Effect of silicon on the activity coefficient of Au (a highly siderophile element) in liquid Fe

Rick Rowland II[1], Kevin Righter[2]

[1]Jacobs, NASA Johnson Space Center, Mail Code XI3, Houston, TX 77058, USA
[2]NASA Johnson Space Center, Mail Code XI2, Houston, TX 77058, USA

Richard.L.Rowland@NASA.Gov

Introduction: Light elements can alloy into the iron cores of terrestrial planetary bodies. It is estimated that the Earth's core contains ~10% of a light element, most likely a combination of S, C, Si, and O; Si probably being the most abundant (Hirose et al. 2013). Si dissolved into Fe metal liquids can have a significant influence on the activity coefficients of siderophile elements, and thus the partitioning behavior of those elements between the core and mantle (Righter et al. 2016, 2017, 2018). Many of these elements have been investigated extensively at ambient pressure, and studies up to 1 GPa are becoming more common, but few have been studied at pressures above this (Righter et al. 2019). The formation of the Earth's core has been estimated to have formed at pressures between 40-60 GPa (Wade and Wood 2005; Righter 2011; Siebert et al. 2011), so investigating the effect pressure has on Si's influence on siderophile element partitioning is important for modeling the core formation of the Earth and smaller planets. In this work, we investigate the effect variable Si content has on the partitioning of Au at 10 GPa and 2100°C, with the intention of comparing the behavior to that already investigated at lower pressures (Righter et al. 2018). Additional siderophile elements and experimental conditions will be investigated in the future as results indicate they are warranted.

Experimental: Experiments were conducted in an 880-ton multi-anvil press at NASA's Johnson Space Center Astromaterials Research and Exploration Science division. The COMPRES 10/5 (Leinenweber et al. 2012) assembly in a Walker-module was used to attain conditions of 10 GPa and 2100°C. Starting materials were natural Knippa basalt (Lewis et al. 1993) (70% by mass) mixed with Fe metal (25% by mass), and Au metal (5% by mass). Silicon metal was then added to the silicate and metal mixture at 2, 4, 6, 8, and 10% by weight to create a variable amount of Si alloyed in the Fe metal liquid. The metal and silicate mixtures were packed into single crystal MgO capsules; the MgO reacts with the silicate melt to form more MgO-rich liquids. Experiments were quenched by cutting power to the furnace assembly.

Analytical: Metals and silicate glasses will be analyzed for major and minor elements with Electron Probe Microanalysis at NASA's Johnson Space Center on either a Cameca SX100 or JEOL 8530 FEG microprobe. Metals and glasses are analyzed with the electron beam set to 15 kV and 30 nA, and 15 kV and 20 nA respectively, using various metal, glass, and mineral standards. For both metal and glasses with coarse-grained quench texture, a defocused electron beam of 20-30 μm is used for analysis, with 30-50 analysis points averaged to obtain a representative composition. Trace elements (<100 ppm) will be measured using Laser Ablation Inductively Coupled Plasma Mass Spectrometry at Florida State University using glass and metal standards and either spot or line analyses depending on the size of the metal or silicate regions of interest.

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