ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT ET PHYSIQUE DE L'UNIVERS, PARIS

ed560.stepup@u-paris.fr

Subject title: **Accretion and differentiation of icy bodies**

Advisor: **Limare, Angela, IR-HDR, limare@ipgp.fr**

Second Advisor: **Morbidelli, Alessandro, Professor College de France, alessandro.morbidelli@college-de-france.fr**

Host lab/ Team : **IPGP- Geological Fluid Dynamics – UMR7154**

Financing: Doctoral contract with or without teaching assignment

Presentation of the subject: (Maximum 2 pages)

Meteorites (chondrites, achondrites and irons) are divided into 'carbonaceous' (CC) and 'non-carbonaceous' (NC) families based on distinct isotopic anomalies [1]. This isotopic dichotomy supports the idea that these bodies formed in two distinct chemical reservoirs at different heliocentric distances [2]. The NCs are believed to have formed in the warmer inner Solar System and the CCs in the cooler outer Solar System. It has been proposed that most NCs accreted almost no water due to their formation sunward of the snowline (the distance from the Sun beyond which water condenses to ice), whereas the CCs formed beyond the snowline and therefore accreted water ice [3].

The high abundance of iron meteorites (that represent, in most cases, the cores of their parent bodies) found in both CC and NC meteorite families suggest that differentiated parent bodies were common throughout the early Solar System, regardless of their composition [4]. Yet, little is known about how heating and differentiation occur in a water-rich body, in particular how iron could avoid oxidation due to the melting of ice, to form a metallic core [5]. The problem is relevant also for some satellites of the giant planets. For instance, Ganymede, the largest moon of the solar system and target of the ESA JUICE mission, is differentiated into a water/ice layer, a rocky layer, and a central metallic core with endogenous dynamo.

Ages of CC magmatic iron meteorites are on average ~2My younger than the NC analogues [6]. Previous thermal models for thermal evolution of parent bodies of iron meteorites aimed at explaining the age difference between the NC and CC iron meteorites, but either the water budget of CC bodies was circumvented [7,8], or liquid water convection in a porous media was modelled in an inconsistent manner [9].

Formation of differentiated icy bodies looks intriguing because it has to reconcile high inner temperatures necessary for differentiation, the preservation of metallic iron and the possibility to retain ice at the surface. During this thesis, we wish to address the thermal modeling of icy bodies with a particular emphasis on parent bodies of CC irons and satellites of giant planets. We wish to explain three observations: 1) the oxygen fugacity recorded in both NC and CC iron meteorites [10], 2) the differentiation age and core size of the parent bodies of CC iron meteorites [6,9] and 3) the core size of Ganymede [11].

For this purpose, we will combine analogue experiments of internally heated convection in a porous medium with 1D numerical modelling -based on previously determined scaling laws- of the thermal and structural evolution of a planetesimal during its accretion, and of the chemical reactions between water and the rock with an emphasis on Fe oxidation.

We are looking for a candidate with a strong background in physics, in particular fluid mechanics and with a taste in experimental physics.

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