The age of the Earth-Moon system revisited using xenon isotope systematics

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Recently, xenon trapped in fluid inclusions of Archean samples from North Pole, Pilbara (Australia) was found to be isotopically intermediate between cosmochemical end-members (chondritic or solar) and the atmosphere [1, 2]. These results have been interpreted as resulting from prolonged loss of Xe atoms from the atmosphere to the outer space, that lasted at least until the end of the Archean eon [3]. Archean samples analysis together with modeling could help to put further constraints on the early history of the Earth-Moon system.

We have analyzed noble gases (Xe, Kr and Ar) in fluid inclusions contained in quartz veins from the Barberton greenstone belt (South Africa) in order to (i) check if this noble gas fractionation represents, or not, a worldwide signature of the Archean atmosphere, (ii) get a more precise isotope analysis of Archean noble gases, and (iii) investigate the Xe isotopic evolution through geological periods of time. The Archean (≈3.2 Ga) Xe isotope ratios, analyzed with a permil precision, indicate an isotopic fractionation of 1.0 ± 0.1 $\%.amu^{-1}$ in favor of the lighter isotopes for the Archean atmosphere relative to the modern one. These results confirm the fractionated state of the archean atmospheric xenon, as a result of prolongated Xe escape from the atmosphere through time.

A model has been built to reproduce the temporal evolution of the isotopic composition of atmospheric xenon after a major impact and to take into account the addition of radiogenic/fissiognic Xe atoms from extinct radioactivities (^{129}I, ^{244}Pu and ^{238}U). It permits to put constraints on the I-Pu-Xe age of the Earth-Moon system. The model reproduces with <1% the Xe isotopic compositions of the Archean and the modern atmospheres. It also resolves the unexplained atmospheric under-abundance of Xe isotopes from the fission of ^{244}Pu. When corrected for prolonged loss, I-Pu-Xe ages of the Earth-Moon system are reconciled and shift from 70-100 Ma as previously thought, to 40±20 Ma after CAI.

[1] Pujol *et al* (2009) *GCA* **73**, 6834-6846 [2] Pujol *et al* (2011) *EPSL* **308**, 298-306 [3] Marty (2012) *EPSL*, **313-314**, 56-66