ÉCOLE DOCTORALE SCIENCES DE LA TERRE

Subject offered for a contract starting in September 2012

SUBJECT TITLE:

Core Formation & the Early Differentiation of the Earth

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Host lab/ Team : **IPGP - Géophysique Expérimentale – UMR 7154**

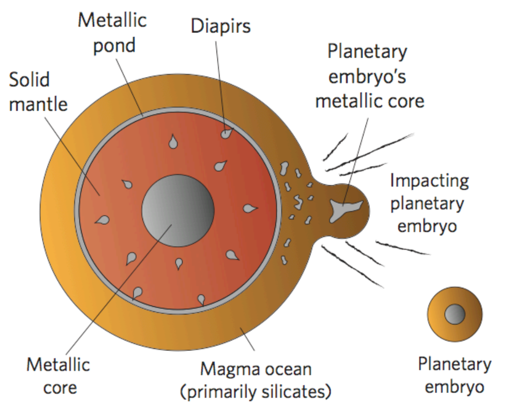
Financing: Doctoral contract with or without assignment

For more information go to http://ed109.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 Earth grew by the collisional accretion of a range of small rocky bodies and Moon- to Mars-sized planetesimals. The Earth, as well as the interior of the large planetary embryos, was sufficiently hot to have substantially melted, allowing the segregation of dense, immiscible molten iron to form a core, separated from the residual overlying silicate mantle.

As the Earth grew, metal from the cores of accreted embryos likewise sank to its centre, after temporarily accumulating (or not…) at the base of silicate Magma Ocean. The hidden elemental inventory of the core was therefore set very early during Earth's history by the ambient conditions prevailing in the Magma Ocean. The chemical (elemental and isotopic) imprint of this process is still present in the geological record today, and be used to lead an effective investigation of the processes and conditions of core formation.



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The preference of different elements for molten iron, relative to coexisting silicate melt, is highly variable and sensitive to temperature, pressure and oxidation state. By assessing which elements are missing from the silicate portion of the Earth, and using laboratory experiments to constrain the partitioning of elements between iron and silicate melts, the conditions under which the core was formed can be determined.

There is a rather extensive metal-silicate partitioning dataset in the published literature, but it is restricted to low pressures (P<25 GPa) and temperatures (T<2500 °C), much lower than the actual conditions at which the core formed. All core formation models are therefore based on thermodynamic modelling and extrapolation, and suffer from large inaccuracies and invalid assumptions. We have put tremendous efforts in recent years to push the P and T limits of the

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measurements, and we can now reproduce the conditions that prevailed during core formation in the lab, using the laser-heated diamond anvil cell.

The aim of this project is to measure new metal–silicate partitioning data at very high pressure and temperature, to probe P and T domains that have never been reached before, to reproduce the conditions under which the core formed in the laboratory, and to measure directly the compositions of our synthetic primitive "cores" and "mantles", rather than model them through extrapolations.

Our main goal is to find a pathway and a process (or series of processes) that produce a core and a mantle that are consistent with the geophysical (density and bulk seismic velocity in the core) and geochemical (siderophile trace-element and isotopic composition of the mantle) observables: any successful model of core formation needs to reproduce the observed concentrations of all the elements in Earth's silicate mantle. We will also help addressing outstanding issues such as the inventory of volatile elements early in Earth's accretion (during core formation), as well as the constraints that puts on the Late Veneer that brought most volatile elements to the Earth after the core formed. We will then use modelling to explore a wide range of accretion scenarios, to find those that satisfy best the elemental abundance and isotopic constraints.

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