Breakthrough Hydrogeochemical Techniques for Exploration and Heap Leaching

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We developed a novel hydrogeochemical technique that de-risks the discovery of epithermal, porphyry, iron oxide-copper-gold (IOCG), volcanogenic massive sulfide (VMS), magmatic sulfide, and sediment-hosted deposits. The technique uses the ratios of metal isotopes at parts per trillion concentrations (e.g., 65Cu/63Cu; 66Zn/64Zn; 56Fe/54Fe; 109Ag/107Ag; 124Sn/122Sn) in ground and surface water as a probe for the presence of specific sulfide minerals beneath cover. The technique accurately distinguishes among, for example, chalcopyrite, chalcocite, and bornite, and hypogene vs. supergene chalcocite. The primary data are effective in the identification of concealed prospects and in the locating of drilling targets. The technique requires 250 mL of water, and results and interpretation are typically available two to three weeks after sample collection. We have successfully used the hydrogeochemical technique to help mining companies conduct brownfield expansion projects and greenfield exploration worldwide. The technique is also used to monitor mineralogy during copper heap leaching operations. This is done by using the copper isotope ratio of leach solutions and head mineral material, which accurately distinguishes among enargite, chalcopyrite, covellite and chalcocite. These data constrain the relative proportions of copper sulfide minerals that provide copper during hydrometallurgical dissolution and allow operators to tailor lixiviant chemistry to increase metal recovery. Ores that have experienced complex, multiple enrichment cycles contain various ratios of each mineral phase because, for example, covellite and chalcocite can yield different amounts of copper during leaching and quantifying the minerals responsible for providing copper directly impacts the method of extraction chosen for different ore types because not all ores of similar grade leach at the same rate. This information quantitatively assesses the leaching effectiveness of microbes and to constrain the process(es) involved in metal release considering there are a variety of mechanisms operating, including diffusion, redox reactions, and ion conduction.