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Solar System Xenon Reservoirs: Origins and Relationships

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Reynolds and Turner [1] found that xenon in the chondrite Renazzo was enriched in ^{134}Xe and ^{136}Xe - the first evidence of a wide scale variation among solar system xenon reservoirs. Subsequently, it became apparent that bulk carbonaceous chondrites are enriched in this component compared to an underlying fractionated solar wind composition [2, 3].

Neglecting the two lightest isotopes, produced only in a p-process, xenon has 7 isotopes that are produced by the traditional s- and r-processes. Although ^{134}Xe and ^{136}Xe are "r-process only" isotopes, the observed enrichment is not consistent with the r-process determined by subtracting an s-process component from average solar system xenon; variable contributions from two "r-processes" in addition to the s-process (and processes contributing the rare light isotopes) are necessary to account for the range of xenon compositions observed across meteorite samples [4].

Pepin and Phinney (1978, unpublished preprint – see [5]) showed that the underlying composition from which the Earth's modern atmospheric xenon signature evolved was depleted in the same two isotopes relative to fractionated solar xenon. Their derived composition was consistent with a primitive component previously identified by Takaoka [6] as underlying extraterrestrial compositions.

A possible source of this contribution to planetary atmospheres was identified when xenon in the coma of comet 67P/Churyumov-Gerasimenko was shown to be even more depleted in the heavy isotopes [7]. Earth's primordial atmosphere can be accounted for as a mix of contributions from cometary and asteroidal reservoirs, but the mix of nucleosynthetic components is different from that of the average solar system.

I will consider the current state of our understanding of solar system xenon compositions with respect to nucleosynthesis and the pathways by which xenon was incorporated into solid material and contributed to planetary atmospheres.

[1] Reynolds & Turner,1964, J. Geophys. Res., 69, 3263; [2] Busemann et al., 2000, Meteorit. Planet. Sci., 35, 949; [3] Gilmour, 2010, Geochim. Cosmochim. Acta, 74, 380 [4] Gilmour and Turner, 2007, Astrophys. J., 657,600; [5] Takaoka, 1972, J. Mass Spec. Soc. Japan, 52, 159; [6] Pepin, 2000, Space Sci. Rev. 92, 371 . [7] Marty et al., 2017, Science, 356,1069.