SCIENCES SORBONNE UNIVERSITÉ

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Master thesis proposal

Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie

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Title: Stability of Fe^{3+}-bearing phases in the Martian mantle

Keywords: bulk chemistry, phase stability, mineralogy, high pressure and temperature, Mars

Scientific description: All telluric planets of the Solar system present a layered internal structure as a consequence of overall similar formation and differentiation processes: a central metallic core, composed mostly by iron, surrounded by a silicate mantle and a thin crust. However, differences in bulk masses and radii of the individual planets suggest different compositions and different mantle to core size ratios, and imply different pressure (P) and temperature (T) conditions in their centre. Relative distance from the Sun also implies different redox conditions (fO_2). As such, even when forming from similar building blocks, planets show internal structural and compositional variability.
Considerations based on the abundance of refractory elements in Martian meteorites and oxygen isotope systematics led to the proposition of a series of compositional models for the mantle and the core. Yet, which are the stable phases stemming from the bulk chemistry, and how these and their relative proportion vary across the range of pressure and temperature of Martian mantle, remain unclear. Current models are largely built on thermodynamic codes based of energy minimization, which however, do not allow the possibility for iron to exist as Fe^{3+}, but only as metallic Fe or Fe^{2+}-bearing compounds. In view of the large amount of iron in Mars' mantle (about twice than on the Earth) and the more oxidizing conditions during its formation (twice the distance from the Sun than the Earth) this clearly is a critical limitation.
Within this master thesis we aim at confirming preliminary results of stabilization of magnetite (Fe_3O_4) and other Fe^{3+}-bearing minerals at the conditions of the Martian mantle by high-pressure and high-temperature phase equilibria experiments. Obtained results will be used to implement current thermodynamic models and ultimately to link Mars' bulk chemistry to an actual mantle mineralogy.
This project is in relation to the InSight NASA Discovery program mission currently operating on Mars, and the ERC-funded project PICKLE (Planetary Interiors Constrained by Key Laboratory Experiments).

Techniques/methods in use: multi-anvil press, electron microscopy, x-ray diffraction
Applicant skills: Motivation to work on a project at the frontiers between materials science and planetary science.
Industrial partnership: N

Internship supervisor(s): Daniele Antonangeli (daniele.antonangeli@upmc.fr; 0144275222)
Internship location: SU, campus Pierre et Marie Curie, IMPMC

Possibility for a Doctoral thesis: Yes. Financial support from CNES and ERC.