Light Elements in the Core: Constraints from Gallium metal-silicate partitioning experiments

Ingrid Blanchard, James Badro, Julien Siebert (Institut de Physique du Globe de Paris-IPGP)

The segregation of Earth's core has left a compositional imprint on the mantle, depleting and fractionating most of its siderophile (iron-loving) elements. Gallium is a moderately siderophile as well as a volatile element; hence it should be strongly depleted in the mantle. However, gallium concentration in the mantle matches that of lithophile (silicate-loving) elements with the same volatility. That is to say gallium either behaves as a lithophile element during core formation, or a large influx of gallium was brought to the Earth after the core had formed. The geochemical evidence does not support the latter hypothesis, as it would also require all the other lithophile elements with similar volatility to be enriched in the mantle, or for late accretion to be composed of anomalously gallium-rich objects. In order to mitigate this issue, experimental studies have tried to understand how gallium behaves during core segregation by gauging the effects of pressure, temperature and oxygen fugacity on the metal-silicate partitioning of gallium. Alas, none of these parameters provided the first-order change required to match the observation.

We have decided to investigate the influence of the light-elements (oxygen, silicon and sulfur) content in Earth's core on the behavior of gallium during core segregation. We performed a series of isobaric and isothermal metal-silicate partitioning experiments (2 GPa, 2073 K) in an end-loaded piston-cylinder press. We varied the light-element composition of the metal and observed that while Si and S provided a small change to the partition coefficient, O proved to have a very strong influence on the activity coefficient of gallium, making gallium much more lithophile. Hence, we conclude that if the anomalous concentration of gallium in the silicate Earth is due to core segregation, then oxygen must have been very abundant in the core-forming metal, and oxygen should still be to this day a major element in the core.