

## PARTIAL MELTING OF AN ANHYDROUS MARTIAN MANTLE;

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The bulk composition and phase assemblages of a planet's interior are reflected in the nature of the lavas erupted at its surface. Predictions of the Martian mantle bulk composition have been derived from both geophysical and cosmochemical arguments (1, 2, 3, 4). In comparison to terrestrial values, these predictions are characterized by their iron enrichment. Phase assemblages of the Martian mantle have been estimated from the projection of predicted bulk compositions into the experimentally determined phase regions of the CaO-MgO-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub> (CMAS) system as well as from the application of thermodynamic calculations on reactions in this system (5, 6). Possible phase assemblages in a 20kb to 30kb region include spinel lherzolite, garnet lherzolite and spinel-garnet wehrlite where the modal abundances of orthopyroxene in the garnet lherzolite and spinel in the wehrlite are low (<7mol%). Whereas a terrestrial primary melt produced in a 20kb to 30kb region will be controlled by olivine + clinopyroxene + orthopyroxene + either spinel or garnet equilibrium, a primary melt in this region of the Martian mantle may be largely dominated by only olivine + clinopyroxene + garnet equilibrium. Primary Martian melts in a 20kb to 30kb region have been described from a comparison to topologies in the CMAS system as alkali olivine basalts (1, 5). A more definitive description of their nature necessitates the advancement of experimental work in the appropriate iron bearing systems.

The composition of partial melts produced in peridotite melting experiments are elusive due to the overgrowth of quench crystals on stable residual phases (7). The severity of the quench problem for terrestrial compositions can be reduced by sandwiching a basalt between peridotite layers creating a non-quench modified area suitable for analysis (8). The iron rich Martian mantle compositions used in the present experiments produce lower viscosity melts than terrestrial mantle compositions (9). Our experiments have demonstrated that the lowered viscosity enhances the quenching problem and renders the sandwich technique useless for isolating anhydrous patches of melt in the pressure regime of interest. Therefore, the iron rich, anhydrous primary melt composition sought in this study is located by searching for the basaltic composition whose liquidus phases are equivalent in composition to the residual olivine, clinopyroxene and garnet peridotite minerals appropriate to the Martian mantle. The Mg/Fe ratio of the residual olivine is a reflection of the bulk mantle ratio and so provides an initial constraint on the primary melt composition. For an assumed average mantle mg# of 78 (mg#=atomic Mg/Mg+Fe) and a Kd=.30 for Mg/Fe partitioning between olivine and melt, the desired liquid composition, saturated in olivine, clinopyroxene and garnet, will have a mg# of 52.

Starting basaltic compositions were synthesized in a gas mixing furnace at 1000C and an fo2 one log unit below QFM. Experiments were run in 6mm long graphite lined platinum capsules in a solid-media piston cylinder at 23kb. This pressure was chosen to be well inside the garnet lherzolite stability field for the Morgan and Anders composition (6). Results of these experiments are given in Table 1. In Figure 1 the starting compositions are projected from orthopyroxene onto an olivine-clinopyroxene-garnet plane.

Our first choice of liquid composition was based on a terrestrial garnet lherzolite partial melt composition (10) revised to reflect the Martian melt Mg/Fe ratio. This composition was then modified by trial and error until saturated in garnet (while maintaining the correct Mg/Fe ratio). In this manner the cotectic between clinopyroxene and garnet in the iron rich system was located (see Figure 1). Central to the identification of the liquidus phases was the discrimination between quench and stable crystals as these melts fail to quench to glasses. Using an electron microprobe in SEM mode, textural as well as chemical variations were used to make this distinction.

Based on phase proportions, assemblages and temperatures from Table 1, our best estimate of a co-

TABLE I. EXPERIMENTAL RESULTS

RUN #	COMP	T(°C)	PRODUCTS
Tak 2	Fe-Tak	1300	Cpx + Gt + Ol
Tak 3	Fe-Tak	1350	Cpx + Quench Xtals
Tak 4	Fe-Tak	1400	Cpx + Quench Xtals
Tak 5	Fe-Tak	1450	Quench Xtals
Tak 12	TG#1	1330	Cpx + Gt
Tak 13	TG#1	1360	Cpx + Gt + Quench Xtals
Tak 14	TG#1	1390	Cpx + Gt + Quench Xtals
Tak 15	TG#1	1405	Gt + Quench Xtals
Tak 16	TG#2	1375	Cpx + Gt + Quench Xtals
Tak 17	TG#2	1400	Cpx + Quench Xtals
Tak 18	TG#2	1387	Cpx + Gt + Quench Xtals
Tak 19	TG#2	1425	Quench Xtals

All pressures 23kb, run durations from 3-6 hrs.

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tectic (clinopyroxene + garnet) liquid composition is shown as point L in Figure 1. The solidus temperature for a Martian mantle yielding this liquid composition at 23 kb is  $1400 \pm 15^\circ\text{C}$ . Further experiments are needed to exactly locate the point where olivine saturation is reached, which will correspond to the primary melt composition. Based on the analogous terrestrial point (11), we expect the triply saturated liquid to be only slightly richer in olivine than point L. Point L is very close to the liquid composition from run Tak15 and so we can use electronprobe analysis as an estimate of L. That composition is given in Table 2 together with its CIPW norm, which shows it to be on the border between tholeiitic and alkalic basalts. Because our experimentally determined mineral compositions can adequately express most of the accepted model mantle compositions for Mars (1,2,3,4) composition L should represent cotectic liquids formed by small degrees of partial melting of any of those mantles under anhydrous conditions.

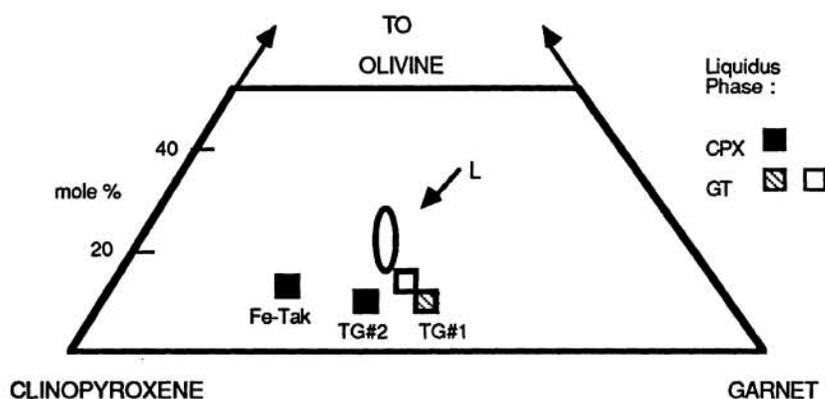


Figure 1. Projection of bulk starting compositions (filled squares have clinopyroxene on their liquidus, shaded squares have garnet on their liquidus), an analyzed liquid composition in equilibrium with garnet (open square), and our estimate of the cotectic liquid composition, L (ellipse). The projection was made using mineral compositions from liquidus experiments for clinopyroxene and garnet and Fo<sub>78</sub> olivine.

Table 2. Estimate of composition L

Oxide	Wt%	Norm	Wt%
SiO <sub>2</sub>	42	Ab	3
Al <sub>2</sub> O <sub>3</sub>	16.5	An	41
FeO	18.5	Ne	2
MgO	10.9	Di	13
CaO	11.4	Ol	40
Na <sub>2</sub> O	0.9		

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