Subject offered for a contract starting in September 2012

SUBJECT TITLE:

Generation and Subsidence of Primitive Mantle Reservoirs

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Financing: Doctoral contract with or without assignment

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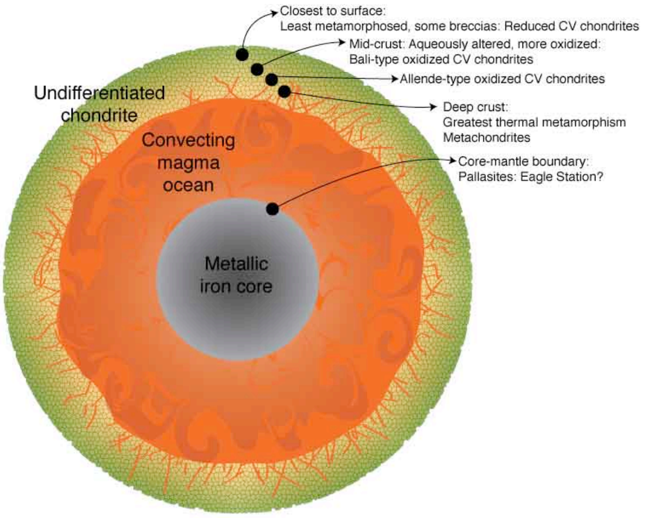
Presentation of the subject: (1 or 2 pages)

Current geochemical models of the Earth suggest that the mantle contains a number of hidden geochemical reservoirs. These reservoirs must have formed very early on, early enough to witness core formation. They also must have been deep, in order to isolate them from the convecting mantle over 4.5 billion years of existence. The most efficient process for producing large-scale chemical heterogeneities (or reservoirs) is fractional crystallisation and/or partial melting. The first few 100 million years after the formation of the Earth saw widespread melting of the mantle, a state known as "Magma Ocean", due to impacting, short-lived radioactivity, and gravitational heating due to core formation. During subsequent solidification, Earth's magma ocean experienced a global differentiation that left a strong compositional imprint on the resulting mantle, and created large-scale reservoirs that may have (at least partially) survived to the present day. To a large extent, present-day compositional structures in the mantle may be leftovers of these primordial reservoirs.



We propose here to determine the composition the various deep primordial reservoirs created during early mantle differentiation, and their potential subsidence to this day. For this, we will lead an experimental geochemical investigation on two fronts: (1) trace-element partitioning between deep mantle phases, and (2) trace-element partitioning between the solid and molten silicates.

Numerous studies have attempted to perform this in the last decade. However, these studies were limited to low pressures and temperatures (25 GPa, 2500 °C) reachable using the multi-anvil press. These are not relevant to the conditions prevailing in a deep terrestrial magma ocean, and we have shown that core formation requires at least pressures of 50 GPa, and temperatures of 3500 °C. We propose to perform the study using the laser-heated diamond anvil cell, which allows us to cover the entire range of P and T prevailing in the magma ocean, up to CMB conditions (135 GPa, 4500 °C). It will allow us to study directly the chemical processes that occurred in the deep primitive Earth, as we recover and analyse the experiments in a typical experimental petrology "cook and look" fashion, using state-of-the-art nanoscale probes (FIB, FEG-SEM and FEG-EPMA, nanoSIMS) in Paris and at EPFL (Lausanne).

We propose to look at the partitioning of a suite of lithophile and siderophile trace elements, both between solid lower-mantle minerals (perovskite), and between solid and liquid silicates. By linking this to trace-element concentrations in the upper-mantle (which is a sturdy geochemical observable), we will determine the depth and extent of the magma ocean (was it global, partial, transient, permanent?) as well as the compositional characteristic of the various reservoirs that are left behind.