Subject offered for a contract starting October 2019

SUBJECT TITTLE: Precise and accurate determination of moderately volatile element abundances in Solar System materials

Advisor: **MOYNIER, Frédéric (Prof) moynier@ipgp.fr**
Second Advisor/ Supervisor:
Bizzarro, Martin, (Prof), bizzarro@ign.ku.dk

Host lab/ Team :
IPGP- Team CAGE – UMR7154

Financing: Doctoral contract with or without teaching assignment

For more information go to http://ed560.ipgp.fr, section: Offres de these (PhD offer), You must apply on the Doctoral School website

Presentation of the subject: (1 or 2 pages)

The objective of this PhD thesis is to study the history of moderately volatile element delivery to planetary materials from the first solids (chondrules) to differentiated planets (e.g. Earth and Moon) by using high precision elemental measurements by isotope dilution. The student will have to develop protocols for precise determination of moderately volatile element concentrations in Solar System materials. While this project will largely focus on samples from meteorites (chondrites, martian meteorites…), Earth and the Moon, this work will develop key techniques for the study of important samples from future sample return missions from the Moon (e.g. Change'5) and possibly Mars. This work will represent an international collaboration with the StarPlan group at the National History Museum of Denmark (prof. Martin Bizzarro), in particular in regards to the work on individual chondrules that will be dated by Pb-Pb technique in Copenhagen where the student will spend 50% of the time.

Trace element concentration data from geological samples are typically obtained by ICP-MS, ICP-AES or similar methods, with typical relative errors of ca. ±10%. The isotope dilution method, offers improvements in the accuracy and precision of concentration measurements by more than an order of magnitude. In this approach, a known amount of an isotopically enriched tracer of the element of interest is added to the sample, and the elemental concentration is determined by the measurement of an isotope ratio rather than using absolute ion intensities. Ion sensitivities are vulnerable to a variety of negative effects, such as signal suppression due to the presence of matrix in the analyte solution and instrumental drift. Isotope ratios are relatively impervious to these effects, and the isotope dilution method thus provides greater accuracy and precision in concentration measurements. In particular it allows an improvement in about 2 order of magnitude in precision that are necessary to test models of volatile element origin. Isotope dilution methods are also more robust to small amounts of blank, and permit accurate measurements to be made on relatively small amounts of sample. As a result, this method has become the standard for the characterisation of elemental concentrations in geological reference materials (e.g., Cotta and Enzweiler, 2013). However, despite the various advantages, the added complexity of the isotope dilution method has somewhat limited its adoption, and the majority of the trace element data for terrestrial and extraterrestrial data in the literature were obtained by less precise and accurate methods.

This study will focus on concentration of moderately volatile elements, i.e. elements with 50% condensation temperatures between 1290 and 704 K (Lodders, 2003). The widespread depletion of volatile elements that is observed in the terrestrial planets and in meteorites (e.g., Halliday and Porcelli, 2001; O'Neill and Palme, 2008) represents a major unresolved issue in cosmochemistry. Various scenarios have been proposed to explain these depletions, including incomplete condensation from solar nebula (Wasson and Chou, 1974; Albarède, 2009), or evaporation on the parent body (Tyburczy et al., 1986; Moynier et al., 2006; O'Neill and Palme, 2008; Paniello et al., 2012; Kato et al., 2015). However, the mechanism of volatile element depletion remains highly debated, despite significant implications for the origin of volatile elements in the terrestrial planets, dynamical processes in the early Solar System, and compositional models of terrestrial planet formation in general.
The student will develop isotope dilution methods for precise and accurate determination of the concentrations of moderately volatile elements in Solar System materials, starting with Rb, Sn, Sb, Cd, and Tl. These methods will permit, for the first time, detailed and high precision investigation of volatility related depletions in a range of important sample types, and make significant contributions to this unresolved problem in cosmochemistry. Further, the development and adoption of these techniques will be central in the near future to requests for precious Apollo lunar samples as well as materials from future sample-return missions to the Moon and possibly Mars.
In conclusion, the student will 1) gain important analytical skills (isotope dilution on rarely analyzed elements), 2) apply this methods to a variety of solar system materials to solve a major question in geosciences 3) the method may be applicable to future sample return missions and the student will in good position for future analysis of mission returned samples.

This PhD thesis will be co-advised by Martin Bizzarro, Prof and director of StarPlan, Natural History Museum of Denmark.