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Xenon isotopic fractionation, an experimental petrology study

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Xenon (Xe) is isotopically fractionated by 35 and 42 ‰.amu^{-1} in Earth and Mars atmosphere, respectively, as compared to the solar wind, twice the value of CI chondrites. Moreover, 95% of Xe budget is missing from Earth's atmosphere, relative to the other noble gases. Those discrepancies are known as the Xe paradox [1] and the missing Xe issue [2].

Xe is, contrary to the other noble gases, prone to bind heteroatoms in solid structures [3]. Interestingly, Xe binds oxygen in silicates at moderate pressure [4], for conditions found in the deep crust and upper mantle. As such the lithosphere has been proposed as a likely "hideout" for the missing Xe [5]. To further investigate this hypothesis and determine if such chemical incorporation in minerals could provoke the isotopic fractionation of Xe, we experimentally loaded sanidine and olivine with Xe enriched gas at moderate pressures and temperatures, 3.5 GPa and 1073<T<1373 K. The gas enrichment ranges from 0.1 to 100 $_{wt}$% for Xe instead of 87 ppb in air.

We observe a positive mass dependent fractionation with dilute gases in which fractionation reach up to 2.5 ‰.amu^{-1} (Figure 1). This trend is not observed for samples doped with pure Xe because of abundant unreacted Xe trapped as bubbles. Our results demonstrates that Xe indeed binds in silicates with a preferential retention of the heavier isotopes.

These results can have profound implications in planetology. Notably we will present a scenario for Xe behaviour during Earth's formation and later evolution of the atmosphere.

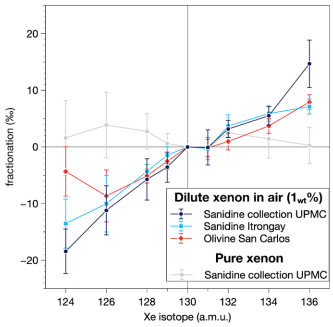

Figure 1. Xenon isotopic fractionation in three different minerals loaded with air enriched in xenon heated up to 1373 K at 3.5GPa for 24 hours.

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