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Title: GEOENVIRONMENTAL MODELS AS THE LINK BETWEEN ECONOMIC GEOLOGY AND ENVIRONMENTAL BEHAVIOR: AN OUNCE OF PREVENTION AND A POUND OF CURE

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Author 1 (CONTACT AUTHOR)
Name: Robert Seal
Org: US Geological Survey
Country: USA

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Abstract: Economic geologists appreciate that all deposits of a particular commodity, for example Cu or Au, are not alike, but instead can be classified into distinct genetic types on the basis of their geological and geochemical characteristics. These diagnostic geochemical associations form the basis of exploration geochemistry, but also provide invaluable insights into the environmental behavior of mineral deposits. Geoenvironmental models - defined as a compilation of geologic, geochemical, hydrologic, and engineering information pertaining to the environmental behavior of geologically similar mineral deposits ñ are a means of organizing these insights into a useful format. The models include information about the geochemistry, mineralogy, and acid-generating and acid-neutralizing potentials of mine wastes; the geochemistry of mine drainage from abandoned mines; and weathering mechanisms.

Massive sulfide and gold deposits illustrate the utility of geoenvironmental models in anticipating potential challenges associated with future mining. Massive sulfide deposits generally have high acid-generating potential and limited acid-neutralizing potential. In contrast, mine wastes from various gold deposit types range from having a distinctly net-acid character (e.g., high-sulfidation epithermal deposits) to having a distinctly net-neutral character (e.g., orogenic deposits). For massive sulfide deposits, the metal ratios in mine drainage from abandoned mines correlate with metal ratios in primary ores such that Cu:Zn in drainage decreases by deposit subtypes with Cyprus > Besshi > Noranda > Kuroko > Sedex, which are identical to those found in the ores. In contrast, Cd:Zn ratios for all of these deposit types overlap, reflecting the source of both in sphalerite regardless of deposit type. Metal concentrations in drainage associated with gold deposits can also be linked to the geologic character of the deposits and reflect deposit types that are endowed with certain metals versus those that are not (e.g., As in orogenic and high-sulfidation epithermal deposits, and Cu in high-sulfidation epithermal deposits).

Increased appreciation of the value of geoenvironmental models by the mining industry and regulatory agencies could improve many aspects of the process to find ore deposits, and to permit, develop, and close mines. Recognition of potential environmental

challenges associated with specific deposit types at the exploration stage may help to define better grade, tonnage, and total-contained metal characteristics that may be needed to offset environmental mitigation costs during and after mining. The ability of geoenvironmental models to highlight challenges associated with specific deposit types should simplify the permit-application review process by focusing attention on specific environmental challenges associated with specific deposit types, which ultimately should translate into more effective waste-management and mine-closure practices.