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# GEOLOGIC RESUME OF THE STEEPLE ROCK MINING DISTRICT

## Location and Topography

Steeple Rock Mining District is potentially a very promising precious metal and base metal ore bearing district. It is situated in western Grant County, New Mexico and in eastern Greenlee County, Arizona. The approximate location, by legal description, is within T 16 and 17 S, R 20 and 21 W, NMPM, and T 6 and 7 S, R 32 EG and SRM. The district comprises a sector of blocked faulted Cretaceous and Tertiary volcanic rocks that have been altered and intruded by rhyolite dikes and plugs. There are mineralized lineations along a trend about 10 miles long and 4 miles wide. Futhermore, there is a possibility that base metal ores will underlay or occur on one side of or in some way associated with precious metal ore bodies. In general, the base metal content in the ores increases with depth as in the Carlisle and other mines. Mineralized trends are intermittent with hydrothermal indications of possibly larger ore deposits in the northwest part of the district and smaller ones in the more narrow vein structures in the southeast part.

The district derives its name from a prominent spiral like mountain peak called Steeple Rock. It marks the southern end of the district and is a component of the prominent south-westward facing frontal fault scarp.

## History of Discovery and Mining

The earlist known record of mining in the Steeple Rock District is in a military report about the dispatch of troops from Fort Thomas in 1860 to protect miners from the Apaches. Records show that the Carlisle Star of the West, the Center, and the Pennsylvania were the first locations to be staked in the district. These claims were filed on January 24, 1881 by Daniel Remington, James Mounts, William Johns and A. G. P. George, all from near Carlisle, Pennsylvania.

Carlisle was a producing mine prior to 1880. In 1883, it was sold to a group which included Marshall Field, N. K. Fairbands and other prominent merchants and capitalists from Chicago. Between 1883 and 1887, the Carlisle group of mining claims were patented and precious metal production was very profitable. This production was from the oxide zone but later and at greater depth complex sulfide ore was found in large quantities. These claims are the Carlisle Lode, the Homestead Lode and the Columbia Lode. During this period the Carlisle Mining Co. was founded. The company constructed a 20 stamp mill and the Carlisle Mine was developed down to the 300 foot and 400 foot levels.

During January 1887, the Carlisle Mining Co. was sold, reportedly for $1,000,000.00, to English interests known as the Golden Leaf Mining Co., Ltd. The owners were Henry Cameron Richardson and the Rothschild Family. The Golden Leaf Mining Co.

later became the Carlisle Gold mining Co. The affairs of the Carlisle Mining Co. were conducted by trustees until 1896 when the Steeple Rock Development Co. was organized and assumed the Carlisle assets. About this time others were operating in the district. These included the Laura Consolidated Mining Co. which also was controlled by English interests.

Steeple Rock Development Co. and its predecessor spent large sums of money developing the Carlisle and other properties. The Carlisle mine was developed to 600 feet and the mill was enlarged to 60 stamp. Thirty-three mining claims were purchased and patented that were later grouped through property consolidations and splits. Out of this, several ownerships developed. Roads were constructed and several mines were systematically developed. It was during this period that the price of silver dropped so precipitiously that the incentive to find ore and develope mines became nil. Since then, portions of the properties have changed hands several times.

In 1914, the Steeple Rock Development Co. properties were sold to George H. Utter. Between 1914 and 1917 Utter developed the Jim Crow mine, sinking a shaft to 300 feet. Mr. Utter also did some mining in the Carlisle but most of his ore production was shipment of the Carlisle mill tailings. He and other individuals shipped small amounts of ore from other properties during the period from 1914 to 1920. In 1920, mining operations for the most part ceased. Between 1920 and 1932, there was very little prospecting; activity was essentially non-mining.

According to Griggs, about $7,000,000.00 worth of metals have been produced from the Carlisle and the East Camp mines. Most of the ore production was achieved during three periods and values during the first two were largely derived from gold and silver. The first major period of mining was from about 1882 to 1897. The second major period followed the rise in the price of gold in 1933. At that time, additional gold and silver ore was discovered at the East Camp mine. The last and third major period of production extended through World War II. When the U. S. became involved in World War II, gold mining was stopped by Presidential Order. The East Camp mine was closed and the Carlisle mine was reopened with the aid of the Bureau of Mines, to mine a sulphide ore body (Cu, Pb, Zn) that had been discovered and somewhat developed during the 1880's. This ore was milled at the converted East Camp mill.

The value of ore produced from other mines in addition to the Carlisle and East Camp mines is unknown. These mines are: Jim Crow, Alabama, New Year's Gift, Imperial, Laura, Summit, Bank, Bilali, Norman King and Twin Peaks. There was some production from other small operations of which there is no record at all.

It is interesting to note that so much ore was produced from several small locales, and even more important to assert that except for the above described mines, the entire Steeple Rock Mining District has been virtually untouched. Other than drilling in and around the Carlisle mine, the only other deep hole (and the deepest) was drilled by Kennicott north of Saddle Mountain in Bitter Creek. In respect to Kennicott's drill site, their location is considered a poor one. A brecciated structural intersection would have been a better choice for a test.

It is of interest to note that former President Herbert Hoover began his mining career in the Steeple Rock Mining District and that the Hoover tunnel, which is still open, was named after him.

Recent Activity

Since 1964, M & M Enterprizes, Inc. of Roswell, N. M. have located and now hold approximately 248 mining claims in various parts of the district. Most of these claims are in groups as shown on the mining claims map. M & M Enterprizes, Inc. also has first priorty mining water rights to provide substantial water for mining and ore milling operations. M & M mining clains and state leases are shown in properties ownership, Tables 1 and 11 A. Known patented and unpatented claims in the Steeple Rock District other than those held by M & M are shown on properties ownership, Table 11.

Recently, reconnisance geochemical geological work was done by Phelps Dodge Corporation on M & M mining clains located in the Steeple Rock Mining District. Primary locations of the sampling are shown on maps numbered 2, 3, and 4. These results of Phelps Dodge Corperation were given to M & M in compliance with an agreement between M & M and Phelps Dodge.

Trace element anomalies (mercury) show northwestward trends and as locales in the Bitter Creek altered area. Mercury anomalies in the Telephone Ridge altered area appear to be localized. The mercury anomalies in the Goat Springs altered area appear consistently strong in a northeastward trend. However, there seems to be weakness in the central part.

The anomalous trace mercury shown by the Phelps Dodge work substantiates a firm belief that the altered masses and altered trends are favorable as targets for ore. To more adequately confirm this concept, additional geochemical data is needed on closer spaced samples. This would also determine the size and shape of the anomalies. Exploratory drilling where the stronger indicators are shown would determine if the trace mercury occurrances are related to ore.

M & M Enterprises, Inc. collected twenty-six water samples for spectographic analysis and have assayed many rock samples. The water samples have not yet been analyzed. M & M personnel are impressed that possibly substantial gold and silver ore occurs on the westward extension of the Carlisle vein or mineral trend in section 2, the Summit and Bank vein and the Laura vein systems. Base metal occurances are likely in the western portion of the District.

## Geology

The principle geological elements of the Steeple Rock District are: the large volume of volcanic rocks (mostly andesitic), the prominent northwestward-southwestward fault lineations which are expressed by fault scarps, a vast amount of rock alteration, and either known or suspected ore deposits. The structural framework is on a southward trending spur off the Mogollon Rim. This spur is somewhat circum to the Mogollon Rim and appears as a south-projecting prong on the southwestward flank of the Burro Mountain uplift. The Burro Mountains appear to have been a stable Precambrian highland that rapidly eroded during Paleozoic time. Moreover, Paleozoic sediments apparently did not deposit in the area. Mesozoic sediments of Cretaceous age, the Beartooth quartz (lower), and the Colorado shale (upper) is believed to have been mostly removed by erosion. Probably there are some remnants of these sediments underlaying the volcanic rocks.

## Geologic History

Large northsouthward elongated fault basins are believed to have formed before the beginning of late Cretaceous volcanism. A fault trough, northwest-southeastward, is the structural frame of the basin which in part is the Gila River rift valley. The abundant vulcanism extruded large volumes of andesitic and related rock into the trough and probably was the first phase of igneous activity. This is attested to by the wide spread late Cretaceous lavender colored andesite in a large elongate area of west central New Mexico and east central Arizona. Late Cretaceous vulcanism was followed by orogeny and at least two extrusive volcanic phases during early Tertiary time. The deformation appears to be an uplift perhaps folding northwestward-southeastward that uplifted the volcanic rocks that were further uplifted along normal faults that generally tilted the fault blocks northeastward. The Tertiary volcanic rocks, probably were extruded sometime before and during deformation. The igneous phases as expressed on the surface are the extrusive and intrusive rocks. Rock alteration and mineral deposition are believed to be associated with the igneous phases of Tertiary vulcanism. Known base metal and precious metal minerals were deposited in vertical (vein) structures and shatter structures. Following the first phase metalization, there was an enormous amount of rock alteration. The relationship of ore deposition to alteration of the rocks is uncertain, primarily for lack of sufficient surface and subsurface exploration. The base metals were probably deposited first. Field relations indicate that the base sulfides may have been deposited before the phase that so intensely and extensively altered the rocks.

Rocks

The subsurface basal rocks underlaying the district are Precambrian granite overlain by thin layers and patches of sedimentary Beartooth quartzite and Colorado shale. These sedimantary rocks are the lower units of the upper Cretaceous sediments. Immediately above and resting on the basal rocks are basal volcanic debris-like units composed of andesitic breccia, agglomerate and subordinate flows. Also intercalated with the debris units are some discontinuous latite and rhyolite foows. These basal volcanics are estimated to be about 500 feet thick. Above and resting on the basal volcanics is rather thick sequence of purplish-gray andesite flows with some intercalated, varying thickness, andesitic tuff and agglomerated layers. This rock unit is about 1500 feet thick. The flow rock units have very distinctive porphyritic texture. The rock is coarsely porphyritic and the phenocrysts are large, abundant and conspicious. The unweatered rock (fresh break) is dark-gray but it weathers to purplish-gray. By mass effect it has the appearance of being a light grayish-lavender in color. This rock is exposed generally between the Blue Bell fault system along the northeast side of the distict and the Laura (Steeple Rock) fault system along the southwest side of the district. Much of this rock is exposed elsewhere in the vicinity but it has not been differentiated. This lavender andesite is the host rock of the ore and it is intensely altered in the vicinity of the known ore structures as well as in many other parts of the district.

Rhyolite flows overlay the lavender andesite. The thickness of this rhyolite layer is unknown but it could be as much as 100 feet thick. It is exposed along the altered trend on Telephone Ridge and Säddle Mountain as well as many other points. It is silicated to the extent that it may be classed as porcelanite. These rocks are also exposed southeast of the district and south of Steeple Rock.

In contact with and overlaying the pink colored rhyolite is a unit comprised of several flows of dark-gray andesitic basalt that is estimated to be in the range of about 1000 feet thick The individual flow layers are more or less amydgaloidal and uniform textured in appearance and in composition. Most of this rock is finely porphyritic. Small patches of rhyolite tuff are interlayered with the andesitic basalt rock. Reddish-brown andesite porphry caps the amygdaloidal andesite-basalt. This rock is relatively thin where it caps the andesitic basalt along the mineral trend. However, it appears exceedingly thick in the successive westward facing scarps to the northeast.

Structure

The general structure of the Sþeeple Rock District is an elongate, differential uplift that trends northwest-southeast 40 to 50 degrees. This block is formed by a series of high angle normal faults that have tilted the volcanic rocks northeasterly. Less obvious transversal and diagonal shears that trend northeasterly-southwesterly and north-south have broken the dominant northwesterly-southeasterly elongate structures into fault blocks. The volcanic rocks are generally tilted northeastward 10 to 30 degrees in successive uplifts in a framework of successive steps.

East Camp fault and Blue Bell which are the major lineation faults along the northeast side of the district, dip northeastward 60 to 75 degrees. The major lineation faults along the southwest side of the district (Carlisle and Laura) are normal faults that dip 60 to 75 degrees southwestward. The fault blocks are successively downthrown toward the southwest.

The dominant northwesterly-southeasterly fault systems formed horsts and grabens. These structures are outstandingly prominent along the central part of the district. Hydrothermal alteration which is quite pervasive along the structural lineation has produced a most unusual terrain of color and topography. The horsts and hrabens and the pervasive alteration associated with them have never been emphasized.

The fracture pattern is diaplayed by the major fault pattern that formed the horsts and grabens and the transverse shears that broke them into blocks. The pattern is diaplayed as an acute to subrectangular grid. The numerous minor connecting and satelitic fractures modify it to a mesh-like pattern futher modified by curving fractures

The major fault pattern is characterized by bifurcation, curved faults and cymoid loops. This pattern is particularly characteristic of those fracture patterns of mountain blocks that are uplifted by an underlaying vertical force. Presumably the force that formed the structure is an intrusive magmatic body that was uplifted by an underlaying vertical force. Mineralizing gases emanated from the underlaying magma to alter the rock and to deposit ore minerals and the gangue minerals.

Interposed in the Steeple Rock structural framework are localized internal ringed structures and trough structures that probably have never been noticed because they have not been described or emphasized. These structures are associated with the major structural intersections and the horsts and grabens. Within the rings and the troughs are shatter pipes and shatter troughs. Some of these structures are intensely altered and they may be ore carriers. The most apparent ring structure in the district surrounds the Carlisle mine. This mine is within a brecciated ring that appears to be a breccia pipe or perhaps a shatter pipe or shatter column. Other breccia structures are not as obvious and no doubt, there are several other such structures that cannot be seen. The structural pattern is not known in its entirety; only the framework can be seen. The presumed to exist important structures are obliterated by alteration and further covered by a reasidual cap of supergene altered rock.

Additional field work is needed to further define and locate the buried structures. This geologic approach should correlate geological, geophysical and geochemical effort with emphasis on drilling in already indicated targets.

Rock Alteration

The outstanding geologic feature in the Steeple Rock District is the enoromous amount of altered rock. This altered rock is related to the structural framework and is the expression of mineral trends and locales. This was formed by an igneous phase that is believed to be related to ore formation. As previously mentioned, the alteration and the implication of ore occurrences or the relationship to possible ore has never been emphasized. The characteristics are that of epithermal alteration. The age of the altering and mineralizing phase is belived to be about mid-Tertiary.

This alteration is the attraction for the numerous mining claims that are located by M & M Enterprizes as well as those claims that were located in the past. The altered volcanics are vividly displayed along the grabens and horsts and isolated circular patterns. The outstanding altered structures in the Steeple Rock structural framework from southeastward to northwestward are: Telephone Ridge, Summit Peak, and Saddle Mountain. Saddle Mountain is the largest altered structureal feature. The alteration is displayed along Bitter Creek northeastward and in the Iron Cayon locality on the southwest side; where Bitter Creek bends westward the alteration trend bends northward. It extends across the intervening ridge between Bitter Creek and Wampoo Creek and there it seems to terminate. The color brilliance in the multi-colored altered rock is quite variable and color zoned. The epi-center is entensely altered. This is evidenced by intensely bleached rock. The coloration, as is the alteration, is less intense outward from the epicenter which grades into the fresh lavender colored andesite along the margin of the alteration. The variations are buff to tan to grayish-red to grayish-green to lavender on the outer fringe. The colors in the most intensely altered parts are brilliant grayish-white, buff and orange-red. Near the outer fringe, the rock is grayish-green, with the outmost color fringe ranging from purple to lavender. The alteration features at the surface are complex and mostly hidden by a supergene cap. They seem to concide with brecciated fault shatter trends. The most intense alteration seems to be associated with shattered rock that is in and adjacent to structural intersections. Some of these shatter locali-ties appear to be shatter pipes or possibly breccia pipes. The most characteristic visible alteration products are argillite impregnated with alunite and melantinte. The altered masses in part are exposed to the surface. However, most of the alteration is capped by a silicate volcanic tuff that is also altered by silicification. This appears to overlay the lavender andesite. It may possibly [illegible] intrusive sill. The altered surface is further modified an[illegible] marked by a hypogene blanket developed from weathering. U[illegible] the weathered surface are sulfides consisting of marcasite [illegible]d pyrite. The sulfides are disseminated in the altered ande[illegible]tic rock to varying intensities. The intensity of the sulfides appear to be related to the intensity of the alteration. The association of the clay minerals, alunite and the sulfides (pyrite and marcosite) indicate that the sulfide deposition and the development of sericite and clay minerals was contemporaneous. Alteration of the andesite, except at the surface, is hypogene and the sulfides are primary minerals. The surface weathering or supergene alteration is the most conspicuous alteration product that masks the primary alteration. Except for surface changes due to weathering, the alteration masses and the associated minerals appear to exist mostly in the primary state. Oxidation is superficial except in the veins and perhaps other unknown vertical structures. Where there may be porosity in the shattered and brecciated rock, oxidation will extend to considerable depth below the surface. However, co-mingling of hypogene and supergene products on the surface preclude a clear distinctive interpretation.

Physical changes by alteration are very conspicuous and they are an outstanding mineralogical feature displayed by multiple coloration. Melanterite known as copperous is locally a coloring mineral. The affected surface rock is usually capillary and fiberous, stalititic and concretionary, also massive and pulverant. The luster is viterous and the color shades of green passing into white become yellow on exposure. There seems to be a large amount of melanauterite associated with the alunite. Other physical changes are porosity, permeability and other textural changes by addition of exotic mineral constituents. The characteristic minerals are: sericite, abundant clays that may be mostly supergene, quartz, some chlorite, a small amount of epidote, and the sulfides. Calcite and other carbonates are associated and intermingled with quartz. Some of the veins contain calcite apparently dissociated from quartz.

Much of the ore in the district is localized as lense-like bodies within brecciated material between the fault walls. The relative amount of replacement as opposed to open-space deposition is difficult to evaluate. In the Carlisle mine, the sulfide ore body is related to and associated with quartz gang. This gang filled open spaces and in part it replaced gangue breccia and earlier minerals of the country rock. The ore body, that is the combination of the quartz and sulfide ores, replaced perhaps as much as fifty percent by volume of the previously existing material. The high-grade gold-silver ore body in the Carlisle mine was deposited mainly in open spaces.

The predominent vein material associated with sulfide ore and precious metal ore is brecciated, highly silicified wall-rock. The second most abundant vein mineral is fine to medium grained, vein quartz. The individual ore shoots in which the ores occur are in very thin tabular bodies and some fine breccia. The quartz and breccia are intermingled. The breccia veins are filled with metal bearing quartz. In many of the mines, the veins are banded or apparently banded. The vein material and the ore minerals occur in very thin tabular bodies in fine breccia. These are arranged in somewhat sheet zones wherein the sheets of ore are separated from each other by thin ribs of metal bearing quartz and altered breccia. These small mineral bearing sheets or ribs are the principle part of the larger, lense-like ore shoots.

The most conspicuous type of wall rock alteration in the veins is silicification which forms where the fault breccias were silicified. Most of the ore bodies are associated with quartz which is the best guide to ore in the district, although it formed mainly if not completely before any of the metals were deposited. The reason for the common association is that both the greatest silicification and the ore deposition apparently took place along through-going channels where the mineralizing probably had a particular voluminous and steady flow.

Analysis of the structural setting indicates that the fault intersections as previously stated were very important in the localization of ore bodies. As previously stated, the Carlisle mine locality is belived to be a breccia pipe. This breccia pipe was developed in the locale of the fault intersections and a transversal sheer trend. In this setting where the Carlisle mine was developed the structural situation was such that an exceedingly wide channel-way and the most valuable ore body known in the district was deposited. Further analysis of the structural setting in the Steeple Rock structural frame-work points to other developments such as evident at the Carlisle mine.

Mines and Production

The Steeple Rock District is famous for gold, silver and base metal production. The Carlisle and the East Camp mines are especially well known as gold and silver mines. Although substantial precious metals ore was produced from these mines, they are credited with ore production that came from other mines, such as the Summit, Band, Bilali, Norman King, Center-Pennsylvania, Jim Crow, Alabama, Laura, and the New Year's Gift. This was because the Carlisle and East Camp operators processed and marketed all production under the name of their operations. Documented operations and production information on these mines is meager to non-existent. However, according to information gathered via personal communications from old timers and judging by the size of some of these mines, ore production must have been considerably more than is generally known.

Because the precious metals ore deposits are siliceous, no doubt much of the ore production, unaccounted for, was marketed as flux ore.

The high grade ore that was mined during pioneer days was concentrated in arristes and the concentrates smelted in crude furnaces. Three of these sites, although in advanced deterioration, remain in evidence.

After the price of gold was raised to $35.00 per ounce in 1933, most of the mines were reopened and examined. During the depression years, between 1934 and 1942, about 30,000 ounces of gold and more than 1,000,000 ounces of silver were produced. The East Camp mine was the important precious metal producer during this period. (See Table IV). This mine is apparently now almost depleted.

After World War II erupted (1942), the Carlisle mine was re-opened. Reactivation of this mine was to mine lead, zinc and copper ore from the sulfide base metal ore body. More than 8,000,000 pounds of base metals were produced before the mine was closed in 1946.

Ore Deposits

The vein structures in the district in which the ores occur are an integral part of the Steeple Rock structural framework. These veins systems are, in order of importance, (1) Carlisle (the Blue Goose and Apache faults inclusive), (2) East Camp, (3) Laura (the Jim Crow fault system inclusive), and (4) Summit and Blue Bell fault systems including the intersection near the head of Bitter Creek.

These precious metals veins which contain sparse base metal sulfides are related to wide fault or fracture openings. There is no doubt the fault fractures provided the channel way for the mineral solutions and the openings in which the minerals were deposited. The width of the fault systems apparently controlled the permeability along the faults and in turn the volume and flow of the mineralizing solutions.

Where these structures are obvious, they are ore bearing. Where they disappear or coalesce into the altered masses, the faults or the ore minerals are not apparent. The intense part of the altered masses are in line and without doubt related to the obviously mineralized faults. Therefore, projection of these faults along the massive alteration is reasonable. It must also be reasoned by extrapolation that if there is ore in the obvious part of the fault where alteration is much less, there should be ore along the same fault system where alteration is massive and more intense. If there is any relationship in the amount of ore in a structure to the alteration, by comparison, there should be considerably more ore where the alteration is more massive and intense. If this concept is valid, ore targets are obvious. Moreover, if there is a relationship of ore to volume of altered rock and intensity of alteration, then the larger hidden ore bodies will be more easily discovered.

The veins are interpeted to be epithermal volcanic type. This type is characteristically developed in volcanic rocks. For an economic standpoint the volcanic type quartz veins have been the most important type ore deposits in the world, especially in the production of gold and silver. Additionally, these v. s and the altered masses are believed to be related to deep seated intrusives.

The vein filling is mostly quartz and lamellar calcite. Some of the quartz is fine grained and dense. Some of the more dense quartz is cryptocrystalline. Delicate colloform banding, and comb structures are prominent. This is the part of the vein in which most of the precious metals occur. Intergrowth of quartz and lamellar calcite are a part of the vein filling. The three generations of vein deposition are generally confused because each generation and variety seems to coalesce and exhibit intergrowth. Silification and quartz is the most conspicious vein material. The ore is mostly associated with the intense silicification. From the surface expressions and subsurface indications, silicification is a valid guide in the search for ore. Additional indicators are sericite, chlorite and epidote. This alteration is less prominent but seems directly associated with ore occurences.

Three stages of mineralization are indicated. The first is early quartz, essentially barren, that cemented and hardened the brecciated and shattered rock. By fault rejuvenation and the second mineralizing stage, hydrothermal vein quartz was deposited. Pyrite, galena, sphalerite and chalcopyrite were deposited with the second mineral stage. Gold and silver and probably the fluorite were deposited during the third mineralizing stage. The base metal deposition is believed to be very late Cretaceous and early Tertiary age. If so, the base metals are probably spatially related to the ore deposits in the surrounding region. The precious metal deposition is believed to be about Miocene or mid-Tertiary in age. If so, the precious metal ores are correlative with the known precious metal are deposits also in the surrounding region.

Paragenesis and Origin

The sequence of mineralizing effects in the ore deposits is fairly clear. The earliest stage of mineralizing sequence was metamorphism by chloridization of the rocks adjacent to the faults and the shatter structures. Platty calcite was deposited about the same time as the chlorite, possibly contemporaneously with it. Sericite developed during deposition of the quartz during the second and third stages of mineral deposition. Metamorphism, where observed in the structures, is zoned. The sericite is within and very near the structure where the chlorite is along the outer margin.

To repeat and rephrase, the first stage silicification was apparently accompanied by fine grained pyrite that is disseminated as tiny cubes throughout the altered rock. The second stage quartz deposition was also the principal or intense sulfide stage. The sulfides deposited as the quartz deposition phased out. Sphalerite, galena and chalcopyrite deposited in the sequence given during and following deposition of the pyrite. Chalcopyrite, silver and gold were deposited with quartz during the third and final stage of mineral deposition.

Manifestations of mineral deposition indicate moderate to shallow depths. If judged on the basis of early alteration, the mineralizing solutions must have been of moderate temperatures. The gold and silver deposited during the last stages of mineral deposition must have been from cooler solutions.

## Zoning

Zoning of the mineralized structures and and/or deposits is indicated by succession of minerals given under paragenesis. The apparent sequence from earliest to latest is: (1) alteration of the rocks and (2) deposition of pyrite, galena, sphalerite, chalcopyrite, chalcopyrite with silver and gold.

Zoning is manifested by barren silicated caps overlaying mushroomed and planar alteration masses. The solution channel is deeper under the mushroom or planar structure. The mineralizing agencies on approaching the surface have tended to spread laterally to form these features. Thus mineralogical zoning tends to be horizontal as well as vertical or perhaps oblique between horizontal and vertical. This is because only the upper part of the mineralized structures are exposed. The lower part has not yet been exposed except in the deeper mines. The geologic information from these mines is so meager that a vertical or horizontal zoning sequence is not clear. However vertical zoning appears to a reality. Base metals, especially copper, appear to increase with depth. Correspondingly, the precious metals appear to decrease with depth.

In theoretical mineralogical zoning the high temperature minerals are deposited nearest the magmatic source. Lower temperature minerals are deposited in successive higher or distant horizons and belts.

Ideal zoning, from upper to lower, is as follows:

| Zone | Diagonistic Minerals |
|---|---|
| Ectothermal | Barren |
| Upper Epithermal | Ankerite, barite, calcite, dolormite, fluorite, manganese, siderite |
| Lower Epithermal (Mineral Fringe Zone) | Fluorite, barite, calcite, gold, silver |
| Mesothermal | Silver, lead. zinc. copper |
| Upper Endothermal | Copper, tin uranium, tungestin, molybdenum, magnetite |
| Lower Endothermal | Barren |

Theoretical Considerations

Volcanic emanations, whatever the ultimate source, is a major factor in the origin of the altered rock and the associated ore deposits. The pneumatolatic gases exhalated were probably a mixture of the following compounds: carbon dioxide, hydrogen sulfide, ammonia methane, hydrochloric acid, hydrofluric acid, sodium chloride and ammonium chloride.

Where hydrogen sulfide is in excess, near the surface, oxidation may produce sufficient sulfuric acid to neutralize and make acid the water involved. This results in alteration of the rocks characterized by clays and the sulfate, particulary alurite and melantorite.

This breakdown of the rocks tends to form massive silicification. Some of the silica seems to be resident silica that was redeposited.

As for the ore metals in the ore deposits, volcanic gases would have been adequate as agents that transferred the metallic elements to the extent of alteration seems to have developed by successive floods of pervasive fluids.

Many resemblances of the epithermal mineralization to those of other classifications, particularly the mesothermal and hypothermal in igneous rocks suggest that all fit into one ecletic frame.

Except for changes due to weathering, these alteration masses and the associated ore deposits exist approximately in their original state, thus proferring the minimum of superimposed mineralogical and geological changes.

The linearity of the alteration and the zonal pattern suggests an elongate or linear subjacent source of heat. Compressive forces produced the uplift by faulting. The block faulting characterizes the final stages of the deformation cycle. These surface manifestations of compressive forces are markedly linear, as has been adequately described. Therefore a reasonable conclusion is that the underlaying mobile layer must have comparable linear expression. A further reasonable assumption is probable elongate intrusive masses interposed in the subsurfave beneath the crustal expression. These are believed to be the source of energy and the minerals to produce the alteration and form mineral deposits. The geological sequence suggests that the basement of the Steeple Rock uplift is elevated high beneath the surface blocks elevated by the last stage of the orogenic cycle.

The implications cited point to the Steeple Rock District as being a very attractive field for ore exploration.

The Search for Ore

The search for ore starts with the fact that much of the surface has been examined by at least two generations of prospectors. Undiscovered ore for the most part must be beneath the present surface of the altered masses. Ore bodies associated with these masses does not outcrop. Furthermore there may be concealment by younger volcanics.

The relationship of rock alteration and ore deposition is well known as has been described herein. The relationship in the Steeple Rock District is a matter of integrated observation and interpetation. This can be done by application of sound geological deduction and further aided by appropriate geophysical methods and more geophysical sampling. Finally the scientific techniques must be supplemented by drill holes for subsurface sampling.

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TABLE I

M & M Mining Claims

| Mining Claims Group Name | Number | Locality |
|---|---|---|
| Bittercreek | 97* | Bittercreek and Saddle Mountain |
| Dottie | | Saddle Mountain and Iron Canyon |
| Fierro | 6 | Iron Canyon |
| Wampoo | 8 | Wampoo Creek |
| | 4 | Wampoo Creek in Arizona |
| Lee-Shirley | 29 | Goat Springs in Arizona |
| Borrego | 14 | Goat Springs |
| M & M and Milestone | 53 | Telephone Ridge |
| M & M B and Susan | 16 | Laura Canyon |
| M & M A | 18 | Hext Ranch |
| Bank | 3 | Summit Mountain |
| | 248 | |

All of the above listed properties are located in New Mexico except as indicated.

*Combined total of Bittercreek and Dottie claims.

TABLE II

Properties Ownership

The following is a list of the known patented and unpatented mining claims in the Steeple Rock Mining District other than the unpatented mining claims held by M & M Enterprises. M & M's mining claims are previously described (see Table I ) and shown on maps.

| Name | Number | Status | Ownership |
|---|---|---|---|
| Jim Crow and Imperial Group | 8 | Patented | Utter Estate |
| Mt. Royal | * | Patented | Hirsch Brothers |
| Alabama Group | * | Patented | Terreroca Mining Co. |
| New Year's Gift | 3 | Patented | Carlisle Development Co. |
| Laura | 2 | Patented | James Aspell |
| Carlisle Group | 3 | Patented | Carlisle Development Co. (Mrs. Roy B. Wilson) |
| Progressive Group | * | Patented | Progress Mining Co. |
| Summit Group | 10 | Patented | Dwight L. Smith & Associates |
| East Camp Group | 8 | Patented | Parks Brothers |
| Bilali | 1 | Patented | Utter Estate |
| Mayflower | 2 | Patented | Phelps Dodge Corp. |
| Twin Peaks | * | Patented | Fraser Brothers |
| Norman King | 1 | Unpatented | C. H. Winterhaler |

* Not known

TABLE II, Properties Ownership, continued

| Name | Number | Status | Ownership |
|---|---|---|---|
| Mohawk | 1 | Unpatented | * |
| Ontario | 8 | Unpatented | Ben Billingsley |
| Center | 1 | Unpatented | Ben Billingsley |
| Pennsylvania | 1 | Unpatented | Ben Billingsley |
| Golden Rod | * | Unpatented | Ben Billingsley |

* Not known

TABLE II A

General Mining Leases between the State of New Mexico and M & M Enterprise, Inc.

| Institution Land | Acres | Subdivision | Sec. | Twnship | Range |
|---|---|---|---|---|---|
| Lease No. 70-0132-1 dated 3-12-65 | | | | | |
| Common Schools | 40 | SE1/4SE1/4 | 20 | 17S | 20W |
| Lease No. 70-0133-1 dated 3-12-65 | | | | | |
| Common Schools | 160 | NE1/4 | 22 | 17S | 20W |
| Common Schools | 40 | NW1/4NW1/4 | 23 | 17S | 20W |
| Lease No. 70-0134-1 dated 3-12-65 | | | | | |
| Common Schools | 480 | E1/2E1/2W1/2 | 23 | 17S | 20W |
| Lease No. 70-0137 dated 3-12-65 | | | | | |
| Common Schools | 640 | All | 34 | 17S | 20W |
| Lease No. 70-0138 dated 3-12-65 | | | | | |
| Common Schools | 640 | All | 35 | 17S | 20W |
| Lease No. 71-0111 dated 3-18-66 | | | | | |
| Common Schools | 640 | All | 16 | 16S | 21W |
| Lease No. 70-0480 dated 10-25-65 | 654.50 | All except lot 7 | 2 | 17S | 21W |
| Lease No. 70-0481 dated 10-25-65 | 2.94 | Lot 7 | 2 | 17S | 21W |
| Lease No. 71-0015 dated 1-18-66 | 640 | All | 32 | 16S | 21W |
| Lease No. 70-0470 dated 10-7-65 | 360 | E1/2NE1/4 NW1/4 | 36 | 16S | 21W |

TABLE III

| Period | Gold (oz) | Silver (oz) | Copper (lb) | Lead (lb) | Zinc (lb) | Total Value $ |
|---|---|---|---|---|---|---|
| 1880–1897 | 102,000 | 1,618,000 | | | | 3,000,000 |
| 1911–1921 | 2,200 | 48,500 | 133,500 | 839,000 | 139,500 | 500,000 |
| | | | (Wartime) | | | |
| 1932–1947 | 33,000 | 1,382,000 | 983,750 | 3,712,000 | 3,321,000 | 3,000,000 |
| * | | (Depression and Wartime) | | | | 500,000 |
| | 137,200 | 3,048,500 | 1,117,250 | 4,551,000 | 3,460,500 | 7,000,000 |

*Years other than main periods and unaccountable production of all metals and non-metals

METAL PRODUCTION DURING THREE MAIN PERIODS OF PRODUCTION IN THE STEEPLE ROCK MINING DISTRICT

TABLE V

Rock Sequence in the Steeple Rock Mining District

| Era and System | Rock Unit | thickness (feet) |
|---|---|---|
| CENOZOIC | | |
| Tertiary (Miocene) | Welded Tuff Datil Formation | 600'-700' |
| Tertiary (Eocene) | Amydgaloidal Andesite Basalt | 800'-1000' |
| | Quartz Rhyolite and Latite | 50'-100' |
| MESOZOIC | | |
| Upper Cretaceous | Lavender Andesite Porphyry (ore host rock)* | 1300'-1500' |
| | Brecciated agglomerate debris mostly andesitic-discontinuous latite and rhyolite flows | 300' |
| Cretaceous, sedimentary, Beartooth quartzite and colorado shale | | |
| Precambrian | Basement Rock | |

*This is the surface rock along the structural framework of the Steeple Rock Mining District.

## References

Ore production of record is referred to by authors in the following publications:


1. Anderson, E. C., "Metal Resources of New Mexico", Bureau of Mines Bulletin 39; pp 76-77

2. Gillerman, Elliot, New Mexico Bureau of Mines Bulletin 83; pp 18-184