IRON MONOSULFIDE AND PYRITE FORMATION IN SEDIMENTS OF LAKES THAT RECEIVE ACID MINE DRAINAGE

Wicks, C. M. (1), Herman, J. S. (2), Mills, A. L. (3), and Schubert, J. P. (4). ((1) Graduate Student, (2) Assistant Professor, and (3) Associate Professor, Dept. of Environmental Sciences, Univ. of Virginia, Charlottesville, VA, and (4) Hydrogeologist, Argonne Natl. Lab, Argonne, IL). Lake acidification from acid mine drainage (AMD) is an important environmental problem. Acid mine drainage can be ameliorated by the production of the minerals iron monosulfide (FeS) and pyrite (FeS_2) in impacted lake sediments. The authigenic formation of FeS_2 and FeS is hypothesized to occur when ferrous iron reacts with dissolved sulfide (H_2S, HS^-), which is produced by microbially mediated sulfate reduction. The result is that iron, sulfate, and acidity concentrations are decreased, while bicarbonate alkalinity is increased. If the reaction occurs in sediments that receive abundant sulfate ions and organic matter, then iron will be the limiting reactant. As the iron concentration increases, the dry weight percent of FeS or FeS_2 in the sediments should increase. The objective of this study was to determine if porewater iron concentration could be used as an indicator of FeS and FeS_2 formation in the sediments. Samples of lake water, porewater, and sediment were taken from 14 lakes that receive AMD throughout the Appalachian, Eastern Interior, and Western Interior Coal Basins. Concentration ranges observed in the porewater samples were 0.1 to 1,500 mg/L Fe^{2+}, 0.25 to 4.2 mg/L Fe^{3+}, 2.6 to 1,850 mg/L SO_4^{2-}, and pH of 6.05 to 8.0. Values of Eh calculated from the ferrous-ferric redox couple showed oxic conditions existing in the porewater. However, the sediments were dark in color and smelled of hydrogen sulfide, indicating anoxic conditions. The porewater composition, a reducing Eh, and field pH were used in the computer model PHREEQE to predict the saturation state of the porewater with respect to FeS_2 and FeS. Based on these results, in 9 of the 14 lakes pyrite is predicted to be the stable mineral phase. The remaining 5 lakes are significantly undersaturated with respect to pyrite. Authigenic pyrite is not expected to be found in those sediments. For each of these lakes, the reaction is limited by low concentrations of either iron or sulfur. Molar Fe/S ratios in FeS_2 and FeS are 1:2 and 1:1, respectively. All undersaturated waters exhibit extreme departures from these ratios.

Additional Key Words: porewater composition.

HYDROLOGY AND GEOCHEMISTRY OF SURFACE COAL MINE LAKES

Schubert, J. P. (Hydrogeologist, Argonne National Laboratory, Argonne, IL). Lakes are commonly created in surface-mined areas when mine pits or low depressional areas in spoil materials are not completely backfilled and eventually fill with water after mining operations have ceased. These lakes often contain good-quality water and have great potential post-mining benefits, such as swimming, boating, fishing, wildlife habitat, and even drinking water supplies. Some lakes, however, are very acidic (e.g., pH < 4.0) and contain deleterious concentrations of sulfate, iron, manganese, and other trace metals. A study was initiated in an attempt to determine the hydrologic and geochemical characteristics of mine sites that may be controlling water chemistry in the manmade lakes. Twenty-one lakes in the Eastern and Central U.S. have been intensively sampled. Five lakes had pH values between 2.5 and 5.0, three lakes had pH values between 6.0 and 7.0, eight lakes were between 7.0 and 7.5, and five lakes had pH values greater than 7.5. Hydrologic variables such as infiltration rates, hydraulic conductivity, and texture of spoil materials have been measured. Geochemical analyses of soil, spoil, and lakebed samples included: pH, electrical conductance, cation exchange capacity, exchangeable cations, total sulfur, and neutralization potential. Multivariate statistical procedures have been utilized to determine which watershed characteristics, hydrologic variables, geochemical parameters, or lake morphometric variables are the most influential on the resulting water chemistry of mine lakes.

Additional Key Words: acidity, trace metals, watershed characteristics.

WATER RESOURCE DEVELOPMENT ENGINEERING AND ACID MINE DRAINAGE IN THE UPPER OHIO RIVER BASIN

Koryak, M. (Limnologist, U.S. Army Corps of Engineers, Pittsburgh District). Acid mine drainage from bituminous coal mines has been the greatest single water pollution problem in the upper Ohio River Basin. Thousands of miles of streams within the western Pennsylvania, northern West Virginia, western Maryland, and southeastern Ohio portions of the basin have been degraded by an acid mine drainage (AMD) load that, until recent decades, was equivalent to more than a million tons/year of sulfuric acid. Severe AMD pollution caused damage by corroding pipes, pumps, boats, gates, and navigation aids. The acid and associated mineralization, and the frequent gross heavy metal pollution degraded the aesthetic and recreational value of local waters. The AMD suppressed and often totally eliminated aquatic life in local impoundments and along substantial reaches of major rivers, and it caused numerous and serious domestic and industrial water supply problems. Because of the extent and magnitude of the problem, AMD considerations have had a significant influence on many aspects of water resource development engineering in the upper Ohio River Drainage Basin. In some areas, AMD necessitated the use of special construction techniques and corrosion-resistant materials, and it increased and complicated maintenance problems. It was a major influence on the planning, design, and operation of large civil works engineering projects constructed prior to passage of the 1972 Clean Water Act. Reservoir operation schedules were developed as integral parts of Corps of Engineers reservoir projects to moderate low-flow AMD degradation extremes. As dramatic progress has been made recently in AMD abatement, these projects and operations continue to provide, for the most part, very substantial AMD mitigation benefits.

Additional Key Words: heavy metal pollution, water resource development, upper Ohio River Basin.