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Terrestrial kryptology: Deciphering the tale of Earth's volatiles

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Planetary habitability is tied to the history of volatile accretion, volatile loss, and the evolution of surficial environments. The study of krypton isotopes, i.e., 'kryptology', can paint a remarkable portrait of the processes associated with volatile delivery, loss and the early distribution of volatiles in different terrestrial reservoirs [1-3]. Although krypton isotopes had long been ignored due to technical difficulties with making high-precision measurements, recent advances now make such measurements possible in mantle-derived basalts [3]. Combining the krypton isotopic compositions with information obtained from xenon isotopes in the same sample is a powerful approach to unravel Earth's accretion, early degassing history and volatile exchange between the interior and exterior reservoirs. Here we will present all six krypton isotopes along with xenon isotopic measurements that are resolved from air in a MORB sample from the Mid Atlantic Ridge between the Kane and Atlantis fracture zones.

The high-precision Kr isotopic measurements reveals that an exact match to the mantle's primordial krypton isotopic composition is not present in the meteoritic measurements so far, although carbonaceous chondrites provide the closest match. Moreover, the Kr and Xe isotopic measurements allow us to deconvolve the proportions of primordial and subducted components in the mantle and derive the noble gas elemental ratios in the Earth's mantle prior to the injection of atmosphere-derived volatiles. The results indicate significant differences in noble gas elemental ratios in the interior in the aftermath of Earth's accretion. These noble gas elemental ratios also provides constraints on the distribution of the major volatiles in the early Earth, which we will discuss in this presentation.

[1] Holland et al., *Science* 326, 2009. [2] Broadley et al., *PNAS* 117, 2020. [3] Peron et al., *Nature* 600, 2021. [4] Broadley et al., *EPSL* 588, 2022.