

## Experimental evaluation of the relative acid drainage potential of pyrite and pyrrhotite

I.N. MacInnis<sup>1</sup>, S.R. Silver<sup>1</sup>, J. Pasava<sup>2</sup>, M.C. Graves<sup>3</sup> and M. Zentilli<sup>1</sup>

<sup>1</sup>Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia B3H 3J5, Canada

<sup>2</sup>Czech Geol. Survey, Prague, Malostranske nam. 19, 118 21 Praha 1, Czech Republic

<sup>3</sup>Cuesta Research Limited, 154 Victoria Road, Dartmouth, Nova Scotia B3K 5S3, Canada

Iron sulphides have been recognised as a source for acid drainage for some time. For example, sulphidic black slates of the Halifax Formation of the Meguma Group occur under certain areas of the Halifax International Airport, Nova Scotia. Physical disturbance of the sulphidic slate during taxiway and hangar construction has resulted in acid runoff causing fish kills, as well as severely degraded water quality and aquatic habitat in receiving streams. Assessment of acid drainage risk is based on the potential production of sulphuric acid, based on the sulphur content and the neutralising capacity of the rock. Such assessment assumes that sulphur is present only in pyrite. However, the predominant sulphide is monoclinic pyrrhotite, not pyrite, in representative slates from the Halifax International Airport. Pyrite and marcasite are less abundant. Therefore, we have conducted simple experiments to determine the relative rates of pyrrhotite and pyrite oxidation, and hence the relative acid drainage risk.

Samples of pyrite and pyrrhotite were mounted together in epoxy and polished to 0.3  $\mu\text{m}$ . Surface observations were made under reflected light. Samples were immersed in distilled water, acidified with HCl to pH 4.5 and pH 2 and effluent containing *Thiobacillus* bacteria from the Halifax International Airport. Within 6 days, pyrrhotite exhibited a thin tarnish (evidenced by interference colours) in pH 4.5 solution and a thicker tarnish in pH 2 solution. Pyrite did not tarnish within 24 days in the distilled water solutions. A thick tarnish appeared on pyrrhotite in the bacterial solution within 1 day, and tabular transparent crystals appeared after 7 days, but the pyrite was not tarnished. The tarnish is

probably an oxidation product, such as amorphous ferrihydrite,  $\text{Fe}(\text{OH})_3$ , and the transparent crystals are possibly jarosite,  $\text{KFe}_3(\text{SO}_3)_2(\text{OH})_6$ .

The results are consistent with the simple observation that polished sections of pyrrhotite become tarnished even in air, while pyrite remains unchanged. Eh-pH relationships show that pyrrhotite will be thermodynamically less stable than pyrite under oxidising conditions; the greater chemical affinity of pyrrhotite for oxidation would indicate faster rates of oxidation according to transition state theory. We suggest that the  $\text{Fe}^{3+}$  in the defect structure of pyrrhotite also increases the oxidation rate, considering that other workers have shown that  $\text{Fe}^{3+}$  in solution accelerates pyrite oxidation. Accelerated oxidation of pyrrhotite by *Thiobacillus* bacteria is consistent with results for pyrite reported in the literature. However, our experiments show that the oxidation rate of pyrrhotite remains faster than pyrite, even in the presence of *Thiobacillus* bacteria. These results support the proposal that the bacteria accelerate oxidation while in direct contact with sulphide surfaces, in this case populating the pyrrhotite surface in preference to pyrite.

It appears the abundance of pyrrhotite is a factor in the severity of the acid drainage problem at the Halifax International Airport. The sulphide mineralogy should be an important consideration in the risk assessment of acid drainage. Also, we suggest that the magnetic susceptibility of pyrrhotiferous rock affords an avenue for field assessment of acid potential.