A new model for volcanic gas compositions in lunar fire fountain eruptions

C. J. RENGGLI[1]*, P. L. KING[1] AND R. W. HENLEY[1]

[1]Research School of Earth Sciences, Australian National University, ACT 2601, Australia (christian.renggli@anu.edu.au)

Sulfur, F, Cl, Zn, Cu, Ni, Ga and Pb are found coating volcanic glass beads from Apollo 17 (A17) and Apollo 15 [1] [2]. The elements occur in sulfides and chlorides deposited from a gas phase [1] [3]. Early volcanic gas models have used Earth-like compositions at lunar oxygen fugacities [4].

We use predicted concentrations of volatiles lost from A17 glass beads by Saal *et al* [5] to provide new constraints on the gas composition and deposition of the coatings. The carbon content was calculated assuming an oxygen fugacity of IW-2 and equilibrium between 15 C-bearing phases. This results in the following gas composition in mol%: H (5.38), O (42.74), C (45.29), Cl (0.06), S (5.86), F (0.67).

We used the Gibbs free energy minimization method to calculate gas compositions and the transport and deposition of metals and salts during decompression from 2 to 10^{-6} bar and cooling from 1500 to 600 °C of the lunar volcanic gas. CO is by far the dominant gas phase as previously suggested [3] [4] [6]. Metals (Zn, Ga, Cu, Ni, Pb) are transported in their gas phase (e.g. Zn(g)) or as chloride and sulfide gas species. The chloride species dominate in the gas phase at lower temperature (T), whereas the sulfides prevail in the products precipitating at 1000-1250 °C and in the high-T gas phase. The speciation depends on pressure (P) with chlorides being more important at higher P. At low P ($<10^{-3}$ bar) pure metal phases become increasingly important in the gas phase, even at lower temperatures (<1000 °C). Over the whole P and T range Zn is enriched in the gas phase compared to Ni and Cu by $>10^4$ and $>10^2$ respectively.

[1] Meyer *et al* (1975) *Proc. Lunar Sci. Conf.* 6th, 1673-1699. [2] Butler & Meyer (1976) *Proc. Lunar Sci. Conf.* 5th, 1561-1581. [3] Rutherford & Papale (2009) *Geology* **37**, 219-222. [4] Fegley (1991) *Geophys. Res. Lett.* **18**, 2073-2076. [5] Saal *et al* (2008) *Nature* **454**, 192-196. [6] Fogel & Rutherford (1995) *Geochim. Cosmochim. Ac.* **59**, 201-215.