

CHEMISTRY OF STREAM SEDIMENTS AND WATER AS GUIDES TO DETERMINE THE IMPACTS OF ABANDONED MINES ON THE UPPER RED RIVER, TAOS COUNTY, NEW MEXICO¹

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Abstract. Placer gold deposits, volcanic-epithermal vein systems, porphyry molybdenum deposits, veins and replacements in Precambrian rocks, and pegmatites are found in the Red River watershed, where more than 250 mining properties comprise parts of the Twining, Red River-Rio Hondo, and Questa mining districts. The purpose of this study is to investigate the effects of alteration, mineral deposits, and mining activities on the chemistry of the upper Red River water and stream sediment.

Fifteen samples of water and 15 samples of stream sediment were collected, each from below a major drainage entering Red River between its headwaters and the Fawn Lakes Campground, 4.5 km upstream of the Molycorp Questa molybdenum mine. The total reach of the Red River sampled was 18.7 km. Water samples were analyzed for major anions and cations by flame atomic absorption spectroscopy (FAA) and trace elements by inductively coupled plasma mass spectroscopy (ICP-MS). Sediments were sieved and divided into two size fractions (2mm-63 microns and <63 microns), then analyzed for Mn, Ti, Fe, and trace elements by X-ray fluorescence (XRF) using pressed powder briquettes.

A distinct change in water chemistry was observed at the upstream limit of regional argillic alteration. In water samples, increased concentrations of Mg (3.9 to 10 ppm), Si (below detection limits to 18 ppm), F (below detection limits to 0.35 ppm), SO₄ (8.3 ppm to 87 ppm), and Na (1.6-4.5 ppm to 9.1 ppm) were found downstream of and adjacent to areas of argillic alteration in the Mallette Creek drainage. Some water samples collected from the Red River were found to be higher in Al and Mn than EPA Drinking Water Standards. These high Al and Mn samples (>0.26 ppm Al and >0.2 ppm Mn) were collected from drainages dominated by Tertiary volcanic/intrusive rocks with areas of argillic alteration. No samples were found to be out of compliance with EPA Drinking Water Standards or New Mexico Ground Water Standards for Domestic Supply in any other elements or ions (Cl, SO₄, F, As, Ba, Be, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Se, Ag, U, or Zn).

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Downstream of Black Copper Canyon and at West Fork, a relationship is indicated between elevated Cu and Zn in river water and mineralized areas. The highest Cu concentrations (0.053 ppm) measured in the river water were collected downstream of West Fork (sample average = 0.026 ppm). At Black Copper Canyon, Zn concentrations increased from 0.0005 ppm to 0.091 ppm.

Sediment samples show an increase in S concentration from 184-1382 ppm to >2584 ppm in both size fractions downstream of the upstream extent of regional argillic alteration. The increase in S in sediment appears to be due to the oxidation of pyrite and the presence of sulfate minerals including gypsum, jarosite, and others in the altered areas. A plot of Ca versus SO₄ from water sample analyses indicates that upstream of this limit, carbonate dissolution results in excess calcium relative to the gypsum dissolution line, while downstream of this limit excess sulfate suggests a significant dissolution of pyrite relative to gypsum.

Arsenic and Pb concentrations in both sediment size fractions increase steadily downstream. Pearson correlation coefficients between As and S (>0.80 in both size fractions) indicate a strong correlation between the two, which suggests that As may be present in the stream in the form of a sulfide or sulfate mineral (such as pyrite, arsenopyrite, tetrahedrite/ tennantite, and arsenic-bearing jarosite). Strong Pearson correlation coefficients also exist between Fe, Ti, and V (>0.79) in the large size sediment fraction, suggesting the presence of significant magnetite-ilmenite.

Integration of the chemical and mineralogical data with geologic data, information on inactive mining properties, and cultural features shows a spatial relationship between high concentrations of Al (>0.26 ppm), Mn (>0.2 ppm), SO₄ (>50 ppm), F (>0.2 ppm), Si (>12 ppm), Cu (0.025 ppm), and Zn (0.084 ppm) in water samples and the upstream limit of mapped alteration within the drainage. Elevated concentrations of these elements may be associated with the oxidation of pyrite in altered rocks, especially in areas of exposed, intense argillic alteration rather than the areas of most mining activity. These data suggest that hydrothermal alteration and associated acid rock weathering is a more significant factor in the observed changes in stream chemistry than is mining activity.

Additional key words: Alteration, volcanic-epithermal veins, placer, Questa, Twining, Rio Hondo, Great Plains Margin gold, alkaline gold deposits, porphyry molybdenum deposits