Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24051

New insights into the noble gas composition of the deep mantle through the analysis of gas from Yellowstone National Park

MICHAEL W BROADLEY[1], PETER H BARRY[1], DAVID V BEKAERT[2] AND ALAN M SELTZER[1]

[1]Woods Hole Oceanographic Institution

[2]CRPG - Université de Lorraine

Presenting Author: michael.broadley@whoi.edu

Volatile elements preserved in Earth's mantle can provide crucial insights into the nature of accretionary material that contributed to the growing Earth, as well as the geodynamic processes that have redistributed volatiles between different terrestrial reservoirs over the course of Earth's history. The heavy noble gases (Ar, Kr & Xe) in particular contain a large number of primordial and secondary isotopes that make them crucial tracers for understanding Earth's volatile evolution. Despite the utility of heavy noble gases, in practice very few heavy noble gas measurements of mantle-derived hydrothermal gas samples have successfully identified clear mantle signatures (with the exception of radiogenic ^{40}Ar) due to extensive and ubiquitous overprinting from the atmosphere.

Volcanic gas emanations from within Yellowstone National Park represent the surface expression of the Yellowstone Hotspot, which is attributed to material rising from a deep primitive mantle source. They therefore represent a unique sample set for investigating the volatile composition of the deep mantle. We will present new and existing [1] ultra-high precision Ar, Kr and Xe isotopic analyses performed on large gas samples (18 in total) collected over three field campaigns in 2021, 2022 and 2023 within Yellowstone National Park. All samples measured have high $^{3}He/^{4}He$ signatures (~16Ra), typical of samples originating from a less degassed primitive lower mantle reservoir.

Using a new approach to measure Ar, Kr and Xe isotopes using dynamic isotope-ratio mass spectrometry [2], we now readily achieve sub per mil levels of precision, allowing previously unresolvable mantle noble gas signatures to be identified. The large amount of data generated from samples collected at Yellowstone allows for physical fractionation of groundwater derived Ar, Kr, and Xe isotopes, that are ubiquitously present in hydrothermal gas samples [1], to be robustly correct. Following correction for physical fractionation, we can reveal the Xe isotopic composition of the Yellowstone mantle source and will discuss the implications regarding the origin of Xe in the deep mantle, and the formation of early-formed mantle heterogeneities as recorded by short-lived systems (^{129}I-^{129}Xe and ^{244}Pu-Xe).

[1] Bekaert et al., (2023), *Sci. Adv.*

[2] Seltzer and Bekaert (2022), *Int. J. Mass Spectrom.*