

EXPERIMENTAL QUANTIFICATION OF THE EVAPORATION OF IRON-LOVING AND SULFIDE-LOVING ELEMENTS FROM METALLIC MELTS. E.S. Steenstra, C.J. Renggli, J. Berndt, S. Klemme, Institute of Mineralogy, WWU, Münster, Germany (esteenst@uni-muenster.de).

Introduction: The chemical composition of magmatic iron meteorites provides fundamental insights into planetary accretion processes. They are distinguished based on their trace element compositions and could represent the cores of more than 50 parent bodies [1]. The primary difference between the different groups is the degree of volatile element depletions, which increases from class I to IV iron meteorites [2]. For example, Cu, Ge and Ag concentrations of magmatic iron meteorites deviate up to 4 log units between the different magmatic iron meteorite groups [2]. The volatile element loss could have occurred prior to (i.e. nebular) or during parent body accretion and differentiation, for example during exposure of a liquid core following a catastrophic impact [3]. Investigating the mechanisms of volatile loss from requires experimental constraints on their volatility, for example during evaporation from metallic melts [3], which is currently poorly constrained. Here, we experimentally determine the volatility of Cu, Ge, Ag and a suite of other elements from metallic melts as a function of pressure (10^{-4} to 1 bar), temperature (1573–1823 K) and time (5–120 min) for two end-member compositions (Fe versus FeS).

Approach: Evaporation experiments were performed in a high-temperature (vacuum) furnace. Experimental starting compositions consisted of metallic Fe or FeS starting powders doped with the (trace) elements of interest. After the required run time experimental run products were quenched in water, mounted in epoxy resin, polished and prepared for subsequent analyses by electron microprobe and LA-ICP-MS at WWU Münster. The LA-ICP-MS analyses were calibrated using the NIST 610 glass and ^{56}Fe as an internal standard. A spot size of preferably $130\ \mu\text{m}$ was used for all analyses, but if this was not possible due to sample limitations the spot size was slightly decreased.

To obtain reference concentrations of the starting materials prior to degassing, starting materials were synthesized at high P - T conditions in a piston cylinder press. The measured concentrations in the experimental run products were then normalized relative to the elemental concentrations measured in the undegassed, high P - T synthesized metal and sulfide liquids. Note that this approach also rules out any potentially significant matrix effects on LA-ICP-MS-derived concentrations of degassed samples: both materials are (near)-identical in major element compositions.

Results: Fig. 1 shows a typical experimental run product. Experiments performed at room pressure generally quenched to a single blob, whereas vacuum experiments occasionally dispersed into several smaller metallic blobs upon quenching. All experimental phases, including different blobs from the same experiment, were found to be un-zoned, suggesting that the evaporation of these elements from metallic melts is not diffusion-limited (Fig. 2).

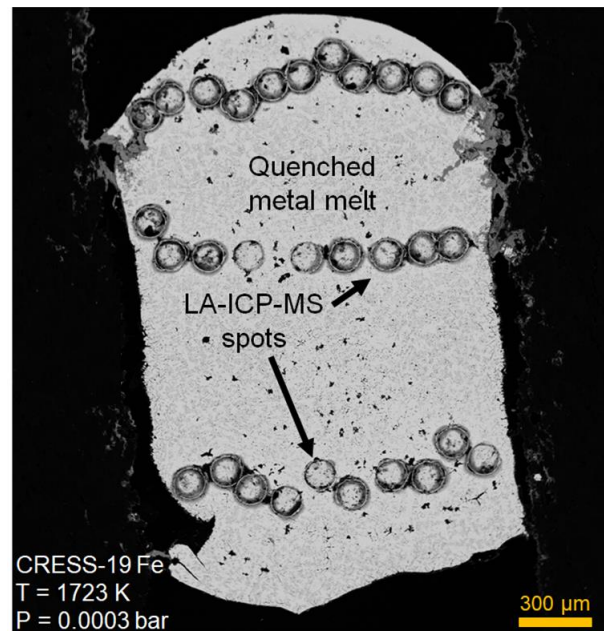


Fig. 1: Backscattered electron image of a typical run product (CRESS-19 Fe).

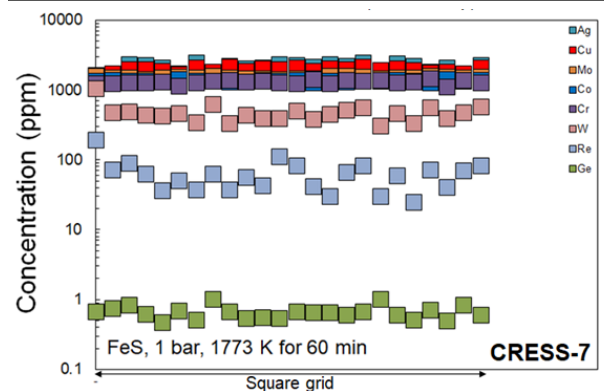


Fig. 2: Concentration profile transects obtained by LA-ICP-MS for run CRESS-7 for a FeS liquid degassed at 1773 K for 60 min. There is so significant systematic variation of elemental concentrations throughout the experimental charge.

The volatility of element i was defined relative to Eq. (1):

$$\text{Evaporative loss factor element } i (f^i) = \frac{\text{concentration } i \text{ exp. sample}}{\text{concentration } i \text{ ref. material}} \quad (\text{Eq. 1})$$

The $f(i)$ values were then normalized to Ni, which is considered to behave non-volatile in our experiments:

$$\text{Ni - norm. evapor. loss factor } i (f^{(i/\text{Ni})}) = \frac{f^i}{f^{\text{Ni}}} \quad (\text{Eq. 2})$$

Figure 3 shows $f(\text{Ag})$ values for FeS liquids. It is directly evident that pressure strongly affects the volatility of Ag and that after 30 min virtually all Ag is degassed at >1673 K. Volatile behavior was also observed for S, Cu, Ge, with the volatility being dependent on composition and P - T . Elements Cr and Co remain non-volatile within the explored P - T conditions.

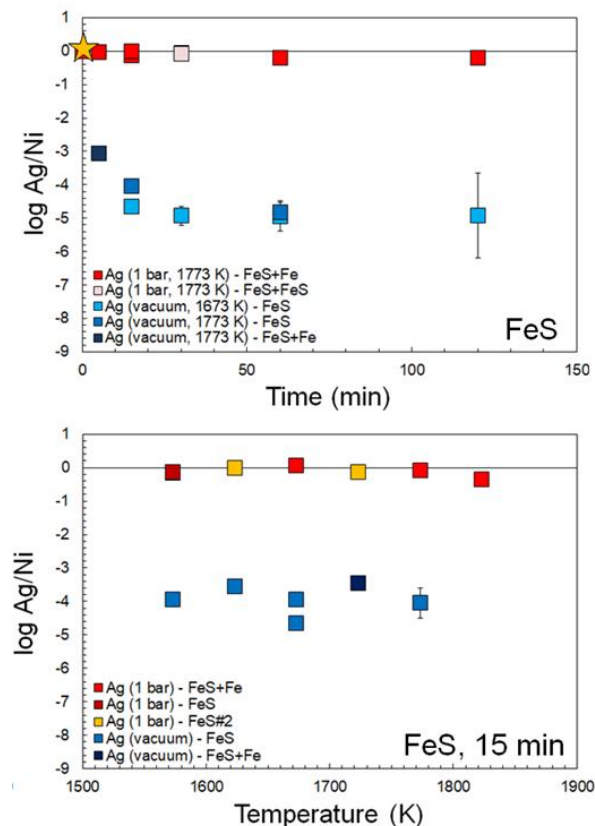


Fig. 3: The $f(\text{Ag})$ values for FeS liquids at 1 bar and vacuum (0.001 bar) versus time and T (K). The star and solid lines indicate the initial concentrations of the starting material. Reported uncertainties are based on maximum errors of LA-ICP-MS measured abundances in both the synthesized starting material and the degassed samples.

The results generally show that the volatilities are significantly different than previously assumed, and that their volatility may be strongly and distinctly affected by the composition of the melt from which they evaporate.

Discussion and outlook Using the new experimental data, parameterizations were obtained that can be used to predict the volatility of the elements of interest [4] in FeS or S-free alloys as a function of T and time. These parameterizations were applied to predict the evaporative volatile loss during different planetary differentiation scenarios. The new data and parameterizations will be discussed at the meeting in light of current models that describe volatile element depletions in magmatic iron meteorite parent bodies.

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References: [1] Goldstein et al. (2009) *Chemie Der Erde – Geochem* [2] Scott & Wasson (1975) *Rev Geophys* [3] Kleine et al. (2018) *LPSC #2083* [4] Steenstra et al. (in prep.)