BUTTE
A WORLD CLASS ORE DEPOSIT

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Abstract

The Butte quartz monzonite is the host rock for early porphyry copper style mineralization and subsequent mesothermal-epithermal, enargite-gold style veining that transects the district. The east-west Anaconda system veins: including the Emma, Anaconda-Original, Syndicate, Badger-State, and Alice-Rainbow veins, each with strike lengths of over 12,000 feet and vertical continuity in excess of 4,500 feet, along with mining widths from 5 to 50 feet, are unique to Butte. The incredible dimensions and tenor of these veins have yet to be surpassed and Butte is still touted as being the "Richest Hill on Earth."

The Anaconda Company was formed in 1895 to develop underground copper reserves in the district and eventually consolidated all operations under one company. Production from underground mining continued through the mid-1970's. Open pit mining in the Berkeley pit began in 1955 with the extraction of supergene ores, along with the remnants of deeper horsetail zones inaccessible to the underground mines. Operations in the Berkeley pit were suspended in mid-1982 because of the rejection of high arsenic, copper concentrates at major smelting facilities throughout the world. Bulk mining of porphyry style mineralization in the Continental pit began in January 1980 to supplement copper production while stripping "C" pushback in the Berkeley pit. The Anaconda Smelter closed in September 1980. A molybdenum circuit was added to the Butte Concentrator in 1981 and mining continued in the Continental pit to produce copper and molybdenum concentrates. A blend of Berkeley and Continental ores were processed to dilute penalty metals in the final concentrates marketed to toll smelters. All mining operations ceased mid-1983 when Anaconda closed the Continental pit and offered the property for sale.

Montana Resources reopened the Continental pit in June 1986 to produce copper and molybdenum concentrates. Operations were suspended mid-2000, because of exorbitantly high power prices, but resumed in November 2003 with rising metal prices. Bulk open pit mining of the early porphyry style mineralization has sustained production over the past twenty years and mining is expected to continue in the Continental pit with favorable prices. Future mining will eventually develop a 500 million-ton geologic resource incorporated in a supergene enrichment blanket situated between the Berkeley pit and the Continental pit. Grades in this enrichment blanket range in the neighborhood of 0.5% copper.

Geologic Setting

The Butte Mining District, spanning an area of some 25 square miles, is located in the southern portion of the Boulder batholith, a multiphased intrusive complex situated in southwestern Montana. The dominant phase, the Butte quartz monzonite (BQM), has been dated at 75.6 Ma and is a medium to coarse grained rock composed of 40% plagioclase, 20% quartz, 20% orthoclase, and 20% hornblende and biotite.

Although of least importance, aplite dikes and sills are common throughout the district; but often, where they are intensely altered by hydrothermal fluids, they are mistaken for quartz porphyry (QP). Aplite dikes and sills are contemporaneous with the host rock and are cut by all other features.

Near surface, in the area of the Berkeley pit three sub-parallel, E-W trending, steeply south dipping, sets of quartz porphyry (QP) dikes, 10 to 50-feet wide, transect the district and cross the Continental Divide. With depth in the Berkeley pit, multiple QP dikes have been mapped and in the area of the Continental pit at least three, through going dikes, are recognized along with a myriad of irregular segments. In general, the dikes are all hydrothermally altered and silica flooding extends outward in an envelope in excess of 50 feet per side. Usually, the dikes terminate upward with a breccia cap rafted in a biotite, k-silicate, magnetite, and chalcopyrite matrix. Fine grained, biotite breccias of similar composition, often, extend further upward as the fissures narrow. All of the QP dikes appear to be of a similar composition and evidently, originally, contained 30-40% phenocrysts of plagicoclase, biotite, and quartz with megacrysts of k-feldspar. Remnant quartz eyes are distinctive features where the original textures have been obliterated by hydrothermal alteration. Dating of micas in the QP dikes indicates cooling ages between 64.5 and 63.1 Ma suggesting that they are closely related to both pre-Main Stage and Main Stage mineralization (Snee et al, 1999). In "C" pushback along the north highwall of the Berkeley pit the northern most dike, the Modoc quartz porphyry, is unique in that it incorporates an E-W, elongated, body of igneous breccia that contains fragments of earlier mineralized and altered QP.

Immediately north and parallel to the Anaconda-Original vein, underground workings have delineated a post-mineralization rhyolite dike that, likewise, transects the district trending E-W, dipping steeply to the south. On the east side of the district in the foothills at the base of the Continental Divide, it is exposed at surface in the hanging wall of the Continental fault. This dike dated around 58.8 Ma (Martin et al, 1999) cuts Main Stage veins as well as the quartz porphyry dikes and marks the end of multiple thermal events that mineralized the district. Offsets in this rhyolite dike indicate vertical movement on the Continental fault to be in excess of 3,500-feet.

The Big Butte rhyolite plug, a conspicuous "cone shaped butte" north and west of the city, is a younger, post-mineralization, feeder that gave rise to extrusives on the west side of the district. Dating indicates emplacement at 51.5 Ma.

Pre-Main Stage Mineralization

Pre-Main Stage, chalcopyrite (cp) and molybdenum (mb) mineralization is elongated along a S70E trend and straddles the QP dikes at depth extending some four miles from the Steward shaft east to the Klepper fault. Molybdenum mineralization occurs below the 2000 Level beneath the Berkeley pit and is exposed at surface in the Continental pit east of the Continental fault. A deep diamond-drilling program completed by the Anaconda Minerals Company, between 1978 and 1981, provided geologists with valuable data regarding the origin of this unique mineralizing system.

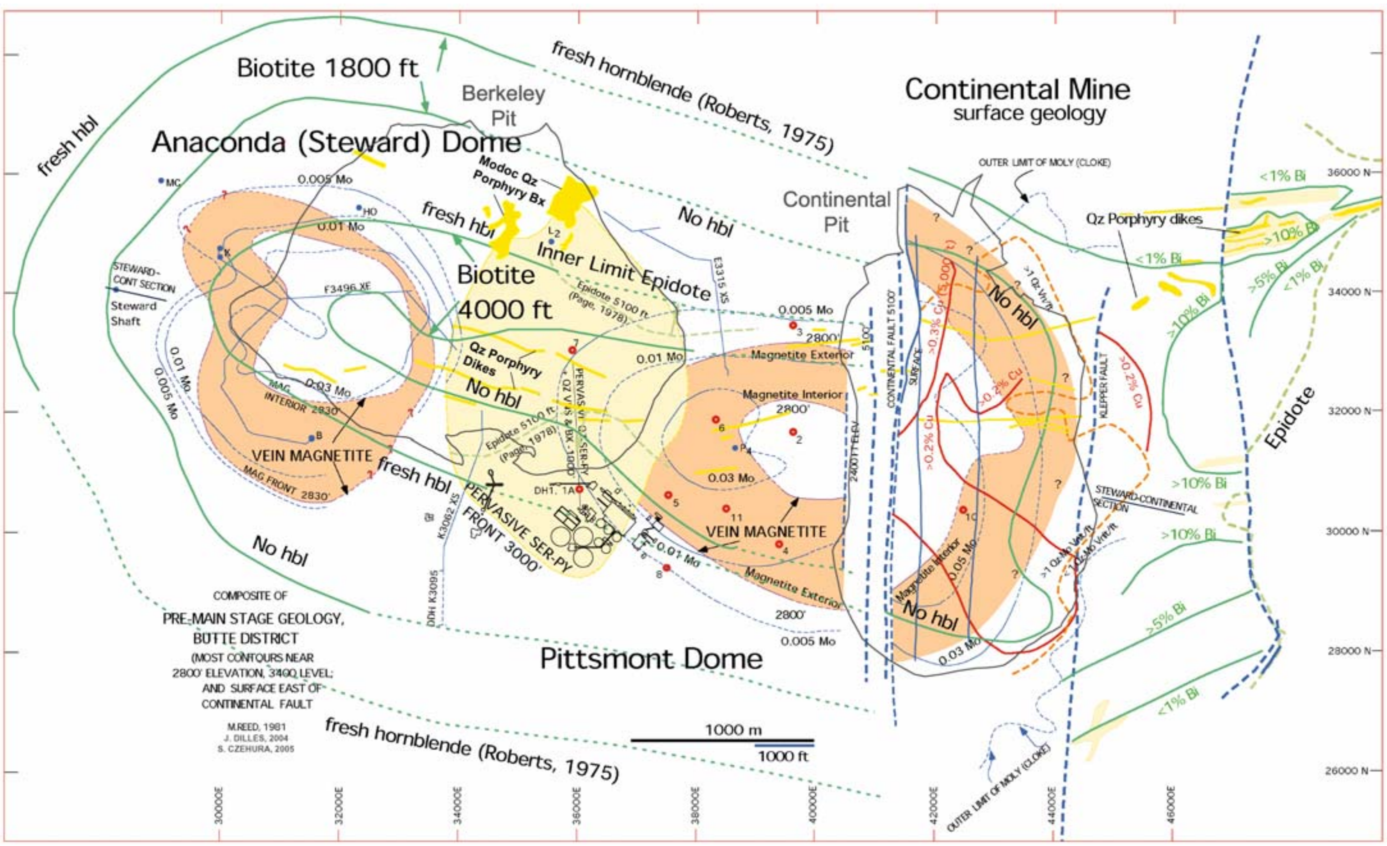

Figure 1. Pre-Main Stage Geology after Reed (1981) and Dilles (2000, 2001, 2004).

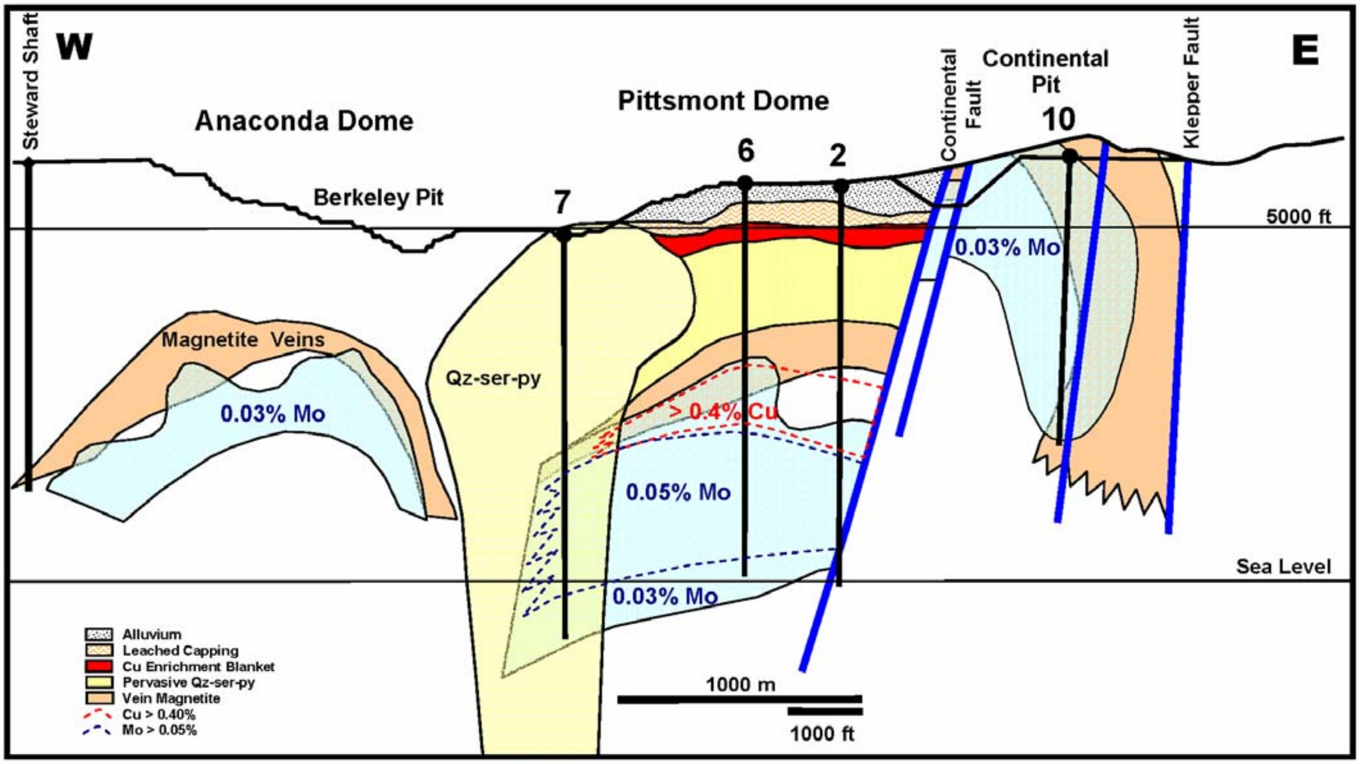

Figure 2. Steward –Continental cross section, looking northeast, after Vian (1980), Reed (1981), and Dilles (2001).

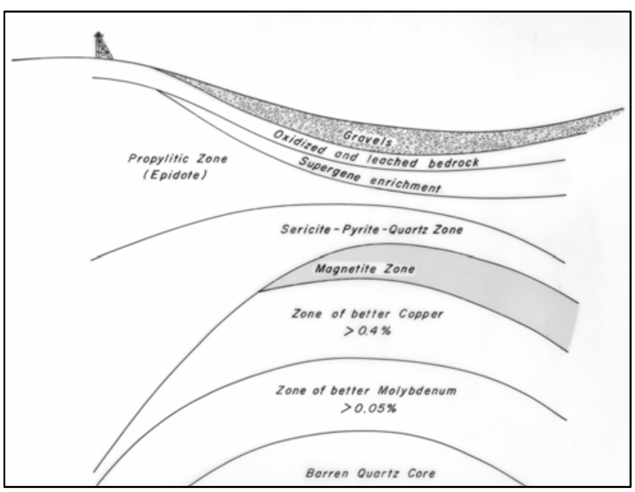

Figure 3. Pre-Main Stage zoning model for the Pittsmont dome (looking northeast), a composite of several sections after Vian (1980) and Reed (1981).

In total some 60,000 feet of drilling was completed with ten holes probing to depths up to 7,000 feet below the surface. From this data, along with information from underground and surface mapping, geologists have identified two centers, or domes (Figure 1 and Figure 2), of pre-Main Stage, cp-mb, porphyry style, mineralization characterized by swarms of interlacing, half-inch, veinlets along with disseminations of chalcopyrite in mafic sites along micro-fractures. Separating the two domes is a large bulbous plug of hard (HGS), gray quartz (qz), sericite (ser), and pyrite (py). Drill Hole No. 7 collared in the lower truck parking lot in the Berkeley pit explored this mass to depths below sea level. In fact, the peninsula left in the bottom of the Berkeley pit between the lower parking lot and just south of the Leonard Shaft was configured to avoid mining this hard waste zone. The earliest veins in the porphyry domes (Figure 3) are known as Early Dark Micaceous (EDM) veins.

EDM veins are generally only about a half-inch wide and are enclosed in an envelope characterized by green biotite and k-silicate alteration, one-half to one-inch per side. These irregular qz-cp-py veins, veinlets, and crackles are, usually, very abundant and carry chalcopyrite in their alteration envelope. As these veins extend outward they carry quartz, chalcopyrite, and magnetite. Typically, EDM veins are characterized by an inner envelope of green sericite followed by an envelope of green biotite with disseminated chalcopyrite.

Later sets of veins and veinlets consist of quartz, molybdenite, rare k-spar, and have no alteration selvage.

These are also abundant and are often rebroken by Main Stage veins in the Steward-Anaconda dome and by quartz and pyrite veins and veinlets, contemporaneous with Main Stage mineralization, in the eastern Pittsmont dome. Exposures of these veinlet swarms in the up thrown limb of the Pittsmont dome can be seen in the eastern highwall of the Continental pit trending N50E, dipping steeply to the south.

Main Stage Mineralization

Main Stage veins with persistent ore shoots are found above the Steward-Anaconda dome and appear to be emplaced in, roughly, conjugate sets of steeply dipping structures striking N60-80E and N40-50W. The Anaconda system veins trend N70E on the west side of the district and rotate slightly toward the south as they approach the center of the district, in the vicinity of the Leonard shaft. Here, along the Leonard-Belmont axis closely spaced SE striking, en echelon, fractures give rise to the famous horsetail zones. Continuing eastward, these veins and horsetail zones die out against a massive bulbous, plug of qz-ser-py alteration. Why these structures are not through going is not clearly understood, but Reed (1980) and Reed and Meyer (1999) postulate that the ductile behavior of this intensely altered rock mass prevented the development of through going structures.

The conjugate Main Stage veins striking N40-50W are known as Blue veins. These cut and offset the Anaconda structures, left laterally, up to several hundred feet. At depth, these structures often merge with the Anaconda system veins.

To describe the Main Stage ore geometry of the deposit, geologists have delineated zoning patterns for the sulfide minerals. Initially three zones were defined by Sales (1913) and subsequently Meyer and others (1968) have further detailed the zoning pattern. The Core of the deposit, locally peripheral to the Leonard shaft at depth, is characterized by highly sulfotaric minerals. Here massive stringers of quartz (qz), pyrite (py), chalcocite (cc), enargite (en) and/or bornite (bn) with covellite (cv) and digenite (dg) dominate the vein mineralogy. Deeper in the system, Main Stage veins carrying qz and tennantite (tn) transect the Steward-Anaconda dome. Main Stage qz-cp veins are also present deep in the system along with porphyry style mineralization.

In general the Main stage veins are zoned both vertically and horizontally. Concentrically upward and outward, veins in the Central Zone are dominated by enargite (en), hypogene chalcocite (cc), and bornite (bn). Sphalerite (sl) and manganese minerals are absent. Expanding further outward, the Intermediate Zone is characterized by ore shoots of en/cc and/or bn/cc with increasing sphalerite (sl) being precipitated outward, as the mineralizing fluids were cooled and neutralized. Mineral ratios, en/cc, decrease outward and upward. The presence of sl with hypogene cc is indicative of the Intermediate Zone. Although chalcopyrite (cp) often dominates the vein mineralogy near the transition boundary, in the Peripheral Zone copper minerals are largely absent. Here manganese minerals, rhodochrosite and rhodonite, along with sphalerite (sl) dominate the vein mineralogy. Galena and pyrite are common.

Alteration

Wall rock alteration in the Butte district (Figure 4) reflects thermal cooling, as well hydrogen ion activity and potassium ion metasomatism. Deep within the mine complex, haloing the early porphyry style mineralization, all hornblende laths, typical of the unaltered host rock, have been altered to a mossy, fine grained, biotite. This is the most outward expression of the early, massive porphyry copper system identified at depth in two, expansive domes (Brimhall and Roberts, 1973). Locally, vein alteration envelopes, both EDM and sericitic-argillic Main Stage envelopes, overprint this pervasive biotitization of the host rock.

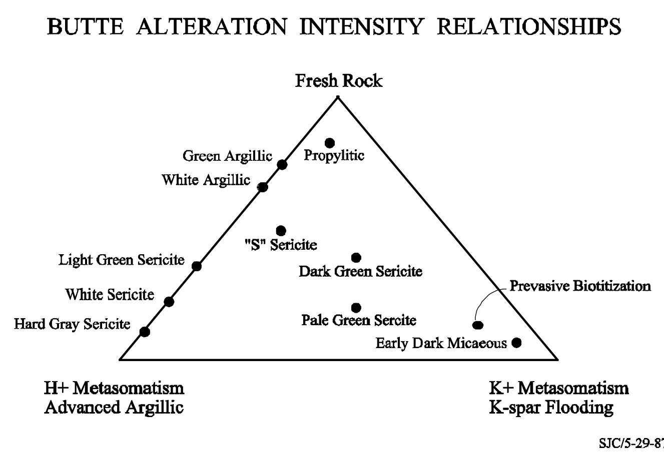

Figure 4. Comparison of Main Stage and Pre-Main Stage alteration.

For the Main Stage features, alteration envelopes in the core of the district near the Leonard shaft are characterized by an advanced argillic assemblage within a zone of pervasive sericitic alteration. Here inner envelopes along

Main Stage veins are dominantly quartz, sericite, and kaolinite along with dickite, alunite, and pyrophyllite. Topaz and zunyite, although minor constituents, are recognized as important indicator minerals. Typically, Main Stage veins have distinct sericitic alteration envelopes that grade outward into white argillic alteration (kaolinite, k-spar, bio-stable), followed by an envelope of green argillic alteration (montmorillonite, k-spar, bio-stable). Where the veins are closely spaced the rock can be pervasively altered as the various envelopes merge. Further out, the sericitic-argillic envelopes on individual veins grade into propylitized rock with a distinct greenish color resulting from saussuritized plagioclase grains and altered hornblende laths. The presence of epidote distinguishes this outer most, often pervasive, alteration.

Supergene Enrichment

In the area of the Berkeley pit weathering of copper mineralization produced a leach capping mottled with iron oxides and secondary green copper minerals overlying a thick zone of supergene enrichment conforming to topography. Enrichment of interlacing pyritic vein swarms from the qz-ser-py plug, simultaneously, with deep enrichment along the Main Stage veins, themselves, resulted in a blanket of rich sooty-chalcocite with molar like roots that sustained open pit mining in the early years of production. Roughly, half of Butte's annual copper production came from the secondary chalcocite blanket during the first twenty years of mining in the Berkeley pit.

Similar enrichment on pyritic vein swarms has resulted in a tabular orebody conforming to the paleotopography between the Berkeley pit and the Continental pit. This ore zone is exposed in the west highwall of the Continental pit overlain by some 100 to 300 feet of leached capping followed by 200 to 600 feet of alluvium (north to south, respectively). The supergene enrichment blanket, characterized by secondary chalcocite replacing pyrite, will sustain production once copper-molybdenum ore is exhausted in the Continental pit.

Even though a noticeable leached capping has developed, ores in the Continental copper-molybdenum orebody are not significantly enriched.

Historic Metal Production

Total metal production reported for Butte places this mining district among the top producers in the world. In fact, the district produced 98 percent of the manganese needed for steel production in the continental United States during both World Wars. Likewise, there were production quotes for copper and zinc to sustain the War efforts.

Metal production during the last twenty years accounts for about 6 percent of the total copper pounds produced, but less than two percent of the silver ounces. The accumulative molybdenum pounds result from ongoing mining in the Continental pit (Table 1).

Table 1. Total metal production compared to that produced in the last twenty years.

Production 1880 - 2004		Butte District	Montana Resources
Copper	lbs	21,554,930,540	1,394,823,528
Zinc	lbs	4,909,202,540	-
Manganese	lbs	3,702,787,341	-
Lead	lbs	854,797,405	-
Silver	oz	715,340,826	11,541,264
Gold	oz	2,922,446	-
Molybdenum	lbs	195,380,975	155,796,277

Geologic Resource

After over a century of mining, the Butte geologic resource still totals some 5.4 billion tons averaging 0.49 percent copper, 0.033 percent molybdenum, and 0.140 opt silver. The district resource incorporates estimates based on polygonal estimation, grade blocking, and ordinary kriging (Table 2).

Table 2. Geologic reserves for the Butte District.

Orebody	Short Tons	% Cu	% Mo	opt Ag	Estimate
Continental Area	538,844,000	0.26	0.033	0.01	Kriging
Enrichment Blanket	504,992,000	0.48	0.000	0.10	Kriging
Pittsmont Dome	2,222,000,000	0.45	0.045	0.12	Polygon
Anaconda-Steward Dome/Underground	2,153,000,000	0.60	0.028	0.20	Grade Blocking
Total	5,418,836,000	0.49	0.033	0.14	

Included in the underground resource are 130 million tons in a block caving configuration, averaging in excess of 1.00 percent copper, 0.345 opt silver, and 0.005 opt gold. The Continental and Central Zone orebodies are amenable to open pit mining and incorporate the proven and probable reserves.

Ore Reserves

As of January 1, 2005 ore reserves for the active mine complex totaled some 406 million tons averaging 0.34 percent copper and 0.027 percent molybdenum with a 0.074 opt silver credit. Copper and molybdenum are joint products. Reserves are reported at a 0.23 percent copper equivalent cutoff. The numbers reported reflect remaining proven and probable mining reserves based on the ore geometry detailed in a computer block model spanning over six square miles.

With sustained metal prices open pit mining is expected to continue for the next 20 years.

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