Noble gas partitioning at magma ocean conditions in the LHDAC and the Earth's He/Ne budget

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The accretion of the Earth from primordial material and its subsequent segregation into a planet with core and mantle are fundamental problems in terrestrial and solar system. Many of the questions about the process are still open and much debated. For example, could the core be a reservoir for helium or other noble (rare) gases?

We have developed experimental techniques to simulate the conditions of the formation of the early Earth in a laser-heated diamond-anvil cell (LHDAC) at high pressures up to the present lower mantle conditions. We have studied Ne, He and Ar solubility and partitioning between metal and silicate liquids at high-pressure and temperature up to 20 GPa and 3000 K. Microanalysis of LHDAC samples with Ultra Violet Laser Ablation Mass Spectrometry (UVLAMP) provided for the first time a spatially-resolved depth profile in samples.

Our results on the solubility of Ar [1], He and Ne suggest that their relative compatibility varies with pressure in silicate melts, indicating that it would be possible for primordial and radiogenic noble gases to be taken deep into the Earth. The experimental results indicate for example that the metal/silicate partition coefficient for He is about 10^{-2} under magma-ocean conditions, substantially higher than previous measurements suggested [2], and relatively pressure independent. Helium would have partitioned then into the Earth's core during its formation and in proportion to its early abundance, creating a plausible reservoir for helium. Core helium could contribute to the mantle ^{3}He-^{4}He budget – highlighting the exchange mechanisms at the core-mantle boundary through the 4.5 billion years of Earth's history.

Our experimental results will also provide strong constraints on the mechanisms of the elemental fractionation between helium and neon: The observed average value of ^{3}He/^{22}Ne in MORB and OIB samples is 7.7±2.6 and is much greater than the most recent estimate of 1.9 of the solar nebula, and so requires some elemental fractionation of incorporated helium and neon.

[1] Bouhifd & Jephcoat (2006) *Nature* **439**, 961-964.
[2] Matsuda *et al*. (1993) *Science* **259**, 788-790.

Fluid infiltration along the South Armorican shear zone

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Giant quartz veins associated with the South Armorican Shear Zone (SASZ) record huge fluid circulation during the Hercynian period. A regional-scale mapping of veins allows identifying two groups of veins on the basis of their geometric relationship with the SASZ (fig. 1). Veins from the fist group are parallel to the SASZ and associated with zones of intense deformation, veins from the second group developed on the southern edge of the SASZ, in an oblique meridian direction. The former likely record infiltration of fluids along permeable pathways; the latter may represent crustal-scale tension gashes associated with East-West σ3 direction in the regional context (North-South shortening and dextral working of the SASZ along a N120 direction).

Figure 1: Simplified geological map of the southern Armorican massif showing two populations of quartz veins.

Microthermometry on fluid inclusions indicate that fluids were mostly aqueous with very low-salinity. Together with very low δ^{18}O values of hydrothermal quertz, down to -2‰, these features argue for a surface origin. Scarce but significant CO_2 fluid inclusions indicate a metamorphic contribution for some fluids, the origin of which probably lying in the exhumed metamorphic HT basement in the southern part of the region. Veins represent SiO_2 sinks and we propose through a geochemical characterisation of deformed granites that mylonitic zones developed after syntectonic granites may represent SiO_2 sources.