

## **Freeze/thaw tests for mine waste and suggestions for a protocol for northern climates**

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Drainage waters with low pH and high trace element concentrations are large problems in Sweden and many other countries. The acidic nature of the drainage is a result of sulphide mineral oxidation, mainly the iron sulphide pyrite, generating acid rock drainage (ARD). ARD generation in arctic regions has been presented in a number of research studies but was earlier not considered noteworthy due to slow pyrite oxidation rates at low temperatures. More recent studies however have shown that ARD is generated in these areas when thawing starts in the spring, both from natural weathering of pyritic rocks and of mining waste dumps.

Humidity cell tests are widely used in order to estimate long-term weathering rates. In a humidity cell the waste is subjected for a weekly cycle of 3-day alternating dry air and wet air followed by leaching. The procedure is repeated for at least 20 weeks and simulates extreme weathering conditions. The oxidation rate slows with time because thin layers of ferrous and ferric sulphates and (oxy)hydroxides grow on the pyrite surface, retarding the oxygen transport. Mine waste in northern climates is however also exposed for extreme physical weathering by repeated freeze/thaw cycles, causing cracks, channeling and exposure of new surfaces.

Since it is unknown how repeated freezing and thawing affect these pyrite surface layers it is vital that we have test methods that consider these effects. For certain remediation planning this is important as well. For example encapsulation of pyrite grains with fly ash additives which have been rather recently studied. The effect of freeze and thaw cycles on the sustainability of the encapsulation is however unknown.

Reference methods for testing are essential and at present a standardized freeze/thaw test is missing. The aim of the present study is to develop a standard protocol for ARD generation and remediation strategies for northern climate conditions. A final protocol aims at combining results both from humidity cell testing and freeze/thaw testing.

Introductory experiments analogous to humidity cell tests started in January 2011. The material is kept in a freezer for 3 days, thereafter exposed for dry air for 3 days, followed by leaching with deionized water. The procedure is repeated during at least 30 weeks. General ARD parameters (pH, Eh, alkalinity, acidity, metals and major anions) are measured in the leachates. Additionally, different oxidation stages give surface films with distinct colors which could be distinguishable with photography.