# Using Imaging Spectroscopy to Better Understand the Hydrothermal and Tectonic History of the Cuprite Mining District, Nevada

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## 1.0 Introduction

The Cuprite area consists of two acid-sulfate hydrothermal alteration centers straddling U.S. Highway 95 in southwestern Nevada. Alteration in the hydrothermal centers involves Tertiary volcanic rocks in the eastern center and Cambrian metasedimentary rocks in the western center (Abrams et al., 1977). The purpose of this study was to determine if these late-Miocene hydrothermal centers developed independently or whether they were created by lystric-faulting of a single conduit along an east-dipping detachment that moved the cooler upper portion of the system to the east relative to the hotter lower portion. The answer has implications for mineral exploration. Geology of the area was studied using imaging spectroscopy, isotopic dates, geologic maps, drill hole data, and D-C resistivity soundings.

## 2.0 Method and Results

Alteration zones were studied with imaging spectroscopy using radiance data collected in 1995 by the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) flown aboard a NASA ER-2 at 20 km altitude. Spectral changes in alunite and muscovite absorptions were used to map paleotemperatures in both centers. Spectral maps of Fe-bearing minerals, clays, sulfates, carbonates, micas, and siliceous sinter were produced using the U.S. Geological Survey Tricorder algorithm (Clark, et al., 1990). These maps reveal that the western center lacks a siliceous cap, has a core of low-grade kaolinite-muscovite and propylitic rock surrounded by a high temperature alunite zone, and that this center was eroded to a deep level, exposing the high temperature kaolinite polymorph dickite and a pyrite-rich zone. AVIRIS spectra also reveal that muscovites become progressively more Al-rich near intrusive dikes of quartz latite in the southern portion of the western center. This muscovite compositional variation probably correlates with increased paleotemperatures near these intrusive bodies. In contrast, spectral maps indicate that the eastern center has an extensive siliceous cap surrounded by a high to intermediate temperature alunite zone, lacks a propylitic core (at least at the present level of exposure), has extensive kaolinite zones lacking dickite, and has volumetrically insignificant jarosite, all consistent with present exposure near the top of the hydrothermal system (Swayze, 1997).

Tabular clasts of Cambrian phyllite, altered to alunite, eroded from the western center, and deposited in a conglomerate below the Spearhead member of the Stonewall Flat Tuff in the eastern center, are evidence that the western center had formed, was uplifted, and eroded prior to 7.6 Ma. Continuous exposures of the Stonewall Flat Tuff and underlying conglomerate can be traced from the argillic zone into the alunite and siliceous zones of the eastern center, implying that this center formed after 7.6 Ma. New $^{40}Ar$-$^{39}Ar$ isotopic dates indicate that the alunite-zone rocks cooled below alunite closure temperatures in both centers by 6.9 - 6.5 Ma with late stage vein alunites forming at 6.2 Ma in the western center (Swayze, 1997). A K-Ar isotopic date from unaltered olivine basalt that erupted onto altered conglomerate, between the centers, implies that all hydrothermal activity ceased by 6.2 Ma. Altogether, hydrothermal activity spanned at least 1.4 m.y. in the western center and had a shorter duration in the eastern center.

Quartz latite intrusives were intersected in 6 of 9 drill holes in the pediment between the hydrothermal centers (Swayze, 1997). Variations in the depth to basement, revealed in drill holes, indicate complex block faulting under the pediment. Total throw on the north-south trending steeply east-dipping normal fault bounding the eastern margin of the western center is about 400 m. A geoelectric profile revealed that a thick (possibly up to 170 m) post 6.5 Ma conglomerate overlies a fault-tilted gently west-dipping Tertiary volcanic section under the pediment (Swayze, 1997). A large zone of low resistivity dipping beneath the eastern center is probably the northward extension of a quartz latite dike which may have been the source of hydrothermal fluids that formed the centers.

## 3.0 Conclusions

The geologic and geophysical evidence collected during this study is most consistent with the separate development, both temporally and spatially, of two hydrothermal centers at Cuprite. These centers formed during and subsequent to activity in the nearby Stonewall Mountain volcanic center. Abundant jarosite in the western center marks the location of oxidized pyrite from an initial stage of mineralization. The lack of a later stage of Cu-sulfide mineralization may explain the absence of gold in the western center. Because the eastern center developed independently, it is a likely target for future exploration, especially in the west-dipping hydrothermal conduit below its siliceous cap.

Imaging spectroscopy at Cuprite revealed that the western center is exposed at a deep, once hotter level and that the eastern center is exposed at a shallow, cooler level very near the original paleosurface. These conculsions are based on spectral identification of mineral assemblages and their compositions characteristic of different paleotemperature regimes within the hydrothermal centers. These spectroscopic tools can be use to remotely understand the structure of other hydrothermal systems on the Earth as well as other planets.

## 4.0 References


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