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Long-term Pb and Zn leaching from Ivittuut mine waste under Arctic conditions

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The former cryolite (Na_3AlF_6) mine at Ivittuut is located along the shoreline of Arsuk Fjord in SW Greenland. The extraction of cryolite generated waste rock with minor amounts of sulfides, including galena, sphalerite, chalcopyrite, arsenopyrite, and molybdenite. The waste rock is deposited on land and in the tidal zone of the shore. The mining lasted for 130 years and stopped in 1982. Since that time, environmental monitoring of the fjord water, mussels, and seaweed has been conducted [e.g., 1]. The concentrations of Pb and Zn in the fjord seawater are clearly elevated, up to two orders of magnitude compared to the Greenland Water Quality Criteria for seawater. Nevertheless, there is a trend over the period of 1982-2010 of decreasing Pb concentration while Zn concentration remains stable.

We performed a 40-week Humidity Cell Test (HCT) leaching experiment using seawater and freshwater in columns filled with waste rock from Ivittuut. The experiments were carried out at room temperature (20-22 °C), in a cooling room at 3 °C and outdoors to simulate the weathering of sulfides in Arctic conditions.

The results show slower leaching rates in the experiments at 3 °C compared to room temperature, and similarly, in freshwater compared to seawater. Leaching rates in the outdoor setting fall between those observed at room temperature and 3 °C. The Pb and Zn concentrations in the leachates increased in seawater and freshwater in the first 15-17 weeks before becoming stable. In contrast, fluorine concentrations decreased during the first 10 weeks and then became stable.

Scanning electron microprobe analysis of galena and sphalerite shows the formation of secondary minerals, coating the surfaces of galena crystals. No secondary minerals were found on the sphalerite grains. From the observations we conclude that leaching processes in sulfides occur slowly under Arctic conditions and that the formation of secondary minerals on galena reduces the release of Pb into the environment. The latter could be an explanation for the decreasing trend of Pb concentration in the fjord.

[1] Johansen P, Asmund G, Rigét F, Schledermann H. (2010) NERI Technical Report No. 812