

# Leaching dynamics of Pb, Zn, and F: Short-term leaching of waste rock from the Ivittuut mine site, South Greenland

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The mining site of Ivittuut was actively exploited for more than 130 years in the interest of cryolite, Na<sub>3</sub>AlF<sub>6</sub>, (Johansen *et al.*, 1995, 2010). The Ivigtût intrusion belongs to the Gardar Province and is located by the Arsuk Fjord in South Greenland (Karup-Møller and Pauly, 1979). Between 1854 and 1987, the cryolite was blasted, crushed, sorted on site before being shipped to Denmark for further processing (Johansen *et al.*, 2010; Søndergaard and Mosbech, 2022). The high-grade ore (i.e., purest cryolite) was prioritized and sold, while the low-grade ore consisting of cryolite, quartz, siderite, galena, sphalerite and chalcopyrite, together with the host-rock material were classified as waste rock (WR). This material was used to build the roads, the quay and barrier between the fjord and the open pit at the mine site (Johansen *et al.*, 1995, 2010). After the mine closed in 1987, little to no remediation was done at the mine site and the waste rock, including sulphides, is exposed to weathering processes. These processes leach heavy metals from the waste rock and release them into the environment as measured in a monitoring project of the fjord, where elevated Zn and Pb concentrations are observed (Johansen *et al.*, 1995). The monitoring project over the past 30-40 years has estimated the release of dissolved Pb into the fjord to range between 133-333 kg (Johansen *et al.*, 2010; Bach *et al.*, 2014). The release of Pb has showed a decreasing trend over this monitoring period, with up to 3 times decrease observed since 1982. In contrast, the release of Zn has shown little to no significant change (Johansen *et al.*, 2010; Bach *et al.*, 2014). This study aims to investigate the influence of temperature and type of leachant on weathering of the WR by applying short-term leaching experiments simulating mineral weathering and dissolution reactions. The shake flask tests were designed to estimate the amount of Pb, Zn and F leaching from a synthetic sample resembling the WR at the Ivittuut mine site. To mimic the sub-arctic conditions at Ivittuut tests were carried out both in a 2-degree cooling room and at room temperature. The two temperatures enable a direct comparison of the leaching process in sub-arctic conditions to waste rock leaching in warmer climate. The waste rock at Ivittuut is located onshore, but also at places partly to fully submerged in the seawater. Therefore, both seawater and rainwater were used as leachants. The experiments involved subjecting the WR to a continuous 24-hour period of shaking, followed by the extraction of leachate and filtration. In addition to testing the WR, control experiments were conducted for both seawater and rainwater to establish the baseline levels of Pb, Zn, and F present in the leachants before any additional factors were introduced. The produced leachants were analysed for changes in physio-chemical parameters and chemical composition, which of results are still awaited.

## References

- Bach, L., Asmund, G. and Riget, F. (2014) 'Environmental monitoring in 2013 at the cryolite mine in Ivittuut, South Greenland', *Aarhus University, DCE--Danish Centre for Environment and Energy*.
- Johansen, P., Asmund, G. and Riget, F. (1995) *Miljøundersøgelser ved Ivittuut 1982-1992, Grønlands Miljøundersøgelse*.
- Johansen, P., Asmund, G., Riget, F. and Schledermann, H. (2010) *Environmental monitoring at the cryolite mine in Ivittuut, South Greenland, in 2010, NERI Technical Report no. 812*.
- Karup-Møller, S. and Pauly, H. (1979) 'Galena and Associated Ore Minerals from the Cryolite at Ivigtut, South Greenland', *Commission for Scientific Research in Greenland*, pp. 2–25. Available at: ISBN 978-87-17-02582-0.
- Søndergaard, J. and Mosbech, A. (2022) 'Mining pollution in Greenland - the lesson learned: A review of 50 years of environmental studies and monitoring', *Science of the Total Environment*, 812. Available at: <https://doi.org/10.1016/j.scitotenv.2021.152373>.