Analyzing Sulfur Isotopes in a Summit, Greenland Ice Core to Understand the Response of Arctic Biogenic Aerosol Abundance to Sea-Ice Decline

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1. Introduction

- **Pollution legislation decreased sulfur emissions:** Since the early 1980s, pollution mitigation legislation in North America and Europe has reduced emissions of pollutants. This decrease in pollution has reduced the concentrations of aerosols that partially offset the warming effect of greenhouse gases. Sulfate, an aerosol that is important to radiative cooling and cloud formation, has anthropogenic sources and three natural sources: sea-salt, biogenic (algae and phytoplankton), and volcanic.

- **Climate change affects natural sources of sulfur emissions:** This project is concerned with how climate change will affect the biosphere in the Arctic by looking at biogenic sulfur emissions. As the Arctic warms and sea-ice melts, is uncertain how the decrease in sea-ice extent will affect dimethylsulfide (DMS), a biogenic sulfate source produced by sea-ice algae.

2. Background

- An ice core was collected from Summit, Greenland to provide a record of atmospheric sulfate in the Arctic from 1200 C.E. to the present (2007).

- The ice core measures ~40 square cm across and sulfate concentrations range from ~25-150 micrograms per liter (very dilute).

- The isotopic composition of sulfur can help indicate the source of sulfate. To analyze isotope ratios, the ice core must be concentrated using the methods described below.

Figure 1: Map of the study area (Summit, Greenland)

Figure 2: Image of an Ice Core

3. Research Questions

1. **How can we analyze ice core meltwater samples to distinguish biogenic sulfate from other sources of sulfate?**
2. How will DMS emissions change with declining sea-ice extent?

4. Methods

Resin Method
This method concentrates SO_4^{2-} ions in Na_2SO_4 by capturing ions in an ion exchange resin. NaCl solution is passed through the resin and SO_4^{2-} ions are replaced by Cl^-. The concentrated SO_4^{2-} solution is collected at the bottom and analyzed with ion chromatography to confirm that all sulfate ions are recovered.

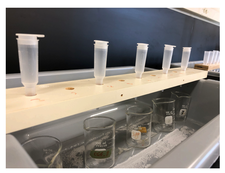

Figure 2: Image of Resin Method at the Alexander Lab

Sulfur Isotope Method
The evaporated samples are analyzed with a stable isotope mass spectrometer to measure their isotopic compositions. These measurements will help determine how much sulfate comes from biogenic vs. anthropogenic sources.

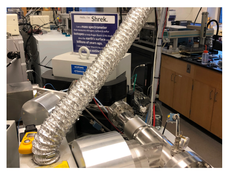

Figure 3: Image of Shrek mass spectrometer in IsoLab

5. Discussion

- From the Sulfur Isotope Method:

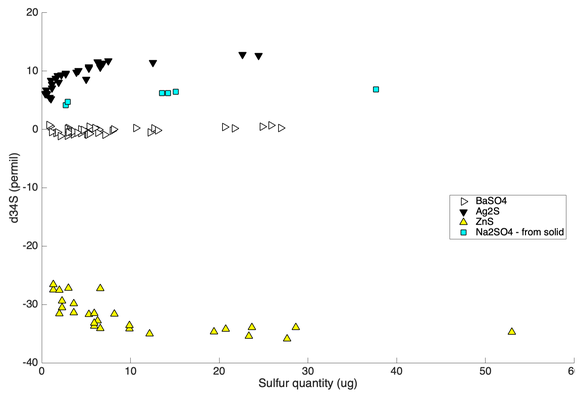

Figure 4: $\delta^{34}S$ vs sulfur quantity (µg) for BaSO4, Ag2S, ZnS, and Na_2SO_4 Standards.

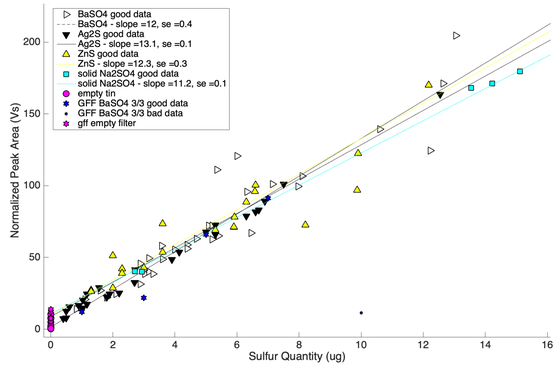

Figure 5: Normalized Peak Area (Vs) vs. sulfur quantity (µg) for BaSO4, Ag2S, ZnS, and Na2SO4.

- The average $\delta^{34}S$ values for BaSO4, Ag2S, ZnS, and $Na2SO_4$ standards are -0.19± 0.49 ‰, 8.78 ± 2.91 ‰, -32.53 ± 2.68 ‰, and 5.76 ± 1.06 ‰ respectively. Isotopic compositions decrease in accuracy with smaller sulfur quantities (see Figure 4).
- The standard error for the slopes of peak area vs. sulfur quantity standards BaSO4, Ag2S, ZnS, and $Na2SO_4$ are 0.4, 0.1, 0.3, and 0.1 respectively. These values all indicate that the precision of the mass spectrometer is relatively high. However, more development is needed to improve the accuracy of the measurements (see Figure 5).

- The resin method requires further development to determine its success at concentrating sulfate samples.

6. Future Research

- **Perfecting the Methods:**
  - Continue refining sulfate retention and release effectiveness in resin with the resin method
  - Strengthen and confirm the precision and accuracy of isotopic composition analyses

- **The Project as a Whole:**
  - Model using GEOS-Chem, a global 3-D model of atmospheric chemistry, to see how biogenic sulfate may change with declining see ice (See Figure 6).

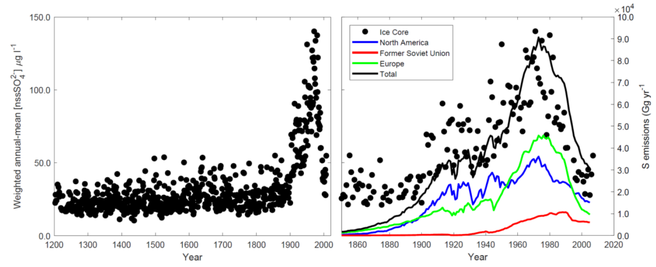

Figure 6: Weighted annual mean of non-sea salt sulfate (biogenic, volcanic, and anthropogenic sources) from year 1200 to the 2000s and sulfur emissions measured in gigagrams per year from 1860 to the 2000s. The black dots represent ice core data of the weighted annual mean of non-sea salt sulfate, and the colored lines represent sulfur emissions from North America, the former Soviet Union, and Europe with the black line representing the total of them all.

References

Core questions: An introduction to ice cores – Climate Change: Vital Signs of the Planet. (2017). Retrieved April 30, 2020, from https://climate.nasa.gov/news/2616/core-questions-an-introduction-to-ice-cores/

Summit Station | Summit Station. (n.d.). Retrieved April 30, 2020, from https://www.geosummit.org/summit-station