Partitioning of HSEs between silicate and iron melts at condition prevailing for the early Earth

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During accretion of the Earth, the high energies of impacts of varying size, planetesimal and embryos [1], with other planetary bodies caused large scale melting that enabled liquid iron-rich melts to segregate in deep silicate magma oceans to form the Earth's core. The key to understanding the details of major core-mantle differentiation processes lies in determining how a wide range of elements partition between silicate and metallic liquids at pressures and temperatures up to those of the core-mantle boundary. Such partitioning behavior determined the composition of the Earth's primitive mantle. Therefore models of core formation are based on high-pressure partitioning data and use mantle composition as the main constraint. Currently most partitioning studies have been performed at pressures below 25 GPa and the data have to be extrapolated to much higher pressures (e.g. 80 GPa) in core formation models. Amid all the elements the Highly Siderophile Elements (HSEs) such as Ru and Pd are found in excess compared to theoretical values and in ratio similar to those found in meteorite. So far this long-lasting dilemma has been explained via two theories:

- A chemical equilibrium at the bottom of a silicate magma ocean while the metallic core forms at a depth of 1100 km-1500 km (40-60 GPa) with lower partitioning coefficient of the HSE in silicate melt at high pressure [2]
- A late chondritic veneer that enriched the mantle 100 ± 50 My after the earth accretion [3].

To elucidate the problem partitioning at much higher pressure are required, that can only be achieved using Diamond Anvil Cell.

The proposal at P02 aimed at installing a set-up for in situ X-ray fluorescence (XRF) formally developed at ESRF [4] that enables mapping and quantifying the distribution of elements in-situ in the Laser-Heated Diamond Anvil Cell (LH-DAC). The proposal was a joint proposal with another study conducted by Manuela Borchert: "Sulphur and selenium partitioning between silicate and metallic melts at core-mantle boundary conditions".

We conducted partitioning experiment of Ru and Pd (easier to detect than Pt and Au, as we had problem with these two elements) between silicate and metallic liquids at very high pressures and high temperatures. Samples consist of a Fe90Ni10 metal foil in contact with a chip of silicate doped glass embedded in a NaCl. Sodium chloride acts as pressure media, insulating material and pressure gauge. Laser heating was performed at the interface of metal foil and chondritic glass until complete melting inferred by diffuse scattering in the X-ray Diffraction pattern. Micro XRF mapping were performed in situ in the LDACs before and after laser heating at the high-

pressure beamline P02.2 using excitation energy of 25.6 keV fig1.

Samples were recovered from the high-pressure experiments. It was even possible to remove completely the salt around the sample by dissolving it in water. Recovered will be analyzed using other techniques.

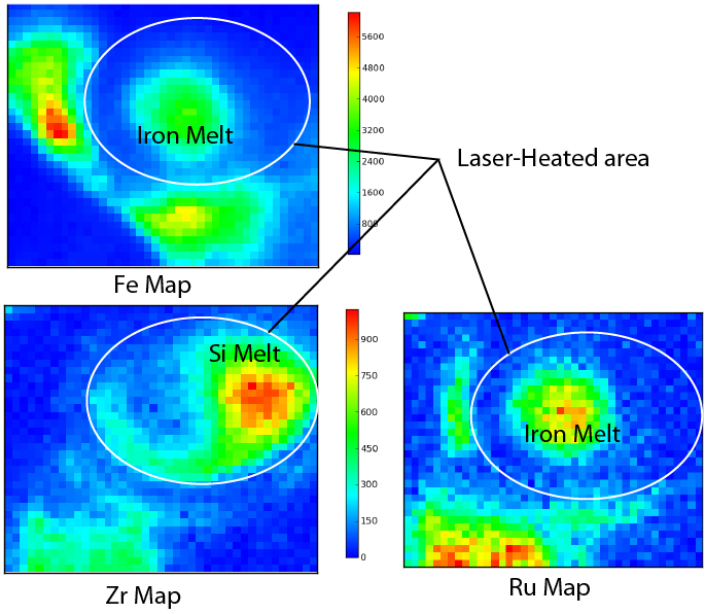

Fig1. Example of maps obtained in the DAC at 30 GPa, after laser heating. The Iron alloy melt and silicate melt immiscibility is illustrated by the differential partitioning of Ru and Zr. Ru, as well as Pd, preferably partition into the Fe rich metal and the incompatible element Zr partition in the Silicate melt.

References

[1] O'Brien D.P., Morbidelli A. and Levison H.F. Terrestrial planet formation with strong dynamical friction. Icarus 2006 **184**(1) : 39-58.

[2] Righter K., Humayun M. and Danielson L. Partitioning of palladium at high pressures and temperatures during core formation. Nature Geoscience, 2008. **1**(5): p. 321-323.

[3] Holzheid A., Sylvester P., O'Neill HSC., Rubie D.C., and Palme H. Evidence for a late chondritic veneer in the Earth's mantle from high-pressure partitioning of palladium and platinum. Nature, 2000. **406**(6794): p. 396-399.

[4] Petitgirard S., Borchert M., Andrault D., Appel K., Mezouar M. Liermann H.-P., An in situ approach to study trace element partitioning in the laser heated diamond anvil cell, Rev. Sci. Instrum. 83 (2012), 013904