Magmatic vapor and the Martian surface: An experimental exploration

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The source of S and Cl in Martian fines [e.g., 1, 2] and the processes that led to their concentration remain uncertain. It is recognized that magmatic gases transport S and halogens to the surface [e.g., 3-5] and can produce both primary vapor-deposited minerals and secondary minerals via surface interaction. However, we know little about vapor-deposited phases contributed to the Martian surface, particularly once the H_2O in the mantle was depleted and the frequency of large explosive eruptions diminished. To explore this, we experimentally generated magmatic gas from an oxidized H_2O-poor, Cl- and S-supersaturated magma of Irvine composition [6], allowed the gas to separate, ascend, and cool in a strong thermal gradient that was well-calibrated, and determined the nature of the vapor-deposited materials precipitated on the walls of the evacuated sealed silica glass tube. The oxygen fugacity of the source was initially set to NNO to simulate gas oxidation by interaction with the surface.

Experimental Results

After each experiment, the tubes of all Cl-+S-bearing experiments showed rings of vapor deposited phases starting at ~700 ^{o}C. For the source with high Cl:SO_3 ratio, with increasing distance from the hot source, the precipitated assemblage changed from silica+maghemite to maghemite+ molysite+halite+sylvite then to hematite + molysite + halite+ sylvite, and in the coolest ring, to an orange S-Fe-Cl-rich assemblage that was a possible intergrowth of native sulfur and ferric chloride hexahydrate. For the source with a 1:1 weight ratio of Cl:SO_3, oxides were not seen, instead, the assemblage was an intergrowth of sylvite+halite molysite+pyrrhotite in the highest temperature ring; in the lower temperature ring, native S "droplets" were seen and a brine condensed. OES-ICP analysis of the vapor deposits and the weight loss of the source allowed constraints to be placed on the bulk initial gas compositions. The assemblage aided in constraining the variation in redox state along the tube.

[1] Meslin *et al.* (2013) *Science* **341**, 1238670-01-10. [2] Bish *et al.* (2013) *Science* **341**, 1238932-1-5 [3] Settle (1979) *JGR* **84**, 8343-8354. [4] Clark & Van Hart (1981) *Icarus* **45**, 370-378. [5] Ustunisik *et al.* (2011) *Am. Min.* **96**, 1650-1653. [6] McSween *et al*. (2006) *JGR* **111**, doi:10.1029/2006JE002698.