

CRYSTALLIZATION EXPERIMENTS ON A GUSEV BASALT COMPOSITION. J. Filiberto¹ and A. H. Treiman, ¹Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX 77058 Filiberto@lpi.usra.edu, ² Lunar and Planetary Institute Treiman@lpi.usra.edu.

Introduction: Until recently, the SNC meteorites represented the only source of information about igneous processes on the Martian surface [1]. Many experiments have been conducted on the SNC meteorite compositions to investigate their parental liquid compositions, and therefore provide information about the mantle that produced such rocks. Recently, the MER rover Spirit analyzed basalts on the surface of Mars which may provide additional data about the Martian mantle.

The Adirondack-class basalts analyzed by the MER rover Spirit are dark, fine-grained vesicular rocks with <25% olivine phenocrysts [2-4] which have been suggested to represent liquid compositions. Experiments on these compositions can provide information as to whether these rocks represent mantle derived melts or subsequent fractionation products.

Liquidus crystallization experiments can determine whether or not a rock is a mantle derived liquid if there is a single pressure and temperature at which the minerals crystallizing on the liquidus have the same composition as those in the mantle that the liquid was derived from. Therefore, in order to investigate whether the Adirondack class basalts are mantle derived liquids, a suite of near-liquidus experiments have been conducted from 15.2 kbar to 3.2 kbar (1 atm experiments are on-going) on one of the analyzed Adirondack-class basalt compositions (Humphrey). The Humphrey composition was chosen because it is probably the least altered of the Adirondack class [2].

Experimental technique: A synthetic powdered starting material of the Humphrey composition was made from a mixture of oxides (Table 1). It was subsequently fired at 1400° C at 1 atm to ensure homogeneity as well as freedom from water and CO₂. The synthetic powder was stored in a desiccator. After loading into a graphite capsule, the powder and capsule were dried at 350°C for at least 12 hours to ensure that they remained volatile free. Experiments were conducted in a piston-cylinder apparatus using BaCO₃ sleeves and crushable MgO spacers from 4 kbar to 16 kbar nominal. Pressures and temperatures were corrected with a negative 0.8 pressure correction and a 10 degree temperature correction. Experiments are currently in progress to determine the liquidus temperature at 1-atmosphere and pressures above 15 kbar. Temperature

Table 1.	Glass	Gellert et al. [4]	McSween et al. [2]
SiO ₂	45.99	46.96	46.49
TiO ₂	0.56	0.56	0.59
Al ₂ O ₃	10.89	10.93	10.55
FeO _T	20.01	19.23	18.95
MnO	0.42	0.42	0.43
MgO	10.89	10.65	10.82
CaO	8.12	8.02	8.26
Na ₂ O	2.44	2.56	2.38
K ₂ O	0.10	0.10	0.09
P ₂ O ₅	0.58	0.57	0.60
FeS	0.00	0.00	0.84
Total	100.00	100.00	100.00

was measured using a W5Re/W25Re thermocouple. Experiments were conducted using a piston-out procedure (i.e. pressurized to two kbar above the experimental pressure and then brought down to the final pressure after heating). Samples were melted for 30 minutes above the liquidus temperature and then rapidly cooled to the final crystallization temperature where they remained for 1-4 hours (longer times were for lower temperatures). Experimental run products were analyzed using a Cameca SX-100 electron microprobe at NASA JSC for major element abundances of the residual liquid as well as the crystal phases. Mass balance calculations were conducted using the least square computations of IgPet [5] in order to determine mineral abundances and ensure that no phase was missed during microprobe analysis.

Results: Figure 1 shows a phase relation diagram for the experiments conducted on the Humphrey composition. Experiments below 10 kbar all have olivine on the liquidus; at lower temperatures, pigeonite is the next phase to crystallize. At pressures above 10 kbar, olivine is still the liquidus phase; however, at these pressures once pigeonite begins crystallizing it becomes the dominant phase in the crystallizing assemblage (Figure 2). This suggests that at higher pressures pigeonite may be the liquidus phase (Figure 1). Experiments are currently underway to investigate the exact location, in P-T space, where pigeonite becomes the liquidus phase.

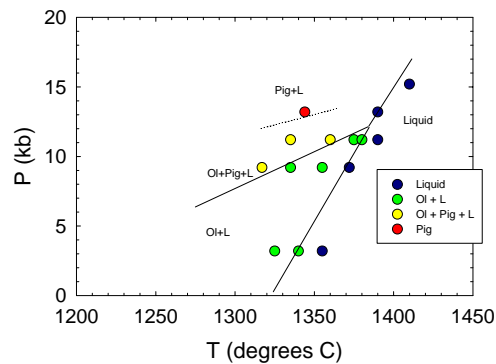


Figure 1. Experimental determined phase relations for synthetic Humphrey basalt. Blue circles are experiments that contained liquid only, green are olivine and liquid, yellow are olivine, pigeonite, and liquid, and red are pigeonite and liquid.

These results are dissimilar from previous work on similar compositions [6, 7], which showed that olivine was the liquidus phase at lower pressures and that orthopyroxene, not pigeonite, was the liquidus phase at higher pressures. Those experiments also had a single multiple saturation point around 10 kbar and 1320°C, and gave lower liquidus temperatures overall. These differences suggest that the bulk composition used by [6, 7] retained a small proportion of water.

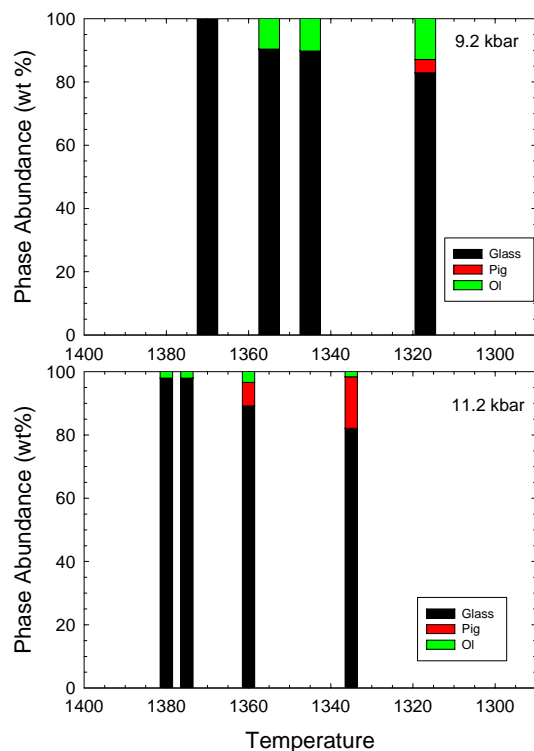


Figure 2. Variation in phase abundance (wt %) for "Dry" Humphrey crystallization at 9.2 kbar (a) and 11.2 kbar (b).

Discussion: If an igneous rock is a true mantle melt there will be a single pressure and temperature at

which the liquidus is multiply saturated with the minerals that melted in the mantle to produce the rock. These experimental results show that a rock with the Humphrey composition does not have a single multiple saturation point. Rather, olivine and pigeonite coexist on the liquidus over a range of pressures. This suggests that Humphrey is an evolved magma composition and not a pristine mantle melt. Also, notably the pyroxene crystallizing from Humphrey at pressure is pigeonite instead of orthopyroxene. If Humphrey were a mantle melt, it would have been in equilibrium with Martian mantle phases (augite, orthopyroxene, olivine) before its ascent to the surface and not a pigeonite phase [8, 9]. However, experimental work has suggested that pigeonite, rather than augite, could be in equilibrium with orthopyroxene and olivine in the Martian mantle [10, 11]. If this is the case and Humphrey has a single pressure and temperature point where these phases are in equilibrium on the liquidus, then Humphrey could be a mantle derived liquid.

In order to test whether Humphrey represents a liquid or a partial cumulate, further crystallization experiments would have to be conducted to see if once 25% olivine has crystallized from the melt the composition of the olivine is similar to those reported from TES and Mossbauer spectrometer.

Conclusion: Crystallization experiments on a synthetic Humphrey composition suggest that it is not a pristine mantle melt, but is a product of lower-pressure magma fractionation. At this time there is not enough data, experimental and petrologic, to suggest whether or not Humphrey contains cumulate olivine.

References: [1] McSween H.Y. (2002) *Meteorites & Planet. Sci.*, 37, 7-25. [2] McSween H.Y. et al. (2006), 111(E2). [3] Morris R.V. et al. (2004) *Science*, 305, 833-836. [4] Gellert R. et al. (2006) *JGR-Planet*, 111(E2). [5] Carr (2000) *Igpet for Windows*. Terra Softa Inc. [6] Monders A.G. et al. (2005), *Lunar and Planetary Sci. XXXVI*, Abstract# 2069. [7] Monders A.G. et al. (2006) *Lunar and Planetary Sci. XXXVII*, Abstract# 1834. [8] Bertka C.M. and Holloway J.R. (1994) *Contrib. to Min. and Pet.*, 115, 313-322. [9] Bertka C.M. and Holloway J.R. (1994) *Contrib. to Min. and Pet.*, 115, 323-338. [10] Bertka C.M. and Holloway J.R. (1993) *JGR-Solid Earth*, 98, 19755-19766. [11] Bertka C.M. and Holloway J.R. (1988) *Proc. Lunar Planet. Sci. Conf*, 18th, 723-739.