ELEMENT PARTITIONING CONSTRAINTS ON FORMATION AND COMPOSITION OF THE EARTH'S CORE. J. Li[1], C. B. Agee[2], and Y. Fei[1], [1]Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Road, NW, Washington DC 20015, USA (jieli@gl.ciw.edu), [2]Johnson Space Center, 2101 NASA Road 1, Houston TX 77058, USA.

Introduction: Element partitioning study provides a number of constraints on formation and composition of the core. First, partitioning of siderophile elements between core and mantle should explain the "excess" siderophile elements in the mantle [1]. Second, partitioning of light element(s) between core and mantle should supply the core with the right amount of light element(s) to account for the density deficit in the core [2]. Third, partitioning of light element(s) between inner and outer core should be consistent with the observed difference in density deficits (relative to pure iron) between these two reservoirs [3].

In this study, high-pressure and high-temperature experiments have been conducted to investigate the pressure, temperature and composition effects on partitioning of siderophile elements Ni and Co between core-forming Fe-alloy and mantle silicate melt and minerals, partitioning of light elements S, O, and Si between core-forming Fe-alloy and mantle silicate melt and minerals, and partitioning of light elements S and C between solid and liquid Fe. The implications of these results for mechanism of core formation and the composition of the core are discussed.

Experiments and Analyses: Two sets of experiments have been carried out. In one set, starting material was finely-ground Allende (CV3) or finely-abraded Homestead (L5). Capsules were made of MgO, C, or Al_2O_3. In the other set, starting material was Fe mixed with FeS or Fe mixed with FeS and C. Capsules were made of MgO. Details on experiments are found in Agee et al. [4]. Experimental products were analyzed by electron microprobe. Details on analyses are found in Li [5].

Results and Discussion: Results from the first set of experiments show that Ni and Co become less siderophile with increasing pressure and temperature. The effects of pressure and temperature are more pronounced for Ni than for Co, so that the partition coefficients of Ni and Co converge at high pressure and high temperature. Partition coefficients of Ni and Co between liquid Fe-alloy and liquid silicate become essentially equivalent at an extrapolated liquidus pressure and temperature of ~24 GPa and ~2400˚C. The observed high abundances and near-chondritic ratio of Ni and Co in the Earth's upper mantle are therefore consistent with chemical equilibrium between liquid Fe-alloy and liquid silicate near the upper and lower mantle boundary.

These experiments also show that S has a strong affinity for liquid Fe-alloy. Partition coefficient of S between liquid Fe-alloy and liquid silicate increases with pressure and decreases with temperature. By extrapolation, partition coefficient of S between liquid Fe-alloy and liquid silicate is ~530 at the proposed pressure and temperature of core-mantle equilibrium during early differentiation. If the present sulfur content of the mantle was established by equilibrium core formation, then the core should have approximately 13 wt% S. In contrast, under all experimental conditions, no more than ~1 wt% O and ~0.1 wt% Si were dissolved in liquid Fe-alloy. Moreover, pressure and temperature have little effects on partitioning of O and Si between Fe-alloy and liquid silicate. The highly lithophile nature of O and Si combined with highly siderophile nature of S during core-mantle differentiation suggests that S remains the most plausible candidate for the principle light element in the core.

Preliminary results from the second set of experiments show that at a constant temperature of 1200˚C, up to 14 GPa, no more than 0.2 wt% S is dissolved in solid Fe. However, nearly a half weight percent of S is found in solid Fe at 25 GPa. Moreover, the amount of S dissolved in solid Fe increases slightly with temperature. Therefore, at the pressure and temperature near the inner-outer core boundary, considerable amount of S may dissolve in solid Fe. By comparing partitioning of S between solid and liquid Fe with difference in density deficit between the two, it can be tested whether S alone can account for the density deficits in both reservoirs. Additional experiments are under way to incorporate C into the system.

Conclusions: High-pressure and high-temperature experiments revealed significant and complex effects of pressure and temperature on element partitioning between phases that are involved in core-mantle and inner-outer differentiation. Based on these data, the estimated abundances of Ni and Co in the Earth's upper mantle are best explained by equilibrium core-mantle differentiation in a deep magma ocean. The observed density deficit in the core is most consistent with S being the dominant light element. Whether or not S alone can account for the density deficit in the core is further tested against the additional constraint from the difference in density deficit between the inner and outer core.

References: [1] Birch F. (1952) *JGR, 57,* 227–286. [2] Jephcoat A. and Olson P. (1987) *Nature, 325,* 332–335. [3] Jones J. H. and Drake M. J. (1986) *Nature, 322,* 221–228. [4] Agee C. B. et al. (1994) *JGR,* 17725–17740. [5] Li J. (1998) Ph.D. Thesis, Harvard University.