National Aeronautics and Space Administration

FY23 Strategic University Research Partnership (SURP)

Assessment of pre-eruptive concentrations of volatiles and post-eruptive loss in lunar basalts

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Objectives:

The objective of this research partnership proposal is to answer some of the most important questions about lunar volatiles, how volatiles are lost from the Moon and what are the mantle abundances of volatiles, by systematically assessing pre-eruptive and post-eruptive volatile element concentrations in lunar basalts.

Background

For the objective, understanding post-eruptive loss of volatiles in lunar basalts is critical in assessing pre-eruptive volatile element concentrations and hence mantle abundances (e.g., [1-7]), but also provides essential data for evaluating isotope fractionation related to degassing in the Moon. However, abundant data are only available for H_2O, F, S, and Cl. For many other volatile elements, data are either limited or nonexistent. This research partnership proposal seeks to expand such knowledge to other volatile elements.

Results

- Either a "U-shaped" or a "W-shaped" profile of F and S in lunar green and orange beads (Figures 1 and 2).
- Numerical modeling accounting for initial outgassing and subsequent in-gassing [A] constrains the cooling history of individual beads (Figure 3).

Approach

- We used the approaches established in the last two years [A] to measure moderately volatile elements (Na, K and Cu) distribution in green beads
- Expanded our measurements to highly volatile elements, F, S, H, and Cl in both green and orange beads

Significance

- **First report of in-gassing of highly volatile elements (F, S) into volcanic beads.**
- **Confirm the common in-gassing behavior of lunar volcanic gas, such as a transient volcanic atmosphere.**
- **In-gassing is non-negligible in interpreting average S isotope data of bulk beads, and thus casting doubt on the claim of a heterogeneous lunar mantle.**

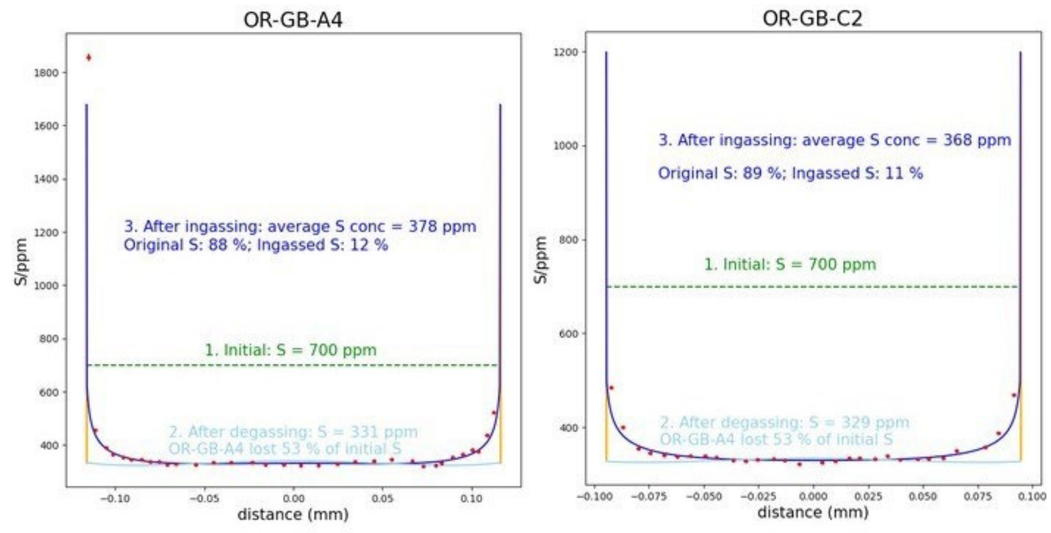

Figure 3. Fitting and mass balance calculation results of two orange glass beads: OR-GB-A4 (left) and OR-GB-C2 (right). Green dashed line shows the initial S concentration, light blue curve shows the calculated S distribution during the transition between outgassing and in-gassing processes, and the deep blue curve shows the fitted concentration profile of NanoSIMS experimental data (red dots). Orange lines represent bead surface.

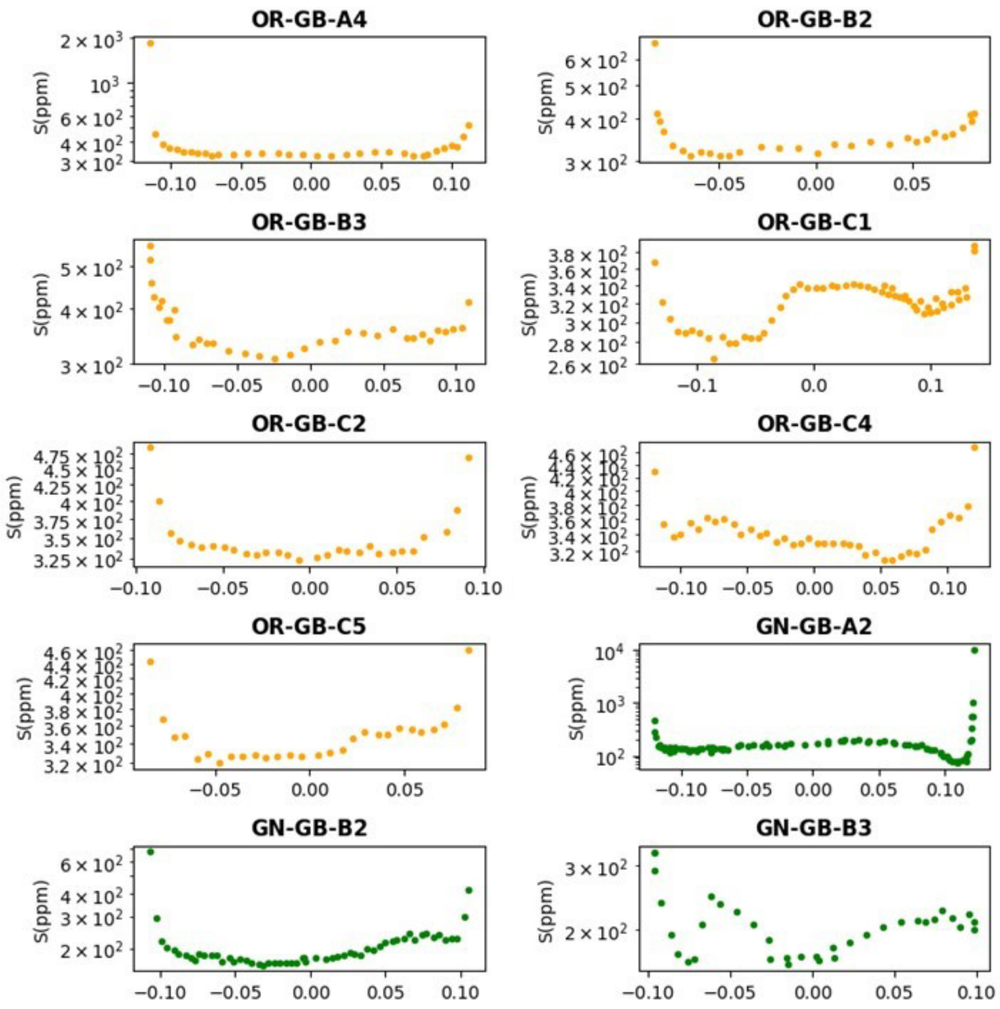

Figure 1. Sulfur concentration profiles of seven orange beads (orange dots) and three green beads (green dots) measured by NanoSIMS.

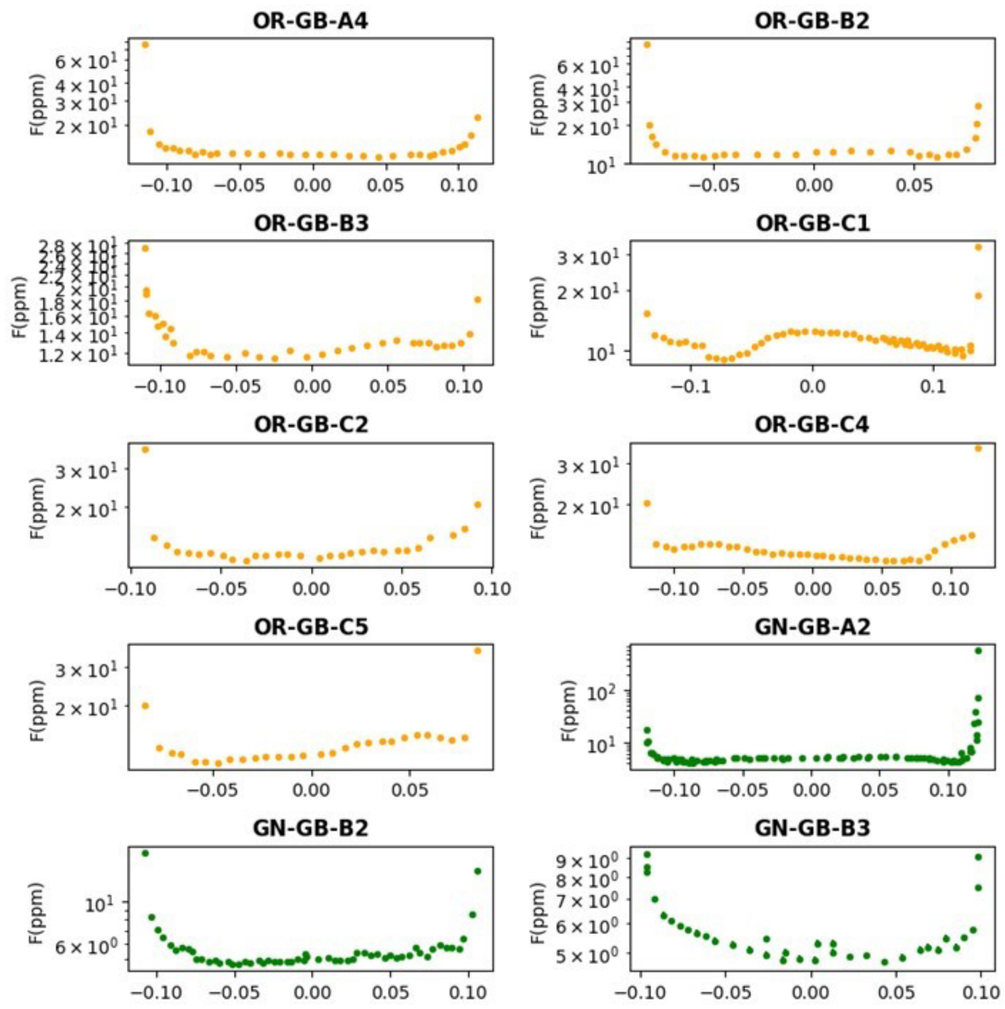

Figure 2. Fluorine concentration profiles of seven orange beads (orange dots) and three green beads (green dots) measured by NanoSIMS.

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Publications:

[A] Xue Su, Youxue Zhang, Yang Liu and Robert M. Holder (2023) Outgassing and in-gassing of Na, K and Cu in lunar 74220 orange glass beads. *Earth and Planetary Science Letters*, 602, 117924.

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