Pyrrhotite composition and its relationship to acid drainage from the Halifax Formation, Meguma Group, Nova Scotia

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Acid drainage from the Halifax Formation has been recognized at least since the early 1960s when it formed as a result of construction activities at the Halifax International Airport. Mitigation efforts at the airport site have been ongoing and continue to the present day. In addition to the airport site, acid drainage has adversely affected various other areas throughout southwestern Nova Scotia, all underlain by the Halifax Formation. In general, acid drainage is attributed to sulphide mineralization within the host bedrock. In the past, little attention has been paid to the sulphide mineralogy, texture, distribution and mode of occurrence. In recent years, however, it has been recognized that the type of sulphide is an important factor. One reason for this is that iron-sulphide minerals contain different molar proportions of Fe and S, and therefore oxidize to form different amounts of H^+ ions. As an example, the overall oxidation of pyrite by oxygen can be shown by the general formula:

$$FeS_2 + 7/2\ O_2 + H_2O = Fe^{2+} + 2\ SO_4^{2-} + 2\ H^+ \qquad (1)$$

This leads to the formation of 2 moles of H^+ ions for each mole of pyrite oxidized. On the other hand, the overall oxidation of pyrrhotite by oxygen can be shown by the general formula:

$$Fe_{(1-x)}S + (2-x/2)\ O_2 + (x)\ H_2O = (1-x)\ Fe^{2+} + SO_4^{2-} + (2x)\ H^+ \qquad (2)$$

where x can vary from 0.0 to 0.125. At the end-member where x = 0 (FeS), no H^+ ions are produced. However, the end-member where x = 0.125 (Fe_7S_8), leads to the maximum amount of H^+ ions produced. In this case, 1 mole of Fe_7S_8 leads to 0.25 moles of H^+ ions produced. Therefore for pyrrhotite, the amount of H^+ ions released into solution is dependent upon its composition. Although quantitatively less H^+ ions are produced for pyrrhotite than for pyrite, previous studies have shown that pyrrhotite oxidizes substantially faster than pyrite. This could result in a "sudden pulse" of acidity in the surrounding environment.

Microprobe data from pyrrhotites in drill core samples from the Halifax International Airport give an average stoichiometry of $Fe_{7.058}S_{8.000}$. XRD studies give typical double peak d-spacings near 2.057 and 2.047. These data indicate the pyrrhotite is 4C monoclinic. For comparison, samples were taken from four other areas including: (1) immediate vicinity of Halifax - contact metamorphic, (2) highway 101 near Mount Uniacke (25 km northwest of Halifax) - contact metamorphic, (3) Beaverbank road (25 km north of Halifax) - regional greenschist facies (biotite grade), (4) drill core from the Eastville zinc-lead deposit (40 km southeast of Truro) - regional greenschist facies (biotite grade). Preliminary data collected to date suggest the pyrrhotite composition is consistent and homogeneous regardless of geological environment and is of the 4C monoclinic type. This study shows that pyrrhotite compositions in the Halifax Formation will lead to the maximum amount of H^+ ions produced for that mineral. We have a worst case scenario for sulphide mineralization, composition, and the development of acid drainage in the Halifax Formation.