

Mineralogical and Geochemical Changes Associated with Sulfide and Silicate Weathering in
Natural Alteration Scars, Taos County, New Mexico
Gabriel James Graf, Newmont Mining
September, 2008

Natural alteration scars occur along the Red River valley, NM were studied as mineralogical analogs to future weathering in rock piles created by Chevron Mining Inc, (formerly Molycorp, Inc.) during open pit mining from the Questa mine. These natural alteration scars provide a glimpse into weathering that may affect these rock piles in the long term (up to 4.5 million years) (Lueth et al., 2006). The alteration scars provided excellent analogues to the rock piles because they are located within close proximity (~2 miles) from the Questa mining operation and contain similar lithologies and hydrothermal alteration mineral suites. The weathering processes (sulfide and silicates) and overall architecture of these systems (open) appear very similar.

Three distinct weathering profiles were collected in the Hansen and Southwest Hansen alteration scars to document chemical and mineralogical changes that occur related to sulfide and silicate weathering. These weathering profiles are different from a classic weathering profiles since they were profoundly influenced by hydrothermal alteration, and commonly contain multiple lithologies.

Within each profile particle size decreases upward, which suggests physical weathering processes are active. The mineralogical changes associated with grain size reduction include pyrite oxidation with the precipitation of gypsum, jarosite and Fe-oxides. Acid base accounting has documented limited acid consuming minerals (i.e. calcite) to buffer the acid created during pyrite oxidation. Stable isotope analysis of pyrite and gypsum indicate $\delta^{34}\text{S}$ pyrite range from -1.0 to -6.6 ‰. $\delta^{34}\text{S}$ of gypsum range from -2.1 to -5.1 ‰ and gypsum $\delta^{18}\text{O}_{\text{SO}_4}$ range from -7.0 to 5.2 ‰. This data provides convincing evidence that sulfates within the alteration scars are formed only in the weathering environment.

Silicate mineralogical changes through the weathering profiles include, decreasing feldspar and increasing clay upwards. The working hypothesis was silicate mineral changes result from feldspar weathering to form secondary clay minerals. Clay mineral analysis, however, indicates the clay minerals are similar to hydrothermal alteration minerals. Much of the fining upward character may be due to hydrothermal alteration. Clay mineral stable isotope analysis, $\delta^{18}\text{O}$ (-0.3 to 4.6‰) and δD (-65 to -95‰), documents clays analyzed are hydrothermal in origin and provide no evidence for weathering clays. Review of USGS (Nordstrom et al., 2005) ground and surface water geochemistry, along with silicate mineral observations, indicate congruent dissolution of silicate minerals is active in the alteration scars.

The major active chemical weathering system in the alteration scars is the oxidation of pyrite. The soil pH of 2 to 3 is compatible with silicate mineral dissolution, and the chemical conditions do not favor precipitation of new clay minerals. Physical weathering in the alteration scars continues by freeze-thaw and precipitation of gypsum, creating a volume increase; providing pathways for fluid and oxygen for the further oxidation of pyrite. This acidic environment is responsible for the precipitation of jarosite, gypsum and dissolution of silicate minerals. Sulfide weathering will continue to occur in the alteration scars until the remaining pyrite has oxidized.