

**EXPERIMENTAL QUANTIFICATION OF THE SULFIDE-SILICATE PARTITIONING BEHAVIOR OF Se AND Te AND IMPLICATIONS FOR THE Se/Te SYSTEMATICS OF PLANETARY BODIES.** A. X. Seegers<sup>1</sup>, E. S. Steenstra<sup>1</sup>, J. Berndt<sup>2</sup>, S. Klemme<sup>2</sup>, S. Matveev<sup>3</sup>, W. van Westrenen<sup>1</sup> <sup>1</sup>Faculty of Science, Vrije Universiteit Amsterdam, the Netherlands ([a.x.seegers@vu.nl](mailto:a.x.seegers@vu.nl)), <sup>2</sup>Institute of Mineralogy, University of Münster, Germany, <sup>3</sup>Faculty of Geosciences, Utrecht University, the Netherlands

**Introduction:** Volatile elements selenium (Se) and tellurium (Te) provide important insights into the volatile budgets of the terrestrial planets [1,2]. Recent studies focused on metal-silicate partitioning experiments have shown that the observed Vestan, Martian and lunar mantle depletions of Se and Te may be largely to fully explained by preferential partitioning into their cores [3-5].

Given the cosmochemical abundance of S in planetary bodies, constraining the sulfide-silicate partitioning behavior of the geochemically similar elements Se and Te is important [1,2,6-9]. For example, crystallization of sulfides may have significantly affected the net abundances of Se and Te in the terrestrial mantle and corresponding S/Se and Se/Te values [10-13]. Unfortunately, the sulfide-silicate partitioning behavior of Se and Te is not well constrained. Here we study this sulfide-silicate partitioning of Se and Te as a function of the silicate melt composition. Related work focused on the silicate melt S contents of these and other experimental run products is shown in a companion abstract [14].

**Approach:** High pressure (P) - temperature (T) experiments were performed using an end-loaded piston cylinder press at 1683-1783K and 1-2.5 GPa using MgO or C capsules. A Pt outer capsule was used in the latter experiments to prevent infiltration of and loss of volatiles. Synthetic equivalents of the lunar low-Ti A15C green glass (A15GG) and high-Ti A14B black glass (A14BG) were combined with a FeS compound with 0.5 wt% Se/Te [15, 16]. The experiments with C capsules were filled following the “sandwich” technique from Wykes et al. (2015), where a layer of FeS compound is added above and below the silicate [17]. The top layer is intended to concentrate Pt contamination, so the bottom layer is Pt-free (fig. 1). The experiments were analysed for major elements (e.g. Fe, S) and trace elements (e.g. Se, Te) with EMPA and LA-ICPMS respectively.

**Results:** Run products performed in C-Pt capsules show well-segregated sulfide blobs in a quenched silicate melt. The Pt contamination was indeed concentrated within the sulfide blob at the top of the capsule, whereas the other is Pt-free or only shows minor contamination (fig. 1). Experiments performed with MgO capsules show multiple very small sulfide blobs that often cannot be measured. Due to interaction of FeS

melt with the MgO capsule, a layer of poorly segregated FeS melts forms along the edges of the capsule.

For A15GG a log FeO (wt.%) range of 0.3-1.2 was found, whereas a slightly higher range of 1.1-1.4 was found for A14BG which is known to have a higher FeO concentration than the more primitive A15GG magma. The variation in experimental FeO is the result of subtle differences in the ratio between FeS compound and the silicate powder in the starting materials. Sulfur concentrations in these two endmember magma’s are very different: 2055ppm for A15GG and 5473ppm for A14BG, which is most likely due to the distinctly different SiO<sub>2</sub> contents of both compositions [14].

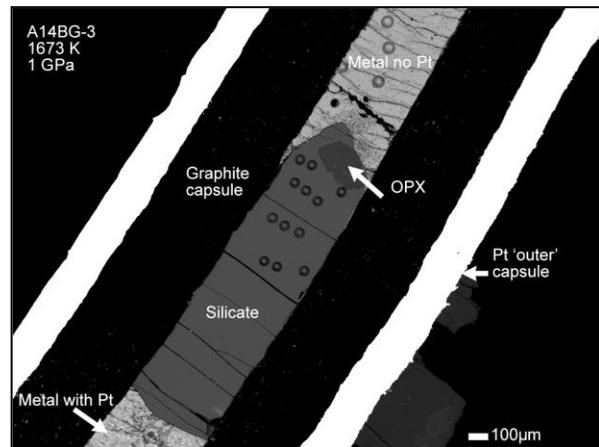


Fig 1: BSE image of typical run product

Comparing our new data for Se, Te partitioning from S-saturated experiments with previous S-depleted work, an increase in the partition coefficient ( $D$ , defined as wt.% of element in sulfide/wt.% of element in silicate melt) is observed with the addition of S [3,5,8]. This indicates an increase in siderophile behavior with the addition of FeS, which is consistent with previous work [8]. In previous studies we indicated a parabolic relationship between  $D$  (Se, Te) and oxygen fugacity (or FeO melt concentration) [3,5]. Fig. 2 shows that for Se (and potentially Te as well) within A15GG this parabolic trend is continued although at higher absolute values than the S-free data from previous work. We observe no parabolic trend for A14BG experiments due to the small range in log FeO (wt.%). At these high FeO concentrations,  $D$  (Se,Te) of the more evolved A14BG magma are likely altered by deviations in oxygen in the FeS compound [see e.g. ref. 18, 19]. Alter-

natively, it could be a result of slight changes in  $P$ - $T$  conditions. Besides FeO, no clear effects of silicate melt composition (i.e., Ti, Si) are apparent from comparison of the A15GG and A14BG series.

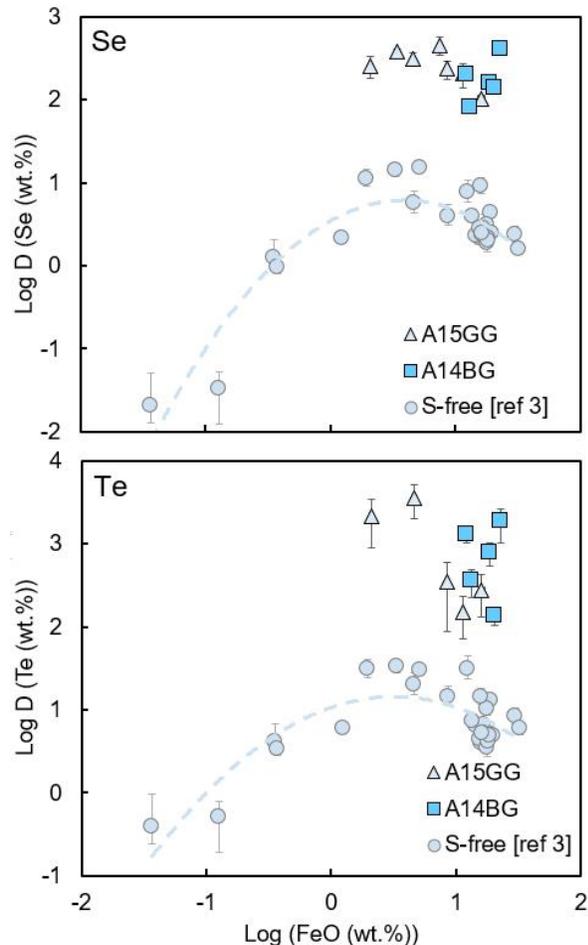


Fig. 2: The effect of  $\log \text{FeO}$  (wt.%) and S in metal on  $D(\text{Se}, \text{Te})$ .

**Discussion:** Our findings have several implications: first of all, the parabolic dependency of  $\log D$  (Se, Te) on  $\log \text{FeO}$  during core formation processes found in previous work seems unaffected by the presence of S. Secondly, the addition of S to planetary cores significantly increases the siderophile behavior of Se and Te. This may have important implications for the partitioning of Se and Te in S-rich bodies. As sulfide-segregation may have occurred in Earth's early history, significantly more Se and Te have partitioned into the core than previously thought [10-13]. The lunar interior on the other hand is unlikely to be S-saturated and the addition of minor amounts of S is unlikely to significantly increase  $D$  (Se, Te) [8, 14].

Recent studies indicate that the Martian interior is enriched in S with widespread sulfate deposits and 10-

16wt% S in the core [19-22]. Based on our new data we can therefore expect increased partitioning of Se and Te into the Martian core and a more Se, Te depleted mantle [see e.g. ref. 23].

Thus our new data supports our earlier indication that currently observed Se and Te concentrations within planetary mantles may be caused by preferential partitioning into the planetary cores, especially if S is present in significant amounts.

**References:** [1] Wang & Becker (2013) *Nature* 499, 328 [2] Wang & Becker (2017) *EPSL* 463, 56 [3] Seegers et al (2017) *LPSC #1053* [4] van Westrenen et al (2018) *LPSC (this meeting)* [5] Steenstra et al (2016) *LPSC # 1851* [6] Lodders (2003) *APJ* 591, 1220 [7] Rose-Weston et al (2009) *GCA* 73, 4598 [8] Steenstra et al (2017) *Sci Rep* 7, 14552 [9] Wood and Kiseeva (2014) *GCA* 145, 248 [10] Zhang et al (2016) *Sci Rep* 6, 22473 [11] Dreibus and Palme (1996) *GCA* 60, 1125 [12] Li and Agee (2001) *GRP* 28, 81 [13] Li et al (2001) *EPSL* 193, 509 [14] Steenstra et al (2018) *LPSC (this meeting)* [15] Delano (1979) *LPSC 10<sup>th</sup>*, 275 [16] Delano (1986) *JGR* 91, 201 [17] Wykes et al (2015) *J Petrol* 56, 1407 [18] Kiseeva and Wood (2013) *EPSL* 383, 68 [19] Kiseeva and Wood (2015) *EPSL* 424, 280 [20] Gaillard et al (2013) *Space Sci Rev* 174, 251 [21] Richter et al (2009) *EPSL* 288, 235 [22] King and McLennan (2010) *Elements* 6, 107 [23] Westrenen & Steenstra (2018) *LPSC (this meeting)*