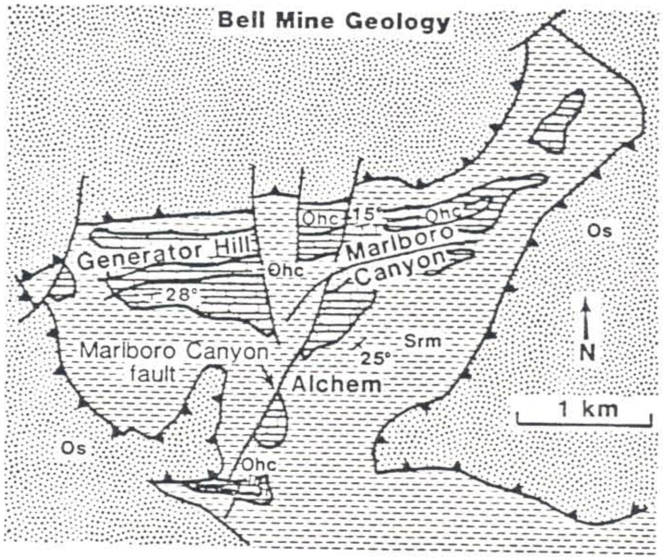


Roberts Mountains thrust

High angle normal fault

	Qal Alluvium	Quaternary
	Tr Rhyodacite flow	Tertiary
Upper plate	Lower plate	
	Pu Eureka Qteite, Hansen Ck Fm, Roberts Mts Fm undifferentiated	Silurian Ordovician
Os Snow Canyon Fm undifferentiated		Ordovician


Meters
90
60
30
0
30
60
90
120
150
180
Roberts Mts Fm
Silurian
Hansen Creek Fm
Ordovician
Resistent unit
Srm (500'+ thick)
Well laminated siltstone.
Alchem, L Marlboro mineralization
Favorable ore horizon
Upper jasperoid unit. Bedded black cherts with interbeds of carbonate rock Extensively silicified.
Light gray massive dolomite, locally absent. Usually silicified.
U Marlboro mineralization
Upper banded limestone.
Favorable ore horizon
Lower jasperoid unit May grade laterally to a massive light gray cherty bioclastic limestone.
Lower banded limestone Minor cherts.



Alteration

Srm Roberts Mts Fm

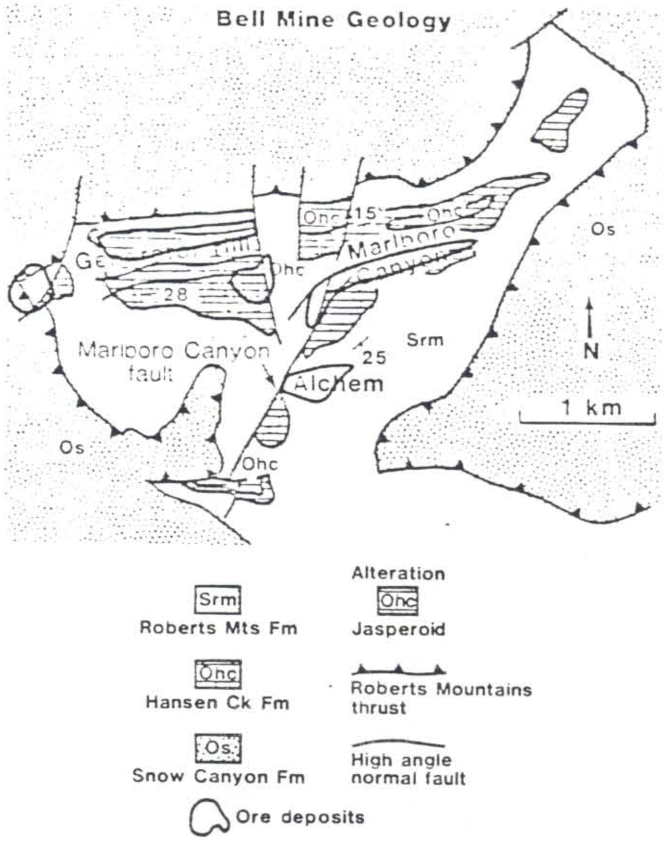
Ohc Jasperoid

Ohc Hansen Ck Fm

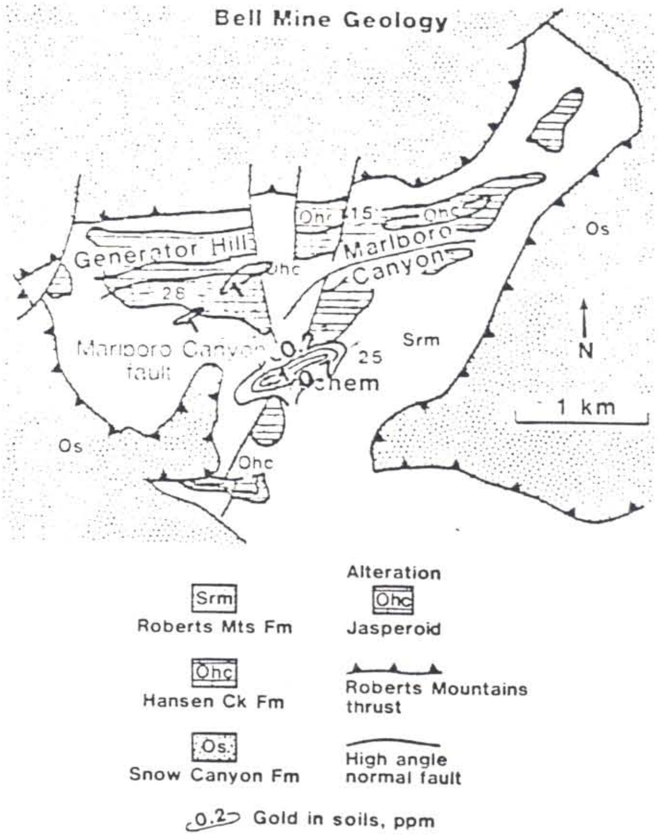
Roberts Mountains thrust

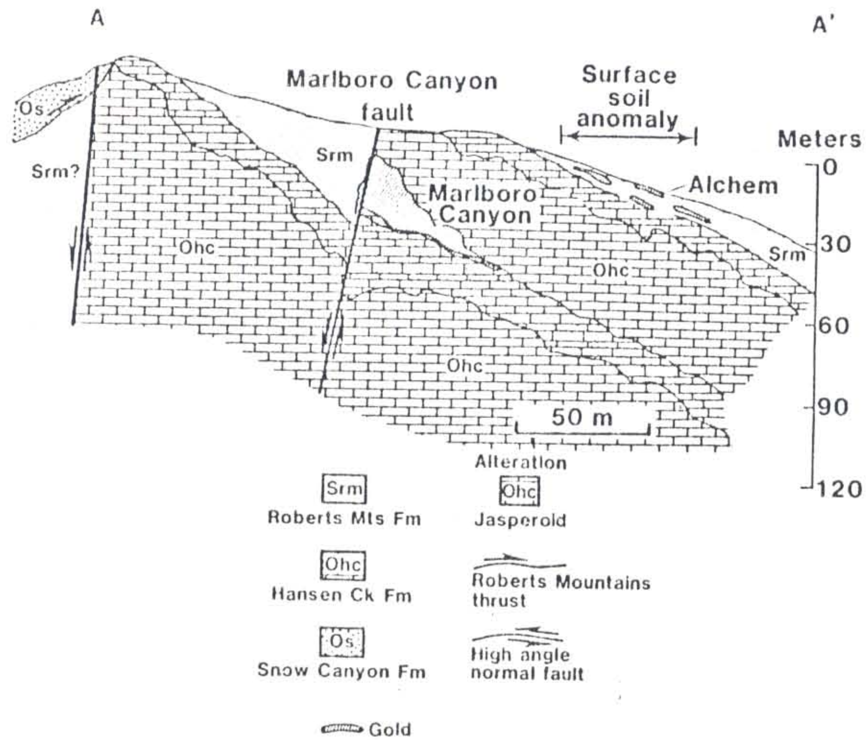
Os Snow Canyon Fm

High angle normal fault



Bell Mine Geology
Onc
15
Onc
Marlboro Canyon
Ohc
28
Marlboro Canyon fault
Alchem
25
Srm
Os
N
1 km
Os
Ohc
Srm
Roberts Mts Fm
Onc
Hansen Ck Fm
Os
Snow Canyon Fm
Alteration
Onc
Jasperoid
Roberts Mountains thrust
High angle normal fault
Ore deposits


Bell Mine Geology
Generator Hill
Marlboro Canyon
Marlboro Canyon fault
Ohc
15
28
25
Srm
Os
0.2
Chem
N
1 km
Srm
Roberts Mts Fm
Ohc
Hansen Ck Fm
Os
Snow Canyon Fm
Alteration
Ohc
Jasperoid
Roberts Mountains thrust
High angle normal fault
0.2 Gold in soils, ppm


A
A'
Marlboro Canyon
fault
Surface
soil
anomaly
Meters
0
30
60
90
120
Alchem
Marlboro
Canyon
Os
Srm?
Srm
Ohc
Ohc
Ohc
Srm
50 m
Alteration
Srm
Roberts Mts Fm
Ohc
Jasperoid
Ohc
Hansen Ck Fm
Roberts Mountains
thrust
Os
Snow Canyon Fm
High angle
normal fault
Gold