

XENON ISOTOPES IN THE SCANDINAVIAN ALUM SHALE: A CLUE FOR THE ORIGIN OF P1(Q) AND P3 XENON COMPONENTS IN NANODIAMOND-RICH RESIDUES FROM PRIMITIVE METEORITES.

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We have analyzed isotopic composition of Xe released from the sample of Alum Shale and found that isotopic structure and Xe release pattern from this sample are remarkably similar to Xe released at temperatures below 1300°C from nanodiamond residues remaining after dissolution of main mass of primitive meteorites. This similarity provides a clue for origin of P3 and P1(Q) components in meteoritic nanodiamonds.

The Scandinavian Alum Shale Formation was deposited in a large, shallow epicontinental sea that covered substantial parts of paleocontinent Baltica. The shale is rich in amorphous organic matter (up to 25 wt. % C) and in syngeneic trace elements, including uranium [1]. Generally, shales are known to carry large quantities of heavy noble gases, to the extent to be considered as a potential sink for “missing” terrestrial Xe [2]. In this work we have analyzed isotopic composition of heavy noble gases released from a particularly uranium rich part of the Alum Shale known as Kolm which have uranium content exceeding 1% [1].

Nanodiamond-rich residues (~ 0.15 wt. %) remaining after chemical dissolution of primitive meteorites contain four distinct xenon components: P3, P1(Q), HL and P6 sequentially releasing from the residue with increase of extraction temperature [3, 4]. The first two components, P3-Xe and P1-Xe, are nearly “normal”, seem to be closer to mass-fractionated solar Xe than the HL-Xe and P6-Xe which are considered to be “exotic” [5]. P3-Xe, released below 800°C, exhibits 1.5 – 3% excesses in A = 129, 131, 132 and 134 relative to more retentive P1-Xe, typically releasing at 1100-1200°C (Fig.1, top panel). All other Xe isotopes are indistinguishable within uncertainties.

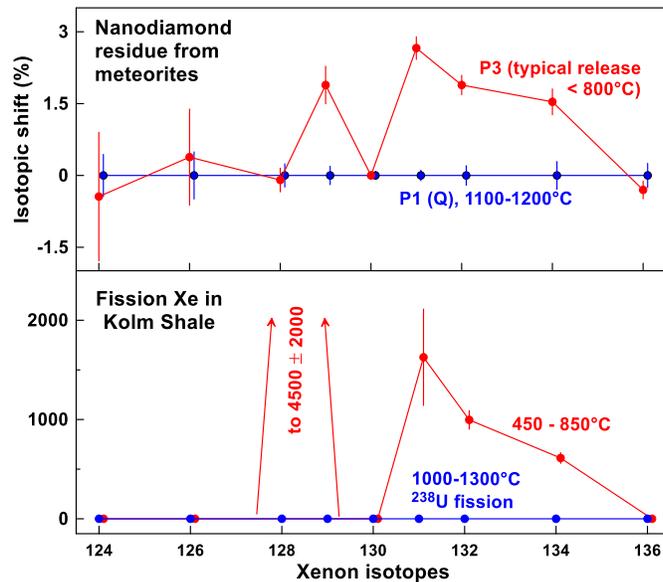


Fig. 1. Isotopic shifts in P3-Xe relative to P1(Q)-Xe in nanodiamond residue (top panel) are nearly identical to those in low temperature release of fission Xe in the sample from Kolm shale (bottom panel). Similar isotopic structure is observed in acid-resistant residue from U-bearing samples [7]. Chemically Fractionated Fission (CFF) is the only known process which can produce the isotopic shifts observed in these diverse samples.

The Kolm shale exhibits two peaks of fission Xe release: minor 450-850°C and major 1000-1300°C. The isotopic composition of the major Xe release corresponds to fission spectrum of ²³⁸U, while the composition of the minor, low temperature Xe release is clearly anomalous (Fig. 1, bottom panel) and is evidently produced by the CFF (Chemically Fractionated Fission) process caused by migration of radioactive Xe precursors in fission chains [6].

It seems highly unlikely that the evident similarities of isotopic differences between P3-Xe and P1-Xe in nanodiamond residue and those between low and high temperature fission Xe in shales are accidental. Rather, they suggest that isotopic excesses in P3-Xe relative to P1-Xe are due to CFF-modified ²⁴⁴Pu which was a dominating source of fission Xe 4.5 Ga ago.

If our interpretation is correct, there is little hope to trace galactic evolution using the low-temperature Xe components (P3 and P1) in nanodiamond-rich residue [7]. The origins of these Xe components are likely to be “local” rather than “presolar”. An apparent excess of ¹²⁹Xe in P3-Xe may not be entirely from decay of primordial ¹²⁹I.

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