Title: Carbon and Sulfur Isotopic fractionations during magma ocean outgassing: comparison of Earth's and Mars' primitive atmosphere

Key words: experimental petrology, carbon, sulfur, isotope fractionation, degassing, evaporation, speciation, silicate melt, gas

Profile and skills required: We are seeking candidates with a high-level background in petrology and geochemistry at the Master level, interested by planetology and cosmochemistry. Interest in learning various experimental and analytical techniques is required.

Niveau d'anglais requis : Intermédiaire supérieur

Project description

The development of life-supporting molecules depends on the availability of volatile elements (H, C, N, O, S) at a planet's surface, which, alongside other critical parameters, allows the maintenance of a stable biosphere (Kasting and Siefert 2002). The processes leading to the unique composition of Earth's modern atmosphere compared to that of Mars are not straightforward to reconstruct. It is commonly accepted that the global volatile budget of rocky planets was forged by various contributions from chondritic and differentiated bodies, comets, and nebular gas, and via planetary formation processes (accretion, differentiation—*i.e.*, core–mantle differentiation, magma ocean crystallization, and **early outgassing**—, atmospheric losses, and complex interactions between planetary interiors and surfaces; Marty 2012) that modified their original volatile element concentrations and isotopic compositions (Wood et al. 2013; Mikhail and Füri 2019; Dalou et al. 2019a, 2022).

The initial distribution of volatile elements between a planet's interior and surface (Elkins-Tanton 2008) was set when it was partially to completely molten, *i.e.,* during its magma ocean stages. This primordial stage encompassed the formation of an early atmosphere by the solidification and subsequent outgassing of the magma ocean. Quantifying volatile elements partitioning and isotopic fractionation during magma oceans' outgassing is thus decisive for understanding the differences between Earth and Mars habitability conditions.

Via an experimental approach, the PhD candidate aims to determine the effects of early outgassing (evaporation and degassing) on the C and S isotopic signatures of Earth's and Mars' interiors to help reconstruct the isotopic signatures of the proto-planetary reservoirs (mantle, pre-biotic atmosphere). Under variable fO_2 conditions, representative of the terrestrial and martian magma ocean, the PhD candidate will conduct kinetic and equilibrium evaporation experiments in vertical furnaces and degassing experiments on the CRPG's piston-cylinder. Experimental samples will be characterized chemically and isotopically via a state-of-the-art methods, including the secondary ion mass spectrometers of the CRPG.

The main goal is to provide new data on the effects of magma ocean outgassing on C and S isotopic fractionations to simulate various evaporation and degassing reactions and in fine, to calculate the bulk $\delta^{13}C$ and $\delta^{34}S$ values of the upper parts and surfaces of magma oceans. This project will also allow comparing the efficiencies of outgassing processes during the early histories of Earth and Mars, bring constraints on the composition of the primitive atmospheres of the Earth and Mars, ultimately propose $\delta^{13}C$ and $\delta^{34}S$ values for proto-Earth and proto-Mars, to be compare with various potential sources for C and S in the inner solar system.

References

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