Geochemical insights into the composition of the Archean atmosphere

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Investigations on the composition of the ancient atmosphere have relied so far on indirect approaches based on geochemical proxies (eg., S isotopes), or on modelling. However, remnants of Archean atmospheric gases are still preserved in ancient rocks. Our group is investigating the composition of the Archean atmosphere, by analysing gases in well characterized and dated barite and quartz fluid inclusions from the Dresser Formation (North Pole, Pilbara, NW Australia). 3.5 Ga ago, the $^{40}Ar/^{36}Ar$ atmospheric ratio was 143±24 (modern value : 298) [1]. The xenon isotopic composition was isotopically intermediate between extraterrestrial and modern atmospheric [2]. The density of N_2 and the nitrogen isotope composition of the Archean atmosphere were comparable to that of the modern atmosphere, but the P_{CO2} could have been as high as 0.7 bar [3].

These results are consistent with: (i) an Archean atmosphere already shielded from interaction with the solar wind by a significant (>50% modern) magnetic field; (ii) enhanced continental crust growth between 3.8 and 2.7 Ga ago, which might have led to atmospheric CO_2 consumption by weathering and the first global glaciations; (iii) no possibility for a higher P_{N2} in the past to counterbalance the faint Sun; and (iv) selective Xe loss from the atmosphere to space resulting in Xe isotope fractionation during the Hadean-Archean eons (and not only at the beginning of Earth's history), resulting presumably from interactions of Xe with the stronger VUV light from the young Sun [4,5]. After correction for Xe escape, the Pu-I-Xe age of the atmosphere (and the Moon forming impact) is ≤50 Ma after CAI [6].

[1] Pujol *et al* (2013) *Nature* **498**, 87 [2] Pujol *et al* (2011) *EPSL* **308**, 298-306 [3] Marty *et al* (2012) *Science*, **342**, 101. [4] Hébrard & Marty (2013) *EPSL* **385**, 40 [5] Kuga *et al EPSL*, in press. [6] Avice & Marty (2014) *Phil. Trans. Roy. Soc. London Ser. A.,* submitted.