The carbon content of Earth's core from metal–silicate partitioning experiments

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Earth's core contains ~10% light elements, such as Si, S, O, and C. The abundances of these elements were primarily established by partitioning between silicate and metallic liquids during core formation, and have implications for Earth's formation, volatile budget, thermal structure, and dynamics. Previous studies of the metal–silicate partitioning of carbon have revealed siderophile behavior, with $\log_{10}D$ ~2–4 [ref 1–6] (where D = wt%C_{metal}/wt%$C_{silicate}$); however, the highest pressure (P) and temperature (T) at which data were previously obtained was 8 GPa and 2473 K [5], significantly lower than the average P–T conditions of core formation in the Earth. We performed a suite of C-bearing metal–silicate partitioning experiments, using a laser-heated diamond anvil cell to achieve P = 37–59 GPa and T up to 5200 K. The recovered samples were polished and analyzed for major and minor elements using electron microprobe and for carbon using nanoSIMS. At these P–T conditions, we find $\log_{10}D$ ~0–2, in agreement with a previous ab initio calculation [7], indicating only slightly siderophile behavior of carbon. Combining our data with those of previous studies, we parameterized D as a function of T, NBO/T, and Si content of the metal. For single-stage core formation at 54 GPa [e.g., 8] and the peridotite liquidus temperature, NBO/T = 2.6, X_{Si} = 0.10, and a mantle C content of 120 ppm [9], the core contains 0.15–0.41 wt% carbon. Carbon is thus not a major contributor to the core density deficit, requiring the presence of other light elements, but the core still accounts for ~90% of the Earth's carbon budget.

[1] Chi et al. (2014) GCA. [2] Stanley et al. (2014) GCA. [3] Dasgupta et al. (2013) GCA. [4] Li et al. (2015) EPSL. [5] Li et al. (2016) NatGeo. [6] Armstrong et al. (2015) GCA. [7] Zhang and Yin (2012) PNAS. [8] Fischer et al. (2015) GCA. [9] McDonough and Sun (1995) CG.