Stable Pb isotope signals in the Arctic: does the general background exist?

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INTRODUCTION

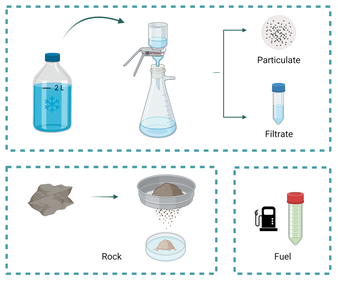
We aim to find a range of Pb isotope compositions that may be regarded as a background signal for the Arctic.

We collected snow from three Arctic localities in Svalbard, Greenland, and Iceland to study the Pb stable isotope signals from atmospheric particles in April 2022.

To learn about possible sources of Pb pollution, we also processed local rock and fuel samples.

METHODS

We filtrated the melted snow through 0.45 µm to analyze the solid particles and the dissolved fraction separately. Rocks were crushed and sieved under 2 mm. We collected around 50 mL of fuel from the local petrol station.



To completely digest the filters, powdered rock and fuel we used a mixture of HNO_3, HCl and HF (6:3:1). Peroxide was added when necessary. Digests were filtered through 0.45 µm.

We determined metal concentrations and Pb isotope composition by ICP-MS.

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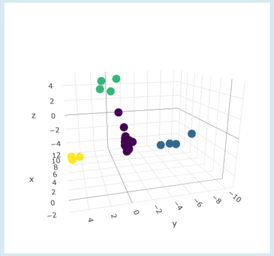
RESULTS

Chemical Composition

Principal Component Analysis (PCA). In combination with a cluster analysis we distinguish 4 groups:

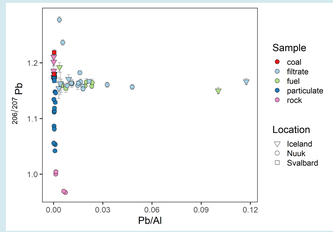
1) Icelandic rocks
2) Svalbard particulate
3) Nuuk fuel
4) Everything else



PCA+Cluster analysis. The axes are PC1, PC2 and PC3. Colors represent clusters.

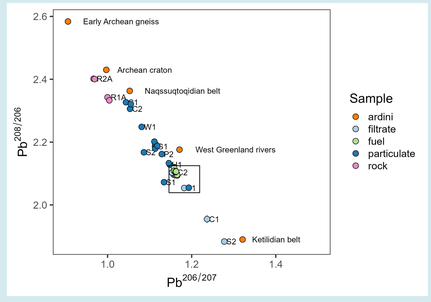
The clear difference of 1) and 2) chemical composition suggest that local rock is not the main source of Pb to the atmospheric particulate in Svalbard and Iceland (in 4)).

3) implies that the fuel in Nuuk is different than that in Iceland and Svalbard.



Normalized Pb to Al concentrations to distinguish natural or anthropogenic Pb enrichment.

Pb Isotope Composition



Mixing line from Nuuk, Greenland. Orange points are Pb isotope compositions from Greenland's crust taken from *Biscaye et al. 1997.*

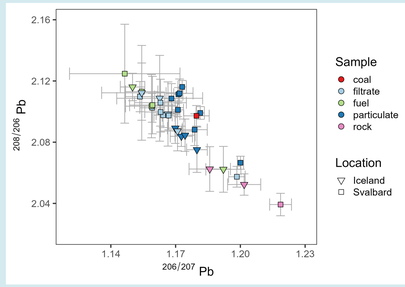
RANGE
Greenland samples show a wide spread of Pb isotope compositions (left), while Iceland and Svalbard values lie within the marked area.

Explanation 1: The presence/lack of a strong source homogenizing the values. (example: Coal in Svalbard)

Explanation 2: The local bedrock have different ranges, reflected in the samples.

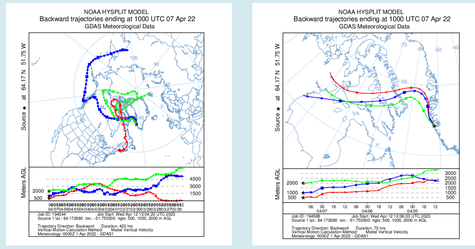
SNOW FRACTIONS
Filtrate overlaps with fuel, suggesting contribution to this fraction.

Particulate lie closer to rocks and coal.



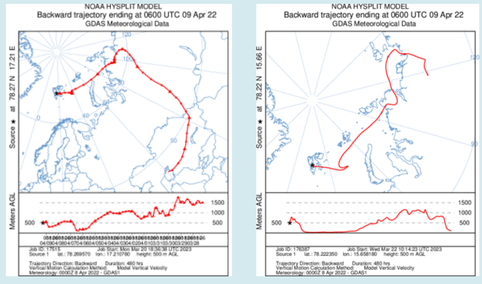
Three isotope plot of data from Svalbard and Iceland.

Wind back-trajectory



Selected wind trajectories ending in Nuuk, Greenland.

The HYSPLIT software predictions situate the major origin of the wind in Nuuk from North Greenland and North Canada (see above), while in Svalbard it mainly comes from North and East Russia (see below).



Selected wind trajectories ending in Svalbard.

CONCLUSION

The broad range of Pb isotope composition in Greenland reflects the wide range in the local bedrock. Fuel participates in the overall Pb signature but does not change it.

Svalbard and Iceland's signature ranges are more homogeneous due to the anthropogenic sources, the closeness of the sources' signatures, or a combination of both.

The obtained general Pb isotope composition range corresponfs to the range in Greenland, due to its wide natural range ($^{206/207}$Pb = 0.967 - 1.278, $^{208/206}$Pb = 1.884 - 2.402).

We propose to consider a different range in Svalbard and Iceland, where anthropogenic or lower variability in natural sources narrow it to $^{206/207}$Pb = 1.146 - 1.219 and $^{208/206}$Pb = 2.039 - 2.125.

Biscaye, P. E., Grousset, F. E., Revel, M., Van Der Gaast, S., Zielinski, G. A., Vaars, A., & Kukla, G. (1997). Asian provenance of glacial dust (stage 2) in the Greenland Ice Sheet Project 2 Ice Core, Summit, Greenland. *Journal of Geophysical Research: Oceans, 102*(C12), 26765–26781. https://doi.org/10.1029/97JC01249
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