NET ACID PRODUCTION, ACID NEUTRALIZING CAPACITY AND ASSOCIATED GEOPHYSICAL, MINERALOGICAL, AND GEOCHEMICAL CHARACTERISTICS OF ANIMAS RIVER WATERSHED ROCKS, SILVERTON, COLORADO[1]

Douglas B. Yager[2], Anne E. McCafferty, Mark R. Stanton,
Sharon F. Diehl, and Rhonda L. Driscoll

Abstract. This report presents results from laboratory studies involving the net acid production (NAP), acid neutralizing capacity (ANC), and magnetic mineralogy of thirty-four samples collected in the Upper Animas River watershed near Silverton, Colo., during the summer of 2003. Sampling focused mainly on the volumetrically important, Tertiary-age volcanic and plutonic rocks that are host to base and precious metal mineralization in the study area.

Rocks in the study have all been subjected to a regional propylitic alteration event that modified the primary mineralogy of the host rock, while introducing minerals with acid neutralizing capacity (ANC) including calcite, chlorite and epidote. Locally, hydrothermal alteration has removed any ANC and introduced minerals, mainly pyrite, that has a high net acid production (NAP). Laboratory studies included hydrogen peroxide (H_2O_2) acid digestion and subsequent sodium hydroxide (NaOH) titration to determine NAP, and H_2SO_4 acid titration experiments to determine ANC on selected samples that generally had low NAP. In addition to these environmental rock property determinations, mineralogical, chemical, and petrographic characteristics of each sample were determined through multiple methods including semi-quantitative X-ray diffractometry (Rietveld method), optical mineralogy, wavelength dispersive X-ray fluorescence, total carbon-carbonate, and 40-element inductively coupled plasma analyses. Magnetic susceptibilities, converted to estimates of volume-percent magnetite were also calculated. Although magnetite is a minor mineral constituent, it is easily measured, and can be positively correlated to measurable percentages of important acid-neutralizing minerals, such as chlorite and calcite and inversely correlated to NAP indicator minerals including pyrite and clay minerals.

Ranks were assigned to the samples based on ANC quantity in kg/ton calcium carbonate equivalent, and ratios of ANC to NAP. Results show the Pyroxene Andesite Member of the Silverton Volcanics has highest ANC with little to no NAP in either the propylitic or weakly sericitically-altered samples. Samples of the propylitically altered Pyroxene Andesite Member also contains the highest mean magnetite abundance (over 8 volume percent) and therefore, may permit its regional mapping using the airborne magnetic and electromagnetic survey data. The Burns Member of the Silverton Volcanics samples, in general have a low ANC, high to moderate NAP, and in general, contain little to no magnetite. Samples containing sparse pyrite ($\leq$ 1 weight percent) have NAP that ranges from non-detectable to 39 kg/ton $CaCO_3$. Samples with no detectable calcite often contain abundant chlorite species (clinochlore and chamosite).

Acid titration was performed on a chlorite mineral separate comprised mainly of the minerals clinochlore and chamosite, collected from a Burns Member lava with a high ANC (second highest ANC of all samples studied) and that lacks calcite. Acid titration results indicate that chlorite species have some ANC over a range between pH 4 and pH 2. The calculated ANC of the chlorite mineral separate is 54 kg/ton $CaCO_3$ equivalent. This indicates that samples that lack calcite, where chlorite is also abundant could supply some ANC.

This study provides information that could prove useful to local stakeholders groups, federal land managers, and others involved in mine cleanup efforts. Several samples studied have ANC values that exceed the 20 kg/ton $CaCO_3$ equivalent necessary for consideration in mine waste remediation treatments. Thus, data collected for the environmental rock properties, NAP and ANC, of Animas River watershed rocks could aid in locating rocks that could be suitable for testing in ongoing mine waste remediation efforts.

Additional Key Words: propylitic alteration, volcanic rocks, Silverton Volcanics, airborne magnetic and electromagnetic survey, magnetic mineralogy, chlorite

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[2] Douglas Yager is a geologist, Anne McCafferty a geophysicist, and Mark Stanton a geologist with the U.S. Geological Survey, Denver, CO, 80225. Sharon Diehl and Rhonda Driscoll are both geologists with the U.S. Geological Survey in Denver, CO.