

ATMOSPHERIC PRESSURE EXPERIMENTAL STUDIES OF A LOW-SILICA MARTIAN MANTLE COMPOSITION; Laurie A. Leshin\*, John R. Holloway and Constance M. Bertka, Depts. of Geology and Chemistry, Arizona State Univ., Tempe, AZ 85287

Several authors have derived bulk compositions for the martian mantle using cosmochemical and geophysical measurements and models (i.e. 1,2). Using such compositions as a guideline, experimental studies can give insight into the chemistry of magmas produced by the partial melting of the martian mantle. Partial melt experiments in the 20-30 kb range have proven useful but difficult (3). By performing atmospheric pressure experiments, many of the difficulties can be eliminated and useful information about martian mantle phase relations can be obtained. These experiments are interesting in a general sense as well, as iron-rich compositions such as those proposed have not been studied in great detail. Of course, this study is intended as a low-pressure, volatile-free end member to be used in conjunction with other studies in an attempt to gain a more complete understanding of high-Fe, Martian mantle-like systems as a whole.

The bulk composition chosen for study was a slight variation on that proposed by Morgan and Anders (1) and is given in Table 1. The starting material was an oxide mix fused and crushed twice. All experiments were run in a one atmosphere gas mixing furnace using CO and CO<sub>2</sub> gases to control the oxygen fugacity at the quartz-fayalite-magnetite buffer. Samples were run on Pt-wire loops to minimize Fe loss and quenched in water with the exception of the 1075°C experiment run in a Pd-Ag capsule. Run durations varied from 11 days at 1100° to 5 hours at 1450°. The 1075°C run, critical to the solidus temperature determination, was run for 5 days, reground, and rerun for 7 days. Run products mounted as polished thin-sections and analyzed on an electron microprobe set at 15kV accelerating potential with a 10nA beam current using 2 and 10 μm beams.

The composition was run at temperatures ranging from 1050 to 1450°C. The solidus temperature was found to be 1062±20°C and due to furnace limitations, the liquidus was never reached, but it must lie very near 1500°C based on extrapolating melt compositions shown in Figs 1 & 2 to the bulk composition. Only the 1075 to 1450°C experiments were analyzed. In experiments above 1075°C, the only phases present were olivine, chromium spinel and melt. The 1075°C run also had plagioclase present. Modal abundances of olivine, spinel and melt are shown in Fig 3. This bulk composition also has orthopyroxene and clinopyroxene present in the subsolidus assemblage at 1050°C, although those phases are not seen in the 1075°C run. Thus the pyroxenes and plagioclase disappear over a very short melting interval in this bulk composition. This result would be significant for melting of the uppermost Martian mantle, but may not be applicable to other proposed Martian mantle bulk compositions.

Table 1

| Starting composition           |       |
|--------------------------------|-------|
| SiO <sub>2</sub>               | 41.60 |
| TiO <sub>2</sub>               | 0.33  |
| Al <sub>2</sub> O <sub>3</sub> | 6.39  |
| Cr <sub>2</sub> O <sub>3</sub> | 0.65  |
| FeO                            | 15.85 |
| MnO                            | 0.15  |
| MgO                            | 29.78 |
| CaO                            | 5.16  |
| Na <sub>2</sub> O              | 0.50  |
| NiO                            | 0.20  |

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Partitioning of Ni and Cr between olivine and liquid was also studied using electron probe

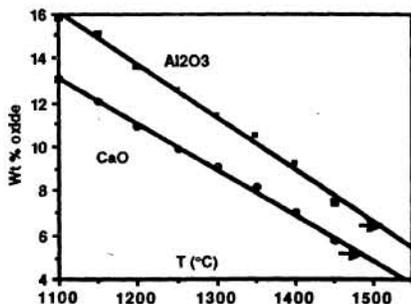


Figure 1. Variation of CaO and Al<sub>2</sub>O<sub>3</sub> in the melt as a function of T. Arrows indicate the starting composition.

analysis. Partition coefficients, calculated as weight % Ni or Cr in olivine/ weight % Ni or Cr in melt, are plotted against temperature in Figs. 4 & 5. It has been stated that the partition coefficient of Ni can be useful as a geothermometer (4,5). The partitioning of Ni measured

in this study is consistent with the model of Hart &

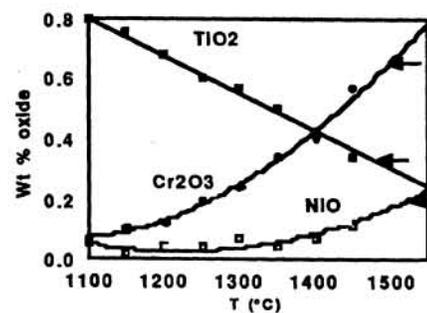


Figure 2. Variation of TiO<sub>2</sub>, Cr<sub>2</sub>O<sub>3</sub> and NiO in the melt as a function of T. Arrows as in Fig. 1.

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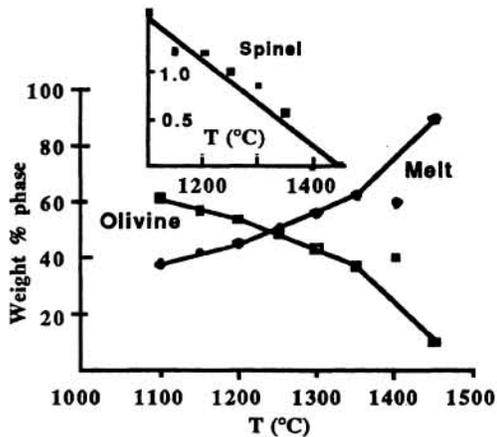


Figure 3. Modes for olivine, liquid, and spinel (inset) as a function of T. Calculated by mass balance from phase and bulk compositions.

Davis (6) for these liquid compositions, showing a pronounced trend with temperature. Chromium also shows a significant temperature dependence (Fig. 5).

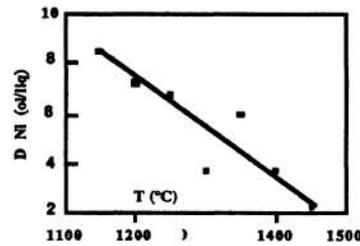


Figure 4. Partition coefficient for Ni between olivine and liquid.

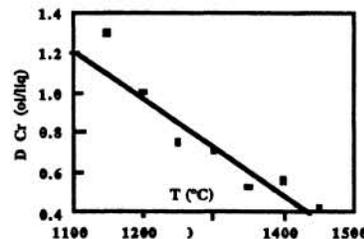
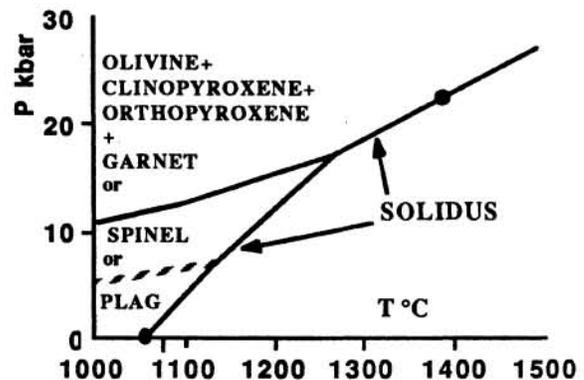


Figure 5. Partition coefficient for Cr between olivine and liquid.

The solidus temperature determined in this study can be combined with the 23 kbar solidus determined by Bertka & Holloway (3) and the position of the spinel-garnet transition for this bulk composition (7) to estimate the position of the anhydrous solidus in the upper Martian mantle (Fig. 6). Because the solidus temperature depends only on the phase assemblage and phase compositions, and not on bulk composition, this solidus will be applicable to any proposed bulk composition with the phase assemblages shown in Fig. 6.



- References: (1) Morgan, J.W. and Anders, E. (1979) *Geochim. Cosmochim. Acta*, 43, 1601-1610. (2) McGetchin, T.R. and Smyth, J.R. (1978) *Icarus*, 34, 512-536. (3) Bertka, C.M. and Holloway, J.R. (1987) *Lunar Planet. Sci. XVIII*, 68-69. (4) Leeman, W.P. and Lindstrom, D.J. (1978) *Geochim. Cosmochim. Acta*, 42, 801-816. (5) Irving, A.J. (1978) *Geochim. Cosmochim. Acta*, 42, 743-770. (6) Hart, S.R. and Davis, K. E. (1978) *Earth Planet. Sci. Lett.* 40, 203-219. (7) Patera, E.S. and Holloway, J.R. (1982) *Proc. 13th LPSC, JGR 87*, A31-36.