

VAPOR/MELT PARTITIONING BEHAVIOR OF S AND Cl IN A C-O GAS MIXTURE. M. G. Nicholis and M. J. Rutherford, Department of Geological Sciences, Brown University, 324 Brook St., Box 1846, Providence, RI 02912: Mike_Nicholis@Brown.edu and Malcolm_Rutherford@Brown.edu.

Introduction: The picritic lunar glass beads are believed to have been generated by gas propelled fire-fountain events due to the oxidation of graphite entrained in the ascending lunar magmas [1, 2, 3, and 4]. The gas phase fueling these eruptions initially, and throughout the duration of the eruption, was dominated by a CO-CO₂ gas mixture [5, 6, 7, and 8]. However, the occurrence of surface coatings composed of volatile elements such as S, Cl, F, Na, B, and many others indicate that though the initial gas composition may have been a mixture of CO-CO₂, the gas evolved to a much more complex composition through the partitioning of these volatile elements from the melt into the gas as the eruption progressed [9, 3, and 6]. Besides the presence of carbon on the surface of the glass beads, both S and Cl may arguably be the most important constituents in the gas-phase which generated the lunar glasses. Although experimental data on the partitioning of S and Cl are available for fluid/melt systems, they have only been investigated in a few experimental studies in which only the role a H₂O- and/or saline-rich fluid phase have been investigated [10, 11, and 12]. In the case of S, the two available completed investigations show conflicting results on the gas/melt partitioning ($D_S^{g/m}$) of S. [10] suggests that $D_S^{g/m}$ increases in reduced conditions, where as [11] advocates that $D_S^{g/m}$ increases in oxidized conditions. None of these studies (of S) investigates mafic magma compositions with intermediate to high FeO melt contents, and no one study (both S and Cl) examines the role of C-O gas. How volatile elements, such as S and Cl, partition themselves between a melt and a C-O gas mixture, such as in the lunar mare fire-fountain events, is still very unclear and needs to be investigated.

Understanding the partitioning of both S and Cl into a C-O gas is not only an important criterion for lunar volcanism (and the evolution of the lunar interior), but also terrestrial magmatic systems. Although CO₂ is the second most abundant volatile found in terrestrial magmas it is most often the first to reach saturation and exsolve due to its low solubility in silicate melts. Therefore, it is

possible that volatile elements dissolved in the melt may partition into the gas prior to H₂O becoming the dominant gas-phase constituent. The focus of this research is to determine the partitioning behavior of both S and Cl between a mafic magma and a CO-CO₂ gas phase.

Experimental and Analytical Methods: Synthetic picritic Apollo 17 orange glass composition was used as starting material for the first set of experiments. This starting material has a glass composition of 39.5 wt.% SiO₂, 22.1 wt.% FeO, 14.1 wt.% MgO, and 9.4 wt.% TiO₂. Natural pyrrhotite (Fe_{1-x}S) was used to add 1950±25 ppm S, and reagent grade KCl was used to add 1100±25 ppm Cl to the starting material. Compressed pellets were sintered in pure Fe-foil under vacuum in silica tubes to reduce the starting material near the WI buffer. Sintered pellets were then placed in Pt capsules lined with graphite powder. The C powder served multiple functions that included inhibiting melt contact with the Pt capsule walls, fixed the f_{o2} to lunar conditions, and reacted with the melt to generate a CO-CO₂ gas phase (graphite oxidation). Isothermal (1370°C) decompression experiments were conducted in a Harwood internally heated pressure vessel. Experiments were equilibrated at an initial pressure of 80 MPa and then decompressed at a controlled rate to a final run pressure of 35 to 70 MPa for time duration of 3 hours. As illustrated by [8] the graphite oxidation surface was intersected at 40 MPa generating a CO-CO₂ gas mixture for both S and Cl to partition into, Figure 1. Experiments were designed to explore the partitioning of S and Cl individually and also in combination with each other.

In addition, similar decompression experiments are being run in TZM pressure vessels at 1200°C, to explore the effects of melt composition, temperature, and fO₂. The starting material in these experiments is an Etna basalt with 48.2 wt.% SiO₂, 10.5 wt.% FeO, 6.3 wt.% MgO, and 1.5 wt.% TiO₂. After being reduced to WI and sintered as in the above experiments the starting material contained 1130±25 ppm Cl. The lower FeO content of this starting material allowed us to in-

investigate both Cl partitioning and graphite oxidation in a melt with a lower FeO activity. Experiments were run at an initial pressure of 80 MPa and then decompressed to 15 to 50 MPa.

Backscatter images and analysis of all experimental products were performed using the SX-100 electron microprobe.

Results: The initial results of the orange glass experiments indicate the following. The production of the first gas-phase in the rising orange glass magma is a CO-rich gas. The pressure at which this gas is generated, for a give temperature, is not affected by the presence of either S or Cl. For a magma of orange glass composition and with an intrinsic fO_2 near WI, the C-O gas will first materialize at 40 MPa (~8 km depth in the Moon), and is accompanied by the appearance of small Fe-metal spherules. S partitions into both the Fe-metal as well as the gas-phase. Analysis of S partitioning into the gas is still in progress.

New analyses of the natural $Fe_{85}Ni_{14}Co_1$ metal blebs in the A17 orange glass have shown that S did partition into the metal phase. However, only 120 ± 20 ppm S is present in the natural metal blebs, where 6500 ± 100 ppm is found in experimental metal blebs. This discrepancy maybe due to the lack of Ni in our experiments; future experiments will be designed to investigate this result.

As for Cl, it appears to have no affinity for a CO-rich gas-phase when dissolved in mafic melts for pressures as low as 150 MPa. Ongoing experiments will investigate if this result holds true for even lower pressures (2.5-10 MPa).

Implications: The results from this study provide new insight regarding the composition of the gas-phase that coexisted with the ascending lunar fire-fountain magmas. It will also further expand the S and Cl vapor/melt partitioning data for mafic melt compositions at reduced oxygen fugacities.

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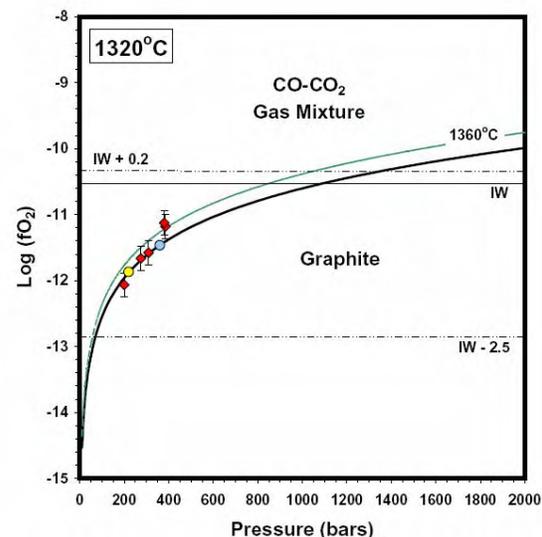


Fig. 1 Graphite-C-O equilibria for the A17 orange glass liquidus temperature of 1320°C as function of pressure. A CO-CO₂ gas mixture will be generated at 400 bars in which both S and Cl can then partition into during ascent.