Mining in Extreme Environments

Waste Rock Biogeochemistry in a Permafrost Environment: Examination of a Cover for a Low Sulfide, Granitic Waste Rock

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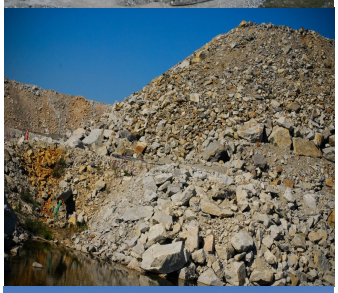
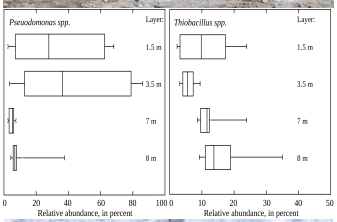
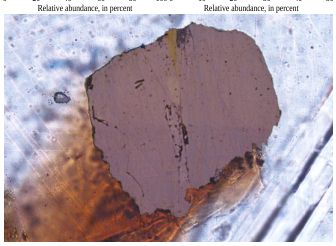
Abstract

At the Diavik Waste Rock Project's mine-research site, the microbial colonization and oxidation of waste rock sulfide minerals is attenuated by the extreme freeze-thaw cycle of a permafrost environment. The closure design for the waste rock stockpile consists of a low sulfide waste rock and low permeability till covering higher sulfide waste rock. This design was examined at the mine site through construction of experimental waste rock piles and active zone lysimeters with and without the till cover. Leachate from these experiments indicates variable pH and SO_4 concentrations that correlate with sulfide content and the thermal-moderating influence of the till cover. The till initially provided a moderated environment for the production of acid, growth of acidophilic Fe- and S-oxidizing bacteria, and enhanced weathering until wet up and freezing of the till and underlying waste rock as a permafrost. Greater sulfide oxidation was observed above the till cover because of greater exposure to the annual freeze-thaw cycle. An examination of the bacterial communities at the genus level indicates the prevalence of *Pseudomonas, Rhodanobacter, Sideroxydans,* and *Thiobacillus* in the waste rock. *Pseudomonas spp.* were dominant in the drier and more extreme temperature environment above the till cover, while *Thiobacillus spp.* were dominant in the more sulfide-rich, wetter/frozen environment below the till. A decreasing trend in *Thiobacillus spp.* from the exterior to the interior, and an opposing trend in *Acidithiobacillus spp.*, suggests greater acid generation deeper in the waste rock further from the extreme temperature variation of the tundra climate. The presence of the till cover moderated temperature variations, enhanced the initial rate of sulfide oxidation, and allowed for greater microbial diversity, but the freezing of the till cover and underlying waste rock drastically reduced sulfide oxidation and the generation of acid rock drainage. These results highlight the importance of temperature on microbially catalyzed acid production and our ability to use the extreme temperatures of the tundra climate to minimize potential environmental impacts from mining through formation of waste rock permafrost.







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