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Tracking Temporal Trends In Volatile Sources To The Earth From The Isotopic Fingerprints Of Krypton And Xenon

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Volatile delivery and retention during Earth's accretion is fundamental to making Earth a habitable planet. Solar, chondritic and cometary sources are the three main sources that could have contributed to Earth's volatile inventory. How the proportions of these sources may have changed during Earth's accretion is, however, not yet determined. The noble gases can provide excellent fingerprints of the different volatile sources to the Earth. However, due to the low abundance of mantle Kr and Xe, and because subduction derived atmospheric noble gases can dominate the mantle's Kr and Xe budget [1], the original accretional signal remains poorly determined.

To better determine volatile sources and their potential time-varying nature, we improved on the measurement precisions for Kr and Xe isotopes in gases trapped in mantle-derived basalts. We find that Phase Q, a carbonaceous phase that is often the only carrier of heavy noble gases in achondrites, and ordinary and enstatite chondrites, cannot be the source of mantle Kr and Xe. Rather, we find that carbonaceous chondrites (CCs) provide a better match to the measured compositions in both mid-ocean ridge basalt (MORB) and ocean island basalt (OIB) mantle sources. While we record a potential nucleosynthetic anomaly in ^{86}Kr in both the OIB and MORB mantle, volatile sources for Kr and Xe appear not to have changed between the deep and shallow mantle. As differences in degassing history is preserved in mantle Ne and Xe isotopic ratios since very early in Earth's accretion [2,3], CC volatiles were likely delivered to Earth all through its accretional history and not just mixed into the deep mantle at a later time. The Kr and Xe in the Earth's atmosphere, however, require an additional late source, potentially comets [4,5], that was added after the formation of the moon.

[1] Holland and Ballentine (2006), *Nature 441, 186-191.* [2] Williams and Mukhopadhyay (2019), Nature 565, 78-81. [3] Tucker and Mukhopadhyay (2014), EPSL 393, 254-265. [4] Marty et al. (2017), *Science 356*, 1069-1072. [5] Bekaert et al. (2020), *Sci. Rep*. 10, 1-18.