Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18363

Lunar magmatic degassing mechanisms and their relation to the Moon's unique Cl isotopic signature

SIOBHAN E. L. KINGHAM, LEE SAPER, GEOFFREY DAVID BROMILEY AND ALAN HASTIE

University of Edinburgh

Presenting Author: siobhan.kingham@ed.ac.uk

Stable chlorine isotope ratios (reported as $\delta^{37}Cl$, where $\delta^{37}Cl = [(^{37}Cl/^{35}Cl_{sample})/(^{37}Cl/^{35}Cl_{SMOC}1]*1000$) in lunar samples range from similar to terrestrial igneous materials ($-0.2 \pm 0.3‰$[1]) to the most isotopically-heavy igneous materials in the Solar System. In lunar highland samples, $\delta^{37}Cl$ values of up to +30.2‰ have been measured in structurally-bound fractions in chemically-leached whole rocks[2], and values measured in mare basalt apatites are as high as +40‰[3]. A potential driver of the extreme fractionation was degassing from the lunar magma ocean and/or from later subaerial volcanism[2][4]. Changes in melt $\delta^{37}Cl$ during degassing is dependent on factors such as temperature, pressure, vapour composition and the evaporating chloride species, with the latter potentially linked to magmatic water content[5].

Our research aims to determine degassing mechanisms of chlorine in a model lunar system by running time-series experiments with variable water contents, temperature and fO_2. A synthetic lunar melt composition[6] doped with Cl ± Zn was used as the starting material. Volatile-bearing glasses fused from the powder were melted in an H_2–CO_2 atmosphere, and held for 1-30 minutes before quenching to glass. Chlorine concentration transects across the quenched glasses track progressive evaporative loss and diffusion in the melt. The Cl profiles will be discussed in the context of available parameterisations of Cl solubility, diffusion and volatility in basaltic melts. Diffusion models fit to concentration profiles can be used to forward model the resulting fractionation of Cl isotopes during diffusion and evaporation. The modelled kinetic isotope fractionation will be compared to SIMS data for temporal and spatial variations in $\delta^{37}Cl$ and these results will be used to discuss the role of degassing in producing the extreme Cl isotopic composition of some lunar materials.

References:

[1] Sharp et al., 2013 Geochimica et Cosmochimica Acta, 107, pp.189-204. **[2]** Gargano et al., 2020 Proc. Natl. Acad. Sci. U.S.A., 117(38), pp.23418-23425. **[3]** Potts et al., 2018 Geochimica et Cosmochimica Acta, 230, pp.46-59. **[4]** Barnes et al., 2016 Earth and Planetary Science Letters, 447, pp.84-94. **[5]** Sharp et al., 2010 Science, 329(5995), pp.1050-1053. **[6]** Delano, 1986 Journal of Geophysical Research: Solid Earth, 91(B4), pp.201-213.