

Leaching dynamics of Pb, Zn, and F: Laboratory and field leaching of waste rock from cryolite mining at Ivittuut, South Greenland

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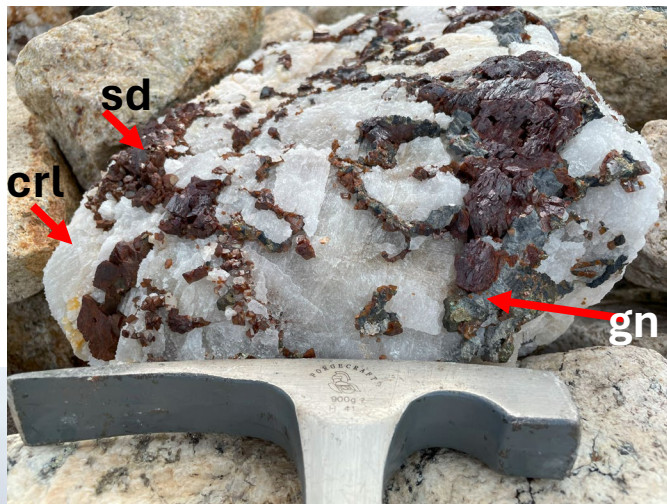
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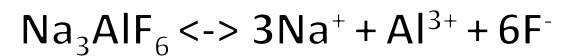
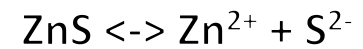
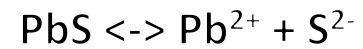
Ivittuut

- Cryolite mine
- Mine activity over 130 years (1854-1987)
- Open pit
- Waste rock was used as landfilling:
 - Quay
 - Roads
 - Barrier between the fjord and the open pit
- Heterogeneous waste rock (WR):
 - Host rock granite and gneiss
 - Ore
 - Cryolite, siderite, galena, sphalerite, chalcopyrite





Dissolving galena,
sphalerite and cryolite:

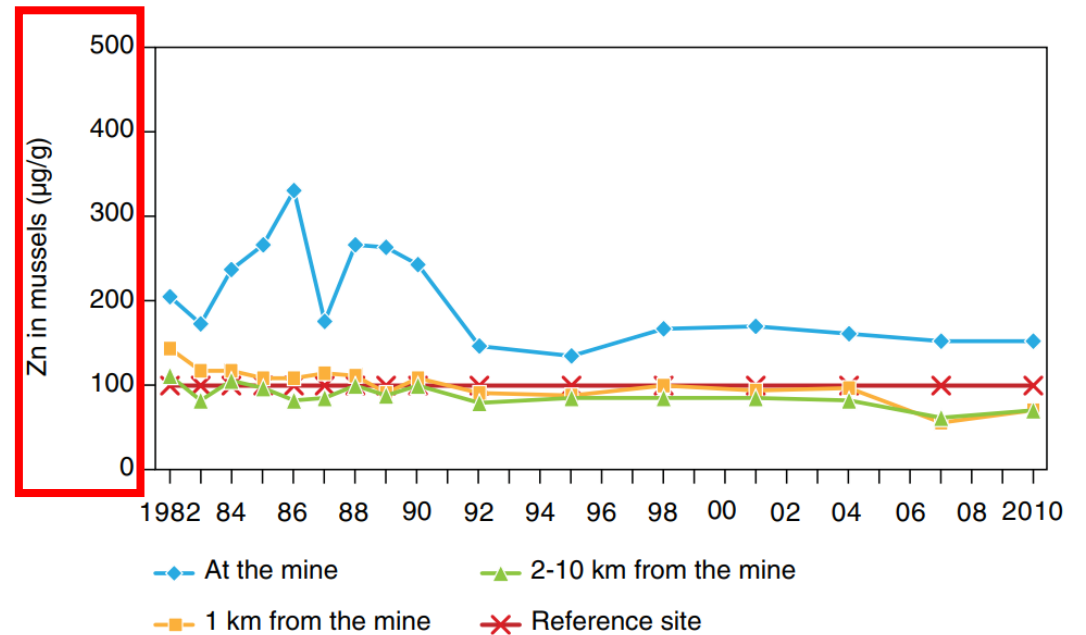
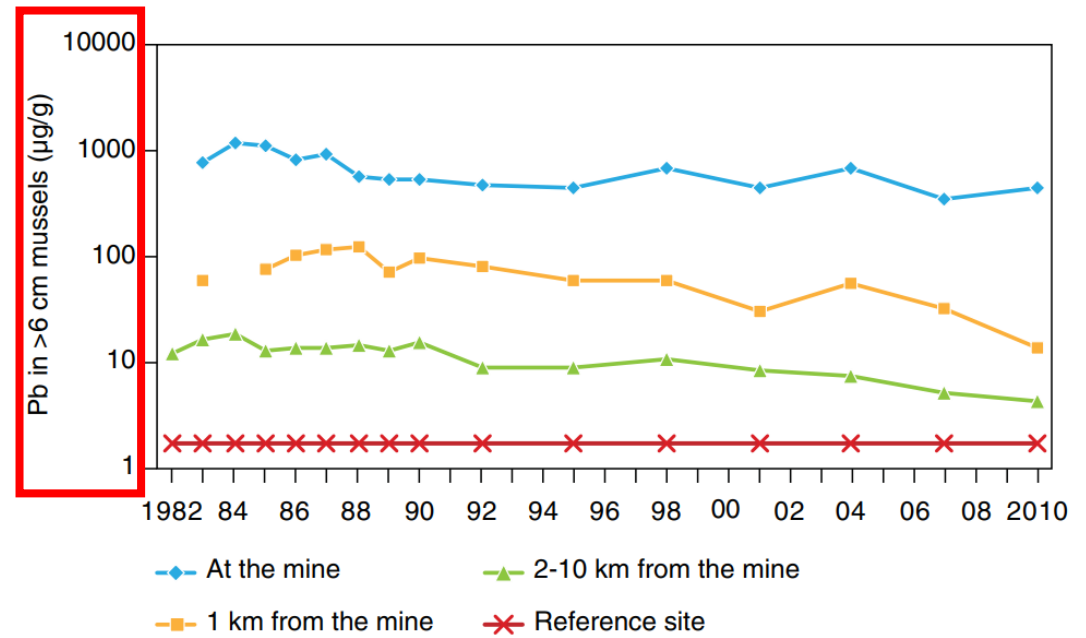


gn = galena (PbS), sph = sphalerite (ZnS), cpy = chalcopyrite (CuFeS₂), sd = siderite (FeCO₃), crl = cryolite (Na₃AlF₆)

Pollution in Arsuuk Fjord



mining companies.



Johansen et al 2010

The experiment: Humidity cell test (HCT)

WR + leaching solution
40 weeks

Objectives:

1. Temperature effect on leaching rates using seawater as leaching solution
 - 25 °C and 3 °C
2. Natural weathering and natural leaching
 - Outdoor conditions

Hypotheses:

1. Weathering processes are slower under Arctic climates
2. Leaching with seawater more effective compared to precipitation water (PW)



40 weeks with
weekly cycles of
water saturation
and air drying

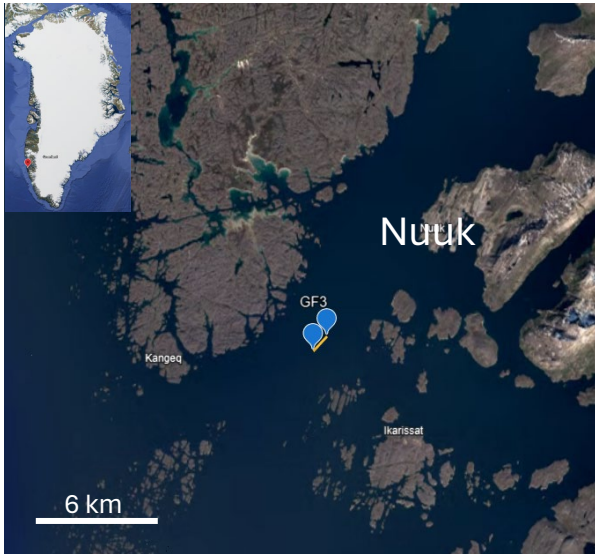
HCT: methodology

Laboratory experiments:

- 1 kg of WR
- 25 °C and 3 °C
- Leaching solution: Seawater
 - L/S ratio = 1
 - Cycle: weekly flooding and sample collection and airdrying for 6 days

Outdoor experiment:

- 1 kg of WR
- Outdoor temperatures (March-October)
- Leaching solution: Precipitation (snow and rain)
- Sample collection was done weekly

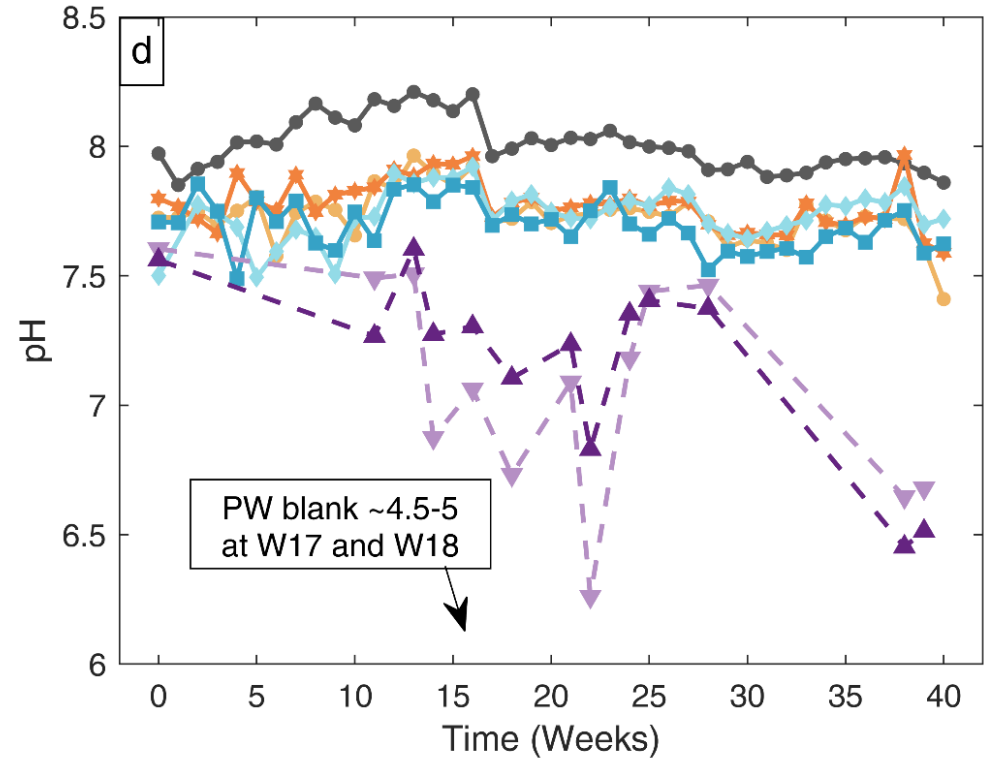


HCT: methodology

- Seawater collected at GF3 in Nuuk Fjord
- Precipitation water at Greenland Institute for Natural Resources (GINR)
- WR from Ivittuut
 - Crushed down to $< 4\text{mm}$ in grainsize
- Weeks sampled for chemical analyses: 0, 1, 2, 6, 11, 17, 22, 26, 31, 36 and 40.
- Physicochemical parameters measured each week

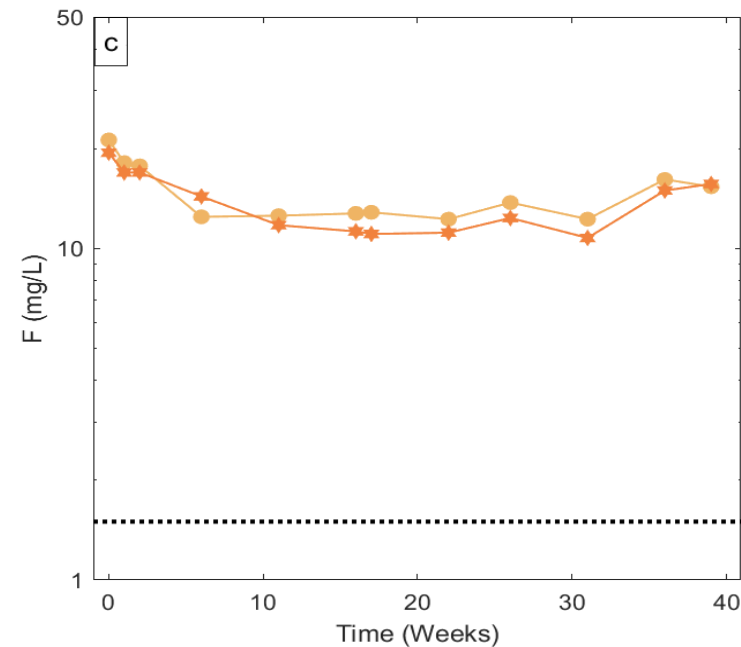
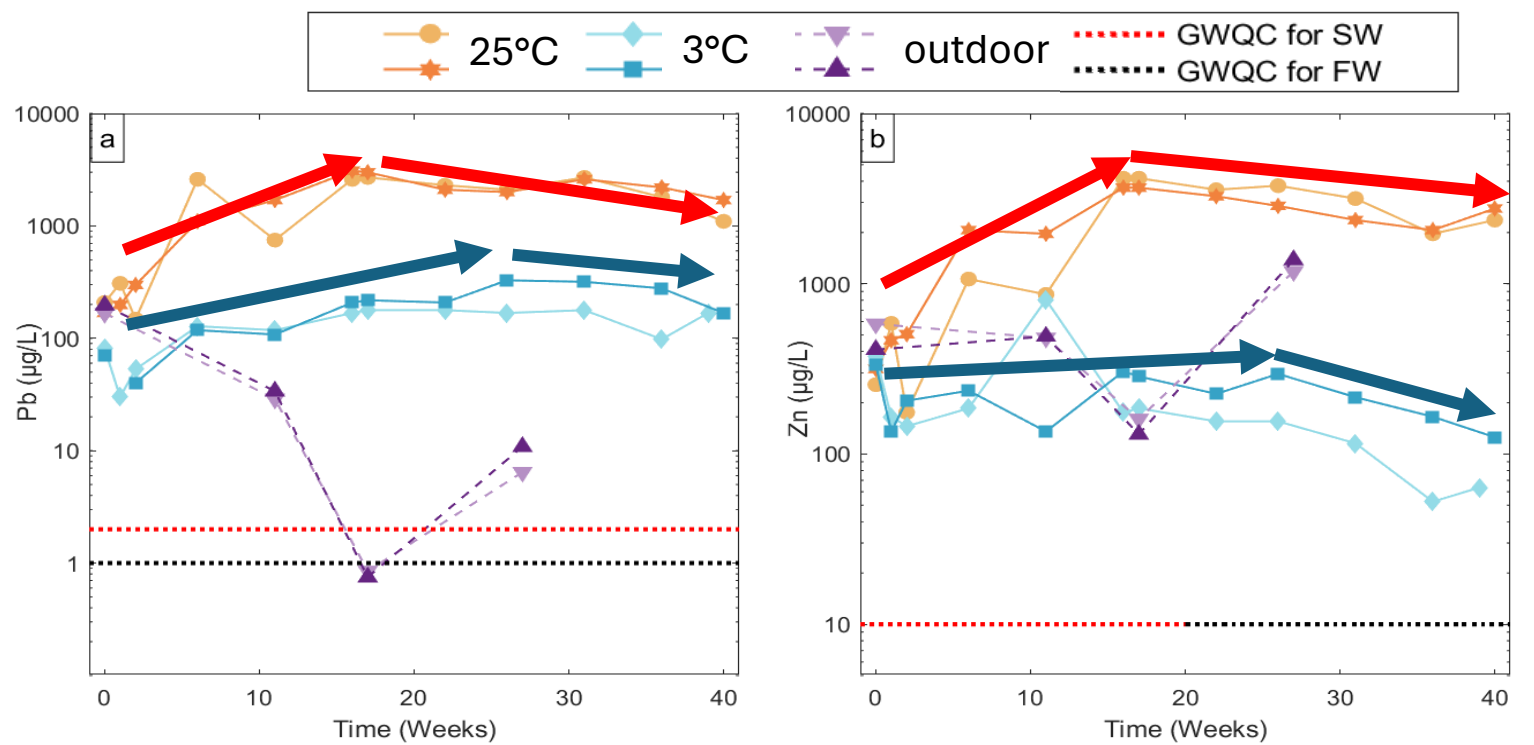
Results: pH

- SW blank has higher pH compared to the SW leachates
- 25 °C and 3 °C experiments result in similar pH measurements
- Precipitation blank has very low pH (4.5 -5)
- Outdoor experiment has lower pH compared to SW leaching but higher compared to the PW blank



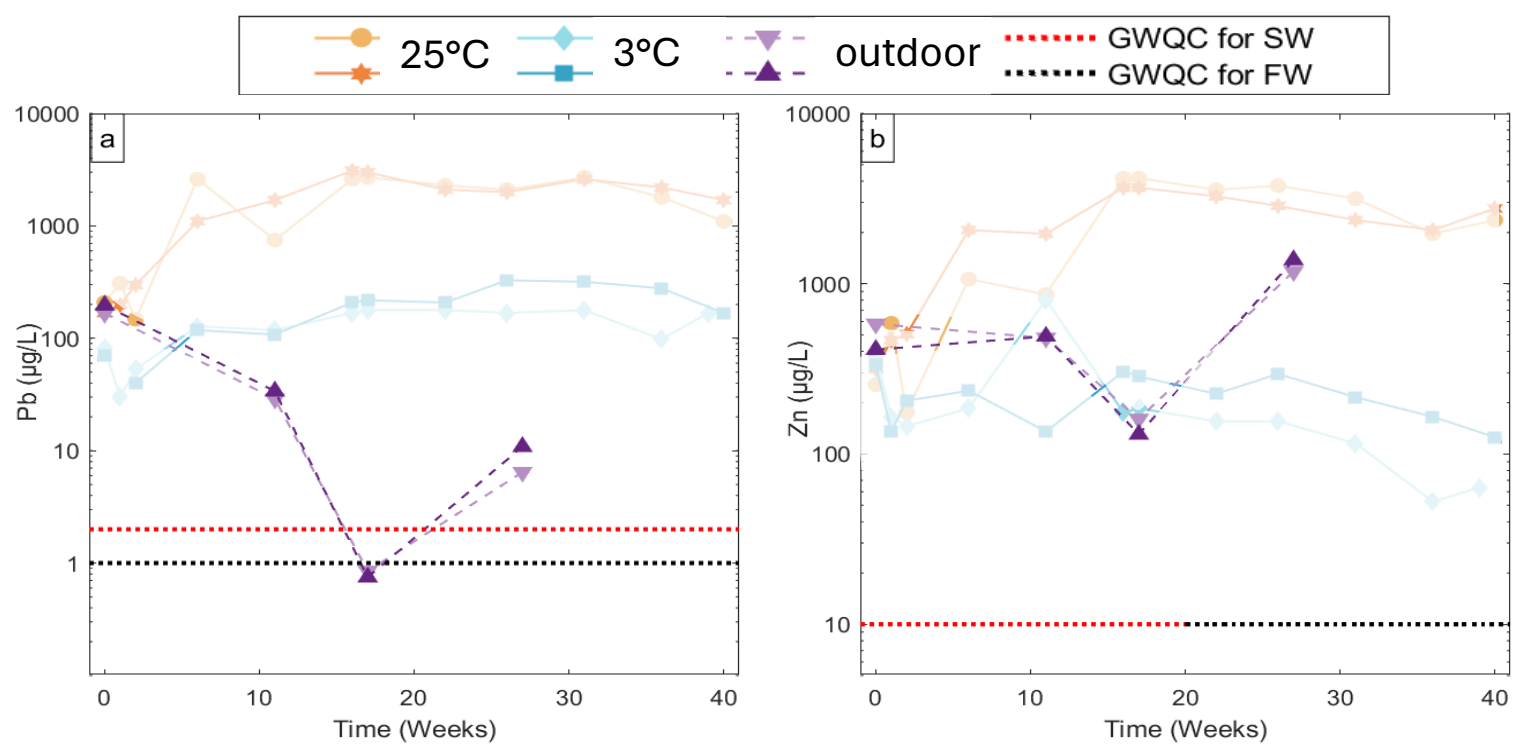
Results: laboratory

- Higher temperature experiments result in higher concentrations of Pb and Zn
- Lower temperatures lower the leaching rate of Pb and Zn
- F concentrations were only measured in room temperature experiment
- F shows opposite trend compared to Pb and Zn

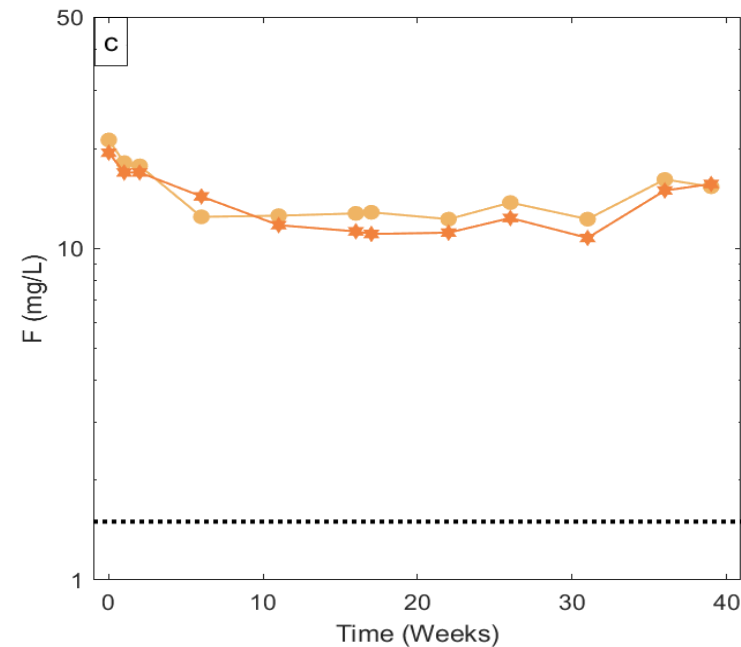


Results: outdoor

- Outdoor experiment fluctuates highly over time
- Outdoor experiments result in concentrations between the 25 °C and 3 °C experiment



Month	Date	Week no	Leachate mass (g):	
			HCT 5	HCT 6
Marts	21.03.18	Week 0	744,79	726,34
Marts	28.03.18	Week 1	Frozen	
April	04.04.18	Week 2	Frozen	
June	06.06.18	Week 11	137	349,6
June	27.06.18	Week 13	47,7	11,6
July	03.07.18	Week 14	74,7	55
July	14.07.18	Week 16	20,1	14,8
July	17.07.18	Week 17	91	92,8
July	23.07.18	Week 18	113,8	103,2
August	23.08.18	Week 22	134,7	133
September	05.09.18	Week 24	52,1	51,2
September	12.09.18	Week 25	50,9	54,2
September	28.09.18	Week 27	108,3	116,6
October	03.10.18	Week 28	26,8	28,5

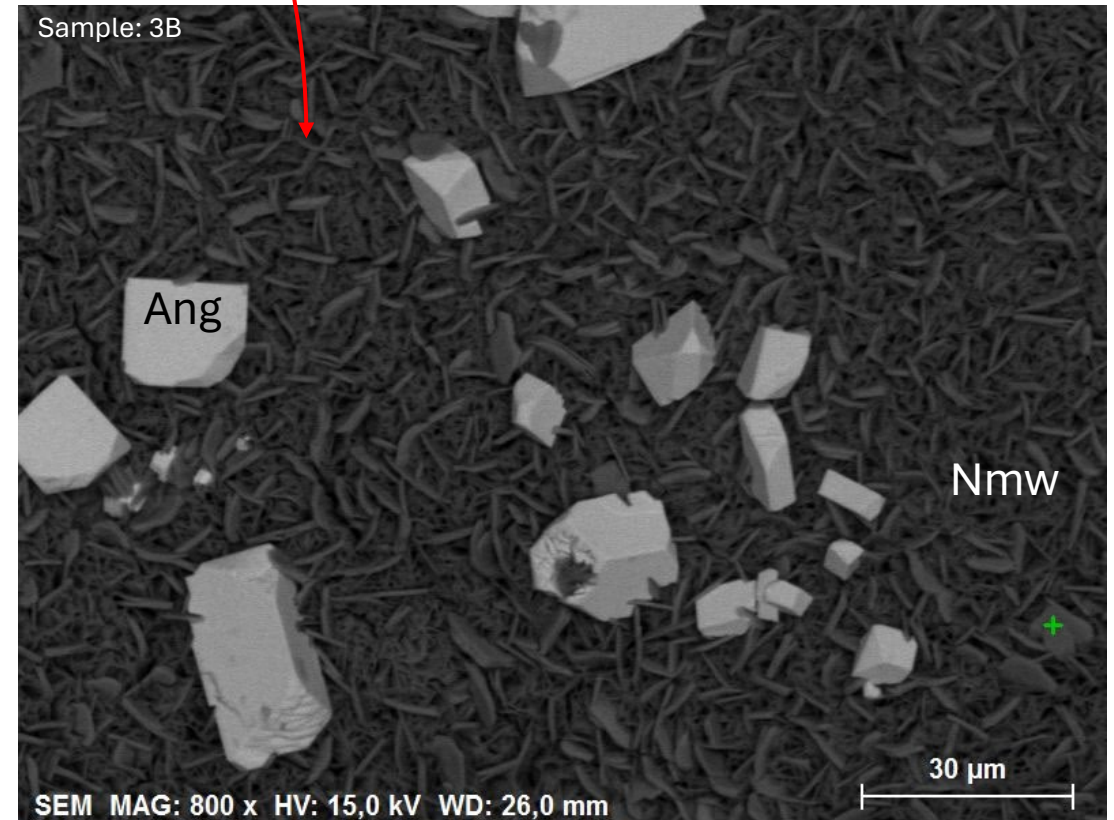
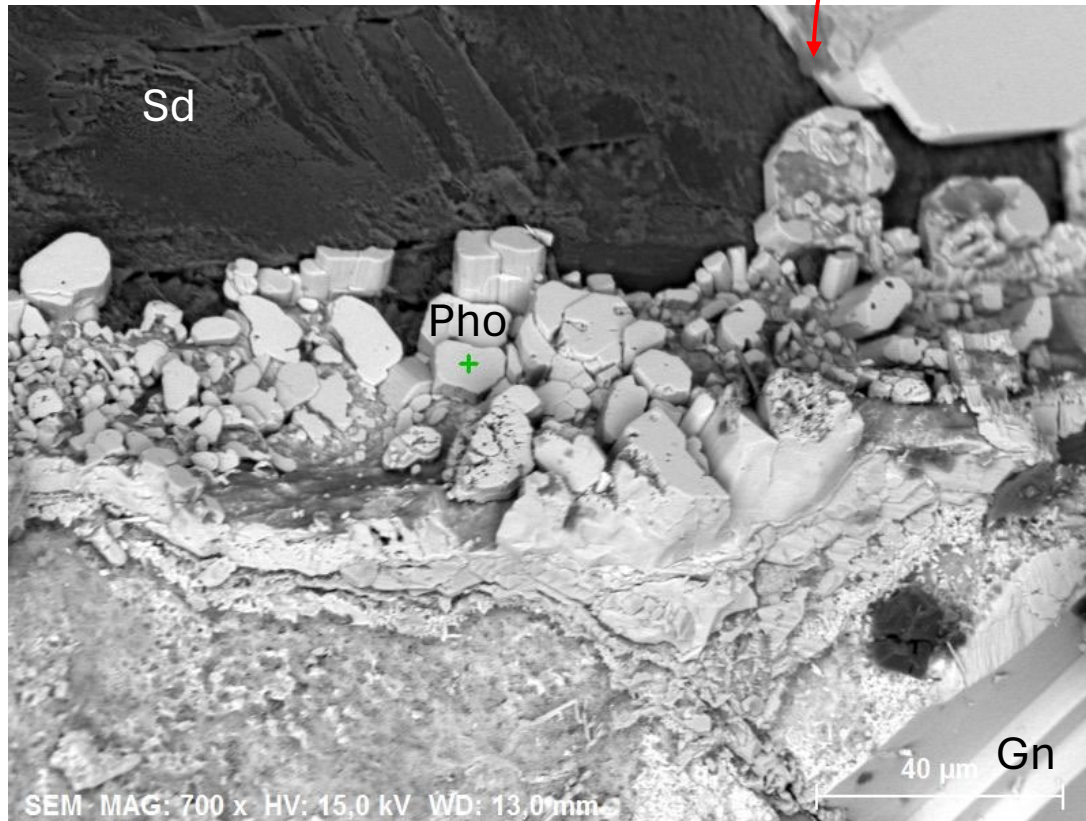


Summary

- Near neutral pH measurements in leachates
 - Regardless of the initial pH of the leaching solution (SW ~8 and PW ~5)
- SW and PW leaching lead to Pb and Zn concentrations exceeding Greenland's guideline values
- Arctic conditions (temperatures) may delay leaching and lower the leaching rates of Pb and Zn when using SW
 - pollutant release occurs at lower concentrations but over longer periods of time?
- Much more complicated in real life
 - The amount of leaching solution
 - Evaporation

- Further work:
 - Fluorine measurements on the other leachates (3 °C and outdoor experiment)
 - Are there any differences between the different temperatures?
 - Another HCT experiment planned to start at the beginning of May 2024
 - Emphasis on leaching with SW and distilled water at different temperatures
 - Outdoor experiment with natural temperature variations with controlled leaching solution volume
 - Controlled mineralogy of WR
 - Mineralogical analyses of before and after leaching
 - Secondary minerals?

Secondary minerals



Thank you for your attention!

Results: DO, EC, ORP and pH

