Evolution of hydrothermal Au-bearing quartz-pyrite veins and mineralization processes in Central City, CO

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Introduction and Background

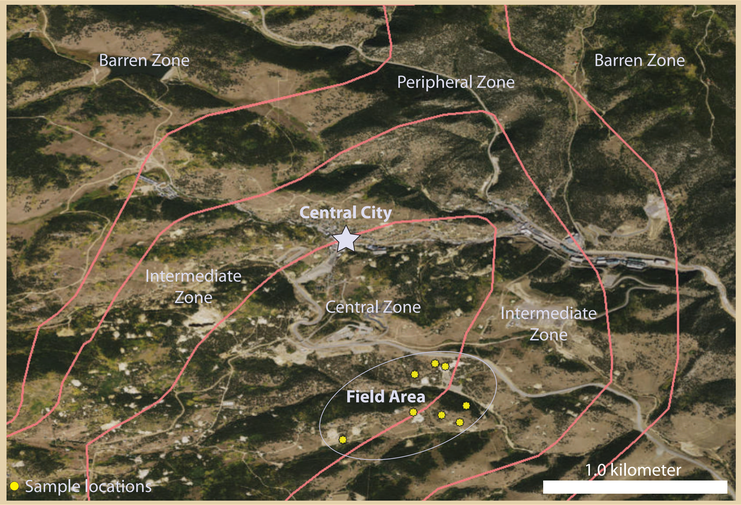
The Central City district in Colorado, just 25 miles west of Golden, was once a thriving mining district in the late 19th and early 20th century. Central City was a major source of gold, silver, copper, and molybdenum, valued at roughly $100 million during the time of production [3]. The host rock lithology is dominantly composed of Precambrian quartzofeldspathic schists that display structurally controlled hydrothermal veins with varying degrees of phyllic and silicic alteration.

Significant research regarding the hydrothermal geochemistry of Central City has not been conducted in the past few decades. This study will investigate the Au mineralizing events at Central City, the characteristics of the fluids responsible for metal transport and mineralization, and their overall effects on rock alteration. The major goal of this study is to improve the current genetic model for the Central City district and determine the key ore forming processes responsible for the veining and observed metal zoning. This study will combine thin section petrography, SEM, CL, and LA-ICP-MS to study different quartz and pyrite generations to yield new insights in the role of hydrothermal fluids for Au transport and mineralization in this historic mining district.

Current Geological Interpretation

Two significant stages of mineralization have been recognized [3], including i) a higher temperature stage characterized by Au (and Mo), and ii) a lower temperature stage characterized by base metal mineralization. These two significant stages were spatially separated into a central and intermediate zone, respectively, both of which contain quartz-pyrite veins. The central zone and intermediate zone are best distinguished by the presence of sphalerite and galena in the intermediate zone, however, together these two zones were responsible for the bulk of economic mines in the area. The peripheral and barren zones are both absent of quartz-pyrite veins and therefore are not a focus in this research. Based on mineralogy, these concentric zonal patterns are presumed to indicate a decrease in hydrothermal fluid temperatures from the central to the barren zone [1]. The occasional occurrence of tellurides in association with molybdenite veins has been described, however, previous studies have not identified their genetic relationship [1].

Based on geochemistry, stable isotope and fluid inclusion analyses, the inferred parent magma is a quartz bostonite or alkali rhyolite emplaced during the Laramide Orogeny [1]. The presence of local alkalic intrusives as well as molybdenite has led a previous study to interpret the mineralization to be related to a porphyry [1]. Samples have been systematically selected from the Au and base metal vein stages of mineralization from the central and intermediate zones, respectively. Samples were collected from several mines dumps along the Russell Gulch and South Willis Gulch including Hidee, Notaway, Silver Dollar, Powers, War Dance, Pittsburgh, and Chase Mine.



Various Pyrite Morphologies and Textures in Thin Section

Samples of interest are quartzofeldspathic schists with muscovite and minor biotite displaying silicification and sericitization. The most conspicuous alteration is seen in feldspar, muscovite and biotite that have been replaced by finer grained phyllosilicates during sericitc alteration. There are commonly 0.5-5mm thick quartz-pyrite veins with varying degrees of pyritization. These rocks have been ductily deformed and locally contain bands of schistose texture and metamorphic minerals. Pyrite exhibits a variety of morphologies: disseminated fine grained pyrite within the host rock, fine to coarse grained pyrite within veins, and pyrite forming in place of muscovite.

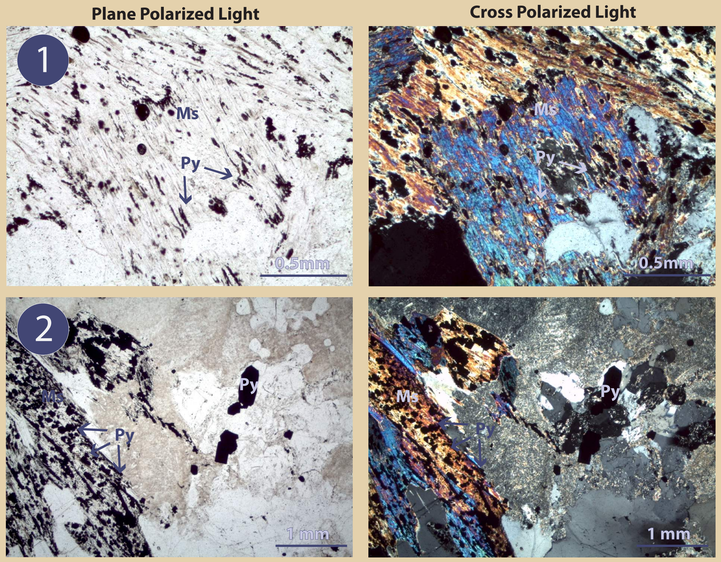


Figure 1 and 2: The common texture of pyrite occurring in place of muscovite is displayed here as finer, more narrow grains in figure 1, and larger equidimensional grains in figure 2, which is adjacent to a discontinuous vein of medium grained, euhedral pyrite.

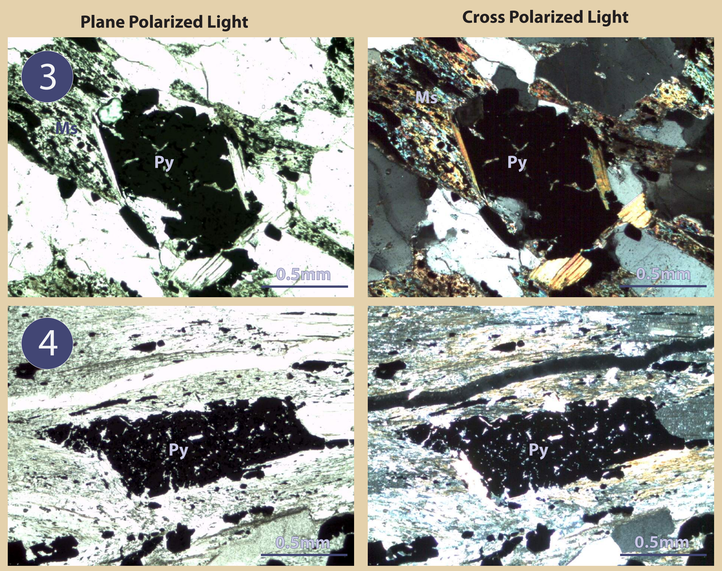


Figure 3: Pyrite appears as a conglomeration of fine grains likely indicating a pseudomorph.
Figure 4: Pyrite resembles a sigma clast indicating replacement during ductile deformation.

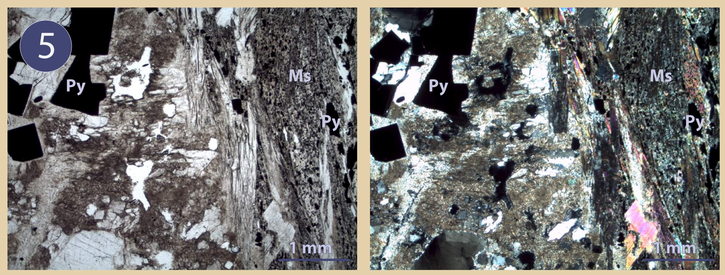
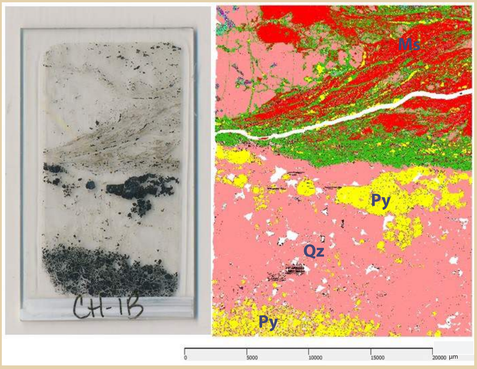


Figure 5 (right): This sample represents the boundary between a quartz-pyrite vein (left) and the host rock schist (right). The two distinct textures of pyrite likely represent two mineralization events.

Automated Mineralogy



Thin section scan of a quartz-pyrite vein and automated mineralogy using QEMSCAN, showing typical alteration textures of metamorphic minerals such as muscovite and biotite replaced by Al-rich phyllosilicates and two different generations of pyrite: disseminated and fine to coarse grained in quartz veins.

- Quartz
- Pyrite
- Al-rich phyllosilicate
- Muscovite
- Biotite

Preliminary Conclusions

Based on initial observations using transmitted light microscopy and QEMSCAN, the study of quartz-pyrite veins indicates a significant hydrothermal overprint of the primary metamorphic mineralogy. This includes the formation of pyrite and muscovite pseudomorphs, several generations of pyrite and phyllosilicates in quartz veins and alteration halos to the host rock. These veins have some similarities to QSP alteration characteristic of porphyry systems, as suggested by [1] for the Central City deposit. Nevertheless, the presence of phyllic alteration and silicification, in addition to vuggy silica observed in these veins, may also point to an epithermal deposit origin for the Central City district. Studying textural relations and alteration stages of the veins and surrounding host rocks in more detail, combined with quantitative geochemical analyses are expected to provide more evidence for testing the current hypothesis, that the quartz-pyrite veins are of epithermal origin.

References

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[3] Sims, P. K., Drake, A. A., Jr., and Tooker, E. W., 1963a, Economic geology of the Central City district, Gilpin County, Colorado: U.S. Geol. Survey Prof. Paper 359, 231 p