INFLUENCE OF PERCHED WATER TABLES BELOW MINE WASTE ROCK ON METAL LOADINGS TO STREAMS, PROSPECT GULCH, SAN JUAN COUNTY, COLORADO[1]

Raymond H. Johnson, Laurie Wirt, Robert R. McDougal, and David L. Fey[2]

Abstract. Infiltration through mine waste to a receiving stream is an important source of metal loading in Prospect Gulch, a steep alpine catchment in southwestern Colorado. Integrated hydrologic, geochemical, and geophysical studies identify contaminant plumes beneath waste dumps and indicate that saturated colluvium beneath mine waste overlies unsaturated bedrock, which becomes saturated with depth. Subsurface geology influences ground-water flowpaths and the occurrence of metal-rich acid drainage is related to the distribution of hydrothermally-altered terrain as well as mining disturbances. The geochemistry of water-bearing layers is compared with stream inflows to determine flowpaths and source(s) of ground water supplying the stream.

Hydrogeochemical data are derived from: 1) multilevel monitoring well installations, 2) shallow piezometer installations, 3) water level and geochemical sampling of wells and piezometers, 4) flow and geochemical sampling of streams, and 5) geochemical sampling of seeps and springs. Geophysical data include shallow resistivity and seismic profiles near the mine waste areas. Integration of these data identifies a perched water table system below the mine waste that occurs in colluvial material (to 15 meters) overlying unsaturated bedrock. At approximately 50 meters, the bedrock becomes saturated as part of a deeper ground-water flow system. Distinct ground-water plumes with high metal concentrations form in the colluvial material below the mine waste. These plumes are identified by both the ground-water samples and geophysical profiles and appear to discharge into the surrounding streams directly rather than recharge the deeper ground-water system. The geochemistry of the deeper ground-water system is consistent with water-rock interaction with the surrounding hydrothermally-altered, sulfide rich, volcanic rocks. Based on well- and stream-sample geochemistry, the deeper ground-water system discharges to lower Prospect Gulch and in nearby Cement Creek, just below Prospect Gulch.

Additional Key Words: acid mine drainage, abandoned mine lands, subsurface impacts, hydrogeochemistry

---

[1]Poster paper presented at the 7th International Conference on Acid Rock Drainage (ICARD), March 26-30, 2006, St. Louis MO. R.I. Barnhisel Published by the American Society of Mining and Reclamation (ASMR), 3134 Montavesta Road, Lexington, KY 40502

[2]Raymond H. Johnson is a Hydrogeologist at the U. S. Geological Survey, Denver, CO, 80225. Laurie Wirt is a Hydrogeologist at the USGS Denver office, Robert R. McDougal is a Geophysicist at the USGS Denver office, David L. Fey is an Analytical Chemist at the USGS Denver office.

DOI http://doi.org/10.21000/JASMR06020844

Metal transport via ground-water creates distinct geochemical zones in the surface water in Prospect Gulch. These zones are characterized by variations in stream metal-concentrations, which can be explained on the basis of measured ground-water geochemistry from inflow springs/seeps and monitoring well/piezometer points. The area of shallow ground-water discharge through the colluvial system is influenced by oxygenated, mine-affected ground water with high concentrations of copper and zinc (Cu up to 10 mg/L and Zn up to 50 mg/L). In contrast, the stream zone that is influenced by discharge of deeper ground water is characterized by ground water with high iron and aluminum concentrations and little to no oxygen (Al up to 20 mg/L and Fe up to 100 mg/L). In addition, the geochemistry of surface water in Prospect Gulch varies throughout the year due to changing proportions of shallow versus deep ground-water discharge, as evidenced by geochemical samples collected at the mouth of Prospect Gulch. For example, the copper concentrations at the mouth of Prospect Gulch are 30 µg/L in the winter months when the contribution of deep ground-water discharge is greatest, versus 270 µg/L in the spring and summer when the contribution of shallow ground-water discharge is the greatest.

An integrated conceptual model of the hydrogeochemistry in Prospect Gulch provides a framework for understanding the complex conditions that occur. This model is developed by defining ground-water flowpaths (i.e., shallow versus deep ground-water flow) with the addition of water-rock interactions along these flowpaths (i.e., interactions within different hydrothermally-altered mineral assemblages as well as mine waste). Geochemical conditions created by mine waste are included in this hydrogeochemical model as an end member that can be removed from the system by on-site remediation. The hydrogeochemistry of Prospect Gulch has broad applicability to other mine-affected drainages in terms of 1) ground-water flow systems in alpine watersheds, 2) the affects of shallow and deep ground-water flow and geochemistry on metal loadings to streams in sulfide rich, hydrothermally-altered systems, and 3) quantifying the added influence of historical mining on metal loadings to streams.