METAL-SILICATE PARTITIONING OF VOLATILE, SIDEROPHILE ELEMENTS: NEW RESULTS FOR Sb AND As.

K. Righter[1], A. J. Campbell[2], M. Humayun[2] and M. J. Drake[3], [1]Mail Code ST, NASA Johnson Space Center, Houston, TX 77058 (kevin.righter-1@nasa.gov), [2]Dept. of the Geophysical Sciences, 5734 S. Ellis Ave., Univ. of Chicago, Chicago, IL 60637, [3]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Introduction: Antimony and As are siderophile elements that also exhibit volatile behavior. Their depletion in planetary mantles can thus be due to segregation of metal during core formation [1], or volatility-related depletion in the precursor materials [2]. This study builds on our previous work [3] and other studies [4] to understand the effect of temperature, pressure, oxygen fugacity and composition on the partitioning of Sb and As between metal and silicate melt. The results will be used to interpret depletions of Sb and As in the mantles of the Earth, Moon, Mars and the eucrite parent body (or 4 Vesta).

Experimental: Metal-silicate partition coefficients, D (wt% in metal / wt% in glass), were determined on two sets of experiments. One set was done at 1 bar, 1260 ˚C and 2.4 log fO_2 units above the iron-wüstite (IW) buffer, in evacuated silica tubes. Alumina crucibles containing Sb-doped basalt and mixtures of Fe-Ni-S metal were sealed into the silica tubes, held in the hotspot for up to 7 days, and then quenched. These runs were reported by [5], but Sb and As concentrations in the silicate were too low to detect by electron microprobe analysis. A second set of runs was done in a piston cylinder apparatus, at 10 kbar, 1500 ˚C, and just below IW, with variable silicate melt composition. Mixtures of Sb and silicate were contained in an iron capsule. Quenched run products from both series were mounted in epoxy, cut and polished.

Analytical: Metal was analyzed for Fe, Ni and Sb, and glass was analyzed for major elements at NASA-JSC using a Cameca SX-100 electron microprobe. Antimony and As were analyzed in glasses using a CETAC LSX-200 laser ablation peripheral with a magnetic sector ICP mass spectrometer, the Finnigan Element™, at the University of Chicago [6]. The NIST reference glass SRM 612 was used as a standard for measurements of ^{57}Fe, ^{69}Ga, ^{75}As, and ^{121}Sb. Locations to be analyzed were selected from polished sections of the experimental run products, using backscattered electron images to avoid interfering metal blebs or particles in the glass. Nevertheless, there was evidence in a few analyses (~10%) that small metal particles had been ablated in addition to the glass; these data were discarded. The dimensions of each laser ablation pit ranged from 100 to 150 μm in diameter and ~15 to 25 μm deep. The laser was operated at 10 Hz for 3 to 5 seconds for each analysis, and data collection from the mass spectrometer continued for ~20 sec as the signal reached a maximum and decayed away. During data collection the mass spectrometer was swept repeatedly over the mass range of interest with a period of about 0.5 sec.

Results: Concentrations of Sb in the experimental glasses ranged from 17 ppb to 1.35 ppm, corresponding to D(Sb) of 1700 to 240,000. Arsenic concentrations in three experiments range from 70 to 170 ppb, resulting in D(As) values of 32000 to 47000. These high D values indicate that Sb and As are strongly siderophile, at odds with the relatively moderate depletion of Sb and As observed in the terrestrial mantle [7,8]. However, the effects of pressure, silicate melt composition, and variable metal activity coefficients in the Fe-Ni-Sb system [5] will have to be evaluated before application of these results may be made to planetary differentiation.

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