Primordial volatilization on Earth inferred from the high-pressure metal-silicate partitioning behavior of gallium

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Gallium is a moderately volatile and moderately siderophile element, which does not seem to be depleted on bulk silicate Earth, compared to lithophile elements of same volatility (*e.g.* sodium). Previous studies predicted from large volume press experiments that metal-silicate partitioning of gallium on Earth should be matched at high pressure and high temperature if few wt.% of oxygen and silicon are solubilized in the core [1].

We performed high-pressure high-temperature experiments using laser heating diamond anvil cell to test this hypothesis. These are the first measurements of gallium metal-silicate partitioning performed at the appropriate conditions of pressure and temperature of Earth's differentiation. Homogeneous glasses doped in gallium were synthesized using a levitation furnace and load inside the diamond anvil cell along with metallic powder. Samples were recovered using a Focused Ion Beam and chemically analyzed using an electron microprobe. We show that gallium partitioning is very different from what was predict from low pressure and low temperature experiments extrapolation. Despite high pressure (47-71 GPa), high temperature (3500 – 4000 K) and solubilisation of O and Si (3-16 wt.%), gallium always stays siderophile ($D_{Ga} \approx 15$). Thus, there is no core-mantle equilibration condition that allows making gallium lithophile on Earth. We conclude that the apparent disagreement between experimentation and mantle geochemistry is not because gallium is less siderophile than expected, but because it is less volatile. We propose that gallium was depleted in the mantle by core formation, and that its concentration in bulk Earth is much higher than expected because of a reduce volatility. We explain this decrease of volatility by numerous impacts that stroke the Earth during its accretion. They probably led to a Si- and O-rich atmosphere, resetting condensation temperature previously derived from proto-solar nebula conditions (*i.e.* H-rich and 10^{-4} atm).

[1] Blanchard *et al.* (2015), *EPSL* 42, 191-201