



ÉCOLE DOCTORALE

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

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Subject title: Accretion and differentiation of icy bodies

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IPGP- Geological Fluid Dynamics – UMR7154

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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 convection in silicate was ignored meanwhile considering water vapor convection in a porous media [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 core size of Ganymede [11] 2) the oxygen fugacity recorded in the CC iron meteorites [10] and 3) the differentiation age of the parent bodies of CC iron meteorites [6,9].

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

We are looking for a candidate with strong background in physics, in particular fluid mechanics and with a taste in experimental physics. Autonomy and ability to work in a team will also be considered in the evaluation process.

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