



The Volatility and condensation behaviour of elements in dependence of T and fO₂: a novel experimental approach

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The volatility of elements is one of the most important variables during geological processes on Earth: its impact ranges from daily out gassing of volcanic vents to catastrophic emissions during volcanic eruptions which might scale up to global impacts on our climate. Volatility played, however, already a major role during the formation of our solar system: the nebular gases and their element budget passed through an elemental fractionation process based on differences in the evaporation and condensation behaviour of matter within the solar nebula - the origin of all the planets within our solar system.

Precise knowledge of the parameters controlling volatility as well as condensation of elements is still lacking. Whether an element behaves volatile or refractory depends highly on the temperature and oxygen fugacity (fO₂) conditions prevailing. To address this issue, we initiated a systematic study of the volatility of 18 volatile elements in respect to fO₂ and temperature applying a modified mechanically assisted equilibration technique (MAE): Approx. 60 g of a haplobasaltic starting composition (An-Di) doped with up to 5000 ppm of volatile elements (Li, K, Na, Ti, Cr, Mn, Co, Cu, Zn, Ga, Rb, Cd, In, Sn, Sb, Cs, Tl) was heated to run temperatures. To investigate the fO₂ dependence 2 experiments at logfO₂ = -11.3 (~ IW -0.5) and -0.7 (pure air) at a constant temperature of 1300 °C were performed, while T dependence was investigated at 1300 and 1500 °C at constant fO₂ in pure air. The original MAE technique was modified by two Al₂O₃ plates extending from the hot spot region up to the upper, cooler regions of the muffle tube. These plates function as condensation traps. The temperature profile of the entire setup including the Al₂O₃ plates under run conditions was calibrated prior to any run. Experiments lasted for up two weeks while experimental conditions were kept strictly constant and were monitored. Up to 46 samples were taken from the melt by time-series sampling to monitor the loss of volatile elements within the melt composition due to their volatility. In the upper, cooler parts of the setup, condensation was observed successfully on the surface of the two Al₂O₃ plates. In this way both evaporation of the investigated elements as well as their condensation behavior can be investigated simultaneously. Major element composition was determined by electron microprobe analysis on quenched samples, while their volatile concentrations were determined by laser-ablation inductively coupled plasma mass spectrometry (LAMS).

Preliminary results show a highly complex behaviour of the investigated volatile elements: At low fO₂, Li, Na, K, Ti, Cr, Mn, Rb, and Cs show no decrease due to evaporation. At high fO₂, however, e.g., Cr and Mn decrease with time due to increased volatility, while Co, Cu, Sb and Tl become less volatile. Due to the relatively small temperature range (200°C), the observed T effect is small compared to the fO₂ dependence. Cr, In, Sn, Sb and Tl exhibit a similar T dependence of their volatility. Mn, Cu, Zn, and Ga show a decrease of their volatility, while Cs and Cd become slightly more volatile with increasing T. The present data indicate an unexpected and highly complex behaviour of the volatile elements due to melt compositional processes: Concentrations do not generally decrease continuously with time as anticipated in previous studies, but stay, e.g., constant for some elements due to the formation of a stable concentration regime. Condensation traps show clear indications for various phases condensing at varying temperature regimes above the hot spot region of the crucible. Additional experiments are necessary and planned to confirm our preliminary findings.