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Xenon high pressure crystal-chemistry, partitioning, and isotopic fractionation: what does that tell us about atmosphere formation on Earth and Mars

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Atmospheric xenon (Xe) is elementally depleted by a factor of 24 relative to krypton in CI chondrites [1] and isotopically depleted by 35 ‰ per a.m.u. [2]. To solve this missing Xe problem, atmospheric escape scenarios require strong EUV radiation and/or magnetic field to selectively ionize Xe amongst other noble gases, a large H_2 drag, and eventually additional Xe-specific processes. Atmospheric escape processes should also be related to the mass of the planet, which is not consistent with Mars, the Moon, and Earth having the same missing Xe problem [3].

Alternative trapping-at-depth scenarios stem from the effect of high pressures (P) to induce Xe chemistry at depth with planetary materials. Xenon covalent bonding to oxygen occurs in silicates from the deep continental crust and upper mantle [4-5]. We will show here by means of high pressure and high temperature experiments, that this chemistry does not extend to the octahedral silicates of the terrestrial lower mantle, therefore excluding this reservoir from the list of suspects.

Xenon crystal-chemistry in tetrahedral silicates has two major consequences. Firstly, Xe is found from *in situ* partitioning measurements at high P and T to be preferentially retained within crystals upon partial melting of both silica-rich and silica-poor compositions. Xenon can therefore be stored in crustal and mantle rocks at depth, as attested by the natural record. Secondly, silicates equilibrated at high P and T with Xe-enriched air are systematically depleted in light isotopes, and enriched in heavy isotopes. This is evidenced by laser ablation noble gas spectrometry analyses on experimental samples.

In the light of these results, a scenario fulfilling all requirements of the missing Xe problem will be presented, providing a better understanding of atmosphere formation and evolution.

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