Relative chemical and biological oxidation of sulphides in the Meguma Supergroup, Nova Scotia: the role of mineralogy, texture and composition

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Large-scale sulphide oxidation in areas of disturbed bedrock causes acid rock drainage (ARD), which is environmentally damaging and expensive to ameliorate. The extensive outcrops of the Meguma Supergroup in Nova Scotia contain disseminated sulphide minerals, which are an on-going environmental problem, because they lead to acidity and high concentrations of toxic metals in surface- and ground-waters. The problem is most intense in the basal Halifax Group where a well-defined suite of sulphide minerals is dominated by monoclinic pyrrhotite and lesser pyrite. Other sulphide minerals found in Meguma rocks include hexagonal pyrrhotite, arsenopyrite, chalcopyrite, galena, and sphalerite. The same sulphide may occur in different textures, sizes, orientations, or mineral associations, depending on such factors as the degree and type of metamorphism, structure, rock type and composition.

This study was conducted to determine the relative rate of chemical and bacterially assisted oxidation of a selected suite of sulphide minerals. Six pairs of polished thin sections containing a wide selection of sulphide minerals and textures were oxidized in a controlled laboratory experiment. One thin section of each pair was placed in a natural uncultured sample of ARD collected from a quarry near the Halifax International Airport (pH between 3.62 and 3.76). The matching thin section of the pair was placed in ARD effluent from the same source but double filtered at 0.2 microns to remove bacteria (pH = 3.16). Air continuously pumped into the water maintained an aerobic environment.

Surface changes were monitored on a regular basis and recorded with photomicrography. Degree of oxidation was determined by the presence of tarnish (color changes) and depth of etching in pits, cracks and polishing scratches. Preliminary evidence of oxidation indicates a significant difference between the treatments. In general, sulphide minerals exposed to unfiltered, biologically active ARD oxidize faster than in filtered ARD. In the bacterial treatment, the relative degree of oxidation among sulphides is galena > hexagonal pyrrhotite > monoclinic pyrrhotite >> sphalerite > arsenopyrite, chalcopyrite and pyrite. In the non-bacterial treatment, the relative degree of oxidation is galena > monoclinic pyrrhotite >> hexagonal pyrrhotite and sphalerite > arsenopyrite, chalcopyrite and pyrite. Although some of the relationships are explainable in terms of solution chemistry, others are unexpected. This study confirms the essential role played by biological agents in ARD, but also shows that sulphide mineralogy, texture, grain size and geology must be considered in the evaluation of ARD potential in Meguma rocks.