

THE COSMOCHEMISTRY OF TERRESTRIAL XENON.

J. D. Gilmour¹ and R. Parai², ¹SEAES, University of Manchester, Manchester M13 9PL, UK Jamie.gilmour@manchester.ac.uk, ²Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, MO 63130, USA rparai@epsc.wustl.edu

Introduction: The relationship between the Earth's primordial Xe composition and extraterrestrial reservoirs has bearing on the origins of terrestrial volatiles as well as on the budgets of radiogenic and fissionogenic Xe in the mantle, which can be used to constrain the timing of the last giant impact on Earth. Xenon in chondrites shows nucleosynthetic anomalies, and radiogenic and cosmogenic effects, but the major reservoir (Q-Xe) can be produced from the solar composition by a combination of mass fractionation and addition of the known presolar component, Xe-HL [1,2] (¹²⁹Xe is excluded because of ¹²⁹I decay). The Earth's atmospheric xenon requires a starting composition related to solar xenon by mass fractionation and *subtraction* of Xe-HL (to make "U-Xe") [3]. Rather than seek evidence of such known endmembers in terrestrial reservoirs, we attempt here to constrain the combinations of fractionation and HL addition/subtraction with which they are consistent. This allows for evaluation of primordial Xe compositions that potentially were present during Earth's accretion, but are not recorded in meteorites.

Approach: In modeling a measured xenon isotope composition, we start from solar xenon (composition from [4]). We allow equilibrium mass fractionation, addition or subtraction of Xe-HL (from [5]), and addition of fission xenon from decay of ²⁴⁴Pu ([6]) and ²³⁸U ([7]). We seek best fits (after [1]) to observed compositions. Uncertainties and covariances are estimated using a Monte Carlo approach. Similar quality fits can be obtained with mass fractionation (1) before and (2) after combination of the other components, and (3) after mixing of solar xenon with Xe-HL but before addition of fission products. However, the processes considered are non-commutative. To understand the effect of this, we mixed artificial components with separate fractionation factors, HL and Pu contributions in different proportions (and orders) and then attempted to match them with a single model. Parameters extracted from the model approximated those expected based on the proportions in the mixture, but the relationship was not exactly linear. Our results thus only closely approximate linear combinations of pathways.

First Results: Like Q-Xe [8], AVCC [3] xenon can be produced from solar xenon by mass fractionation and addition of Xe-HL. Much data characterizing the *Earth's interior components* [9-14] can be accounted for as different mixtures between (1) xenon depleted in Xe-HL similar to, but mass fractionated from, the Earth's atmosphere and (2) a component with a greater contribution from Xe-HL and a correlated degree of mass fractionation from solar. Derived plutonium and Xe-HL contributions often exhibit strong correlation.

Discussion: Relative to solar xenon at least one component is depleted in Xe-HL. Some of this must represent a contribution via the atmosphere (contamination or recycling), but it is possible that an interior reservoir is also present. The second component has more Xe-HL than the first, and than air; it is consistent with a chondrite like mixture of solar xenon and Xe-HL, with mass fractionated solar xenon, and (generally) with a range of fractionated combinations of solar xenon and Xe-HL. Given this and the variation in Xe-HL contributions implicit in air and Q-Xe, we suggest it is too restrictive to associate the second component genetically with either Q or AVCC.

The longstanding issue of a terrestrial component depleted in Xe-HL relative to solar xenon remains [3]. Perhaps some process in the Earth's history replicated a signature that could evolve to a solar composition by addition of Xe-HL. Otherwise, because Xe-HL does not correspond to a solar r-process (defined as [solar xenon] – [s-process xenon]), the observed variation requires that 3 nucleosynthetic processes contributed significantly to the solar system xenon budget; at least two separate pre-terrestrial reservoirs preserved distinct mixtures and each accounted for a significant fraction of solar system xenon; between isolation of U-Xe and the final mixing to produce solar xenon, 8 % of solar ¹³⁶Xe must be added from a "Xe-HL" nucleosynthetic source.

References:

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