

INVESTIGATION OF THE ORIGIN OF HI-TI BASALTS BY POLYBARIC FRACTIONAL FUSION. J. Longhi. Lamont-Doherty Earth Observatory, Palisades, NY 10964 USA

New experiments at 25 and 30 kb help to define the ilmenite saturation surface in liquids relevant to melting of the mare basalt source region. These data have been incorporated into new calculations of polybaric fractional fusion. The calculations show that it is possible to generate composite liquids, similar in composition to the very-high-Ti (VHT) red and black volcanic glasses, by the same process of polybaric fractional fusion proposed for the very-low-Ti green glasses by [1]. The only important difference is the composition of the VHT source, which was the result of adding 10 % of a 1:1 mixture of ilmenite and clinopyroxene to the green glass source composition of [1]. However, calculated densities of the instantaneous melts are distinctively higher than those of the depleting source. As the melt sinks through the rising source, it freezes and becomes denser still. In order to generate the VHT magmas, the frozen VHT primary melts must remain within the source. To do this, the frozen melt must remain in discrete, isolated lenses rather than accumulate into a single mass.

Three melting experiments in Fe-capsules have helped to define the high-pressure ilmenite saturation surface (Table 1). The two ilmenite-saturated runs have $Mg'(liq)$ lower (~ 3) than expected for the mare source. Predictably, ilmenite-saturated liquids with higher Mg' would have higher concentrations of TiO_2 as borne out by the TI1195-1 liquid with 21.8% TiO_2 and no ilmenite. Similarly, garnet saturation in the low- Mg' 30 kb run is at 4.9 wt % Al_2O_3 , whereas there is no garnet in the higher Mg' run despite higher Al_2O_3 (5.6 %) in the liquid.

As a simulation of ilmenite-clinopyroxene masses settling into the lunar interior and mixing with more primitive cumulates, the composition of the hi-Ti mare basalt source region was approximated as that of the green glass source region [1] plus 10 wt% of a 1:1 mixture of ferroan clinopyroxene and ilmenite. The VHT source is thus a mixture of two cumulates. A calculation of polybaric fractional fusion was made for the hybrid source with the same parameters that proved successful for the green glass magma: initial melting at 40 kb, 1 mol % melt/kb of decompression, 50 % of the melt retained in the source at each step. Results of the calculations are shown in Fig. 1. Instantaneous melts are open squares; pooled melts are filled squares. The composition of the final pooled melt is a close, though not exact match for the VHT volcanic glasses. Garnet and ilmenite are residual phases at 40 kb. Garnet melts out in the next increment of melting, but ilmenite persists down to 26 kb. If garnet persisted as well, the instantaneous melts would become too aluminous to produce the VHT compositions. The 40 kb instantaneous melt contains 23 wt% TiO_2 , whereas the 8 kb melt contains less than 5 %. The 1 atm liquidus boundaries are appropriate for liquids with the TiO_2 content of the VHT glasses (15-16 %).

Calculated melt densities are plotted in Fig. 2 and contrasted with the density of the source (compressibilities from [2]). At $P > 24$ kb melts are denser than the source and will sink within the source. Sinking melts will crystallize to garnet and ilmenite-rich masses and become even denser than the liquids. If these masses of frozen melt sink out of the source, the capacity of the source to generate VHT magmas will diminish, if not disappear. As long as the masses remain within the source, they will cycle through episodes of melting (net ascent) and crystallization (net descent) [3]. Because the amount of melting is small, it is possible for these masses to remain within the ascending source as long as the masses remain dispersed because settling velocity depends on volume as well as density. Masses remaining within the ascending source when the source crosses the density cross-over at ~ 24 kb will subsequently melt and form pools of buoyant liquid. These pools will initially have net ascent velocities less than that of the source and will thus form reservoirs into which fresh increments of melt will mix. Limited removal of some of the ilm-garnet masses prior to the source reaching the density cross-over is a possible way of introducing trace element heterogeneities and unsupported isotope ratios in intermediate to high-Ti magmas.

REFERENCES: (1) Longhi J. (1992) *Lunar Planet. Sci.* XXII, 343-353. (2) Agee C.B. and Circone S. (1995) *Lunar Planet. Sci.* XXVI, 5-6. (3) Hess P.C. and Parmentier E.M. (1994) *Lunar Planet. Sci.* XXV, 541-542.

Table 1. Compositions of High-Ti Liquids and VHT Source (wt% oxides)

	SiO ₂	TiO ₂	Al ₂ O ₃	Cr ₂ O ₃	FeO	MgO	MnO	CaO	K ₂ O	Na ₂ O	Sum
895-2 30 kb 1410 °C: cpx, ilm, gar; $Mg'(liq) = 0.28$	29.69	20.54	4.51	.26	30.11	6.41	.27	6.25	.79	.98	99.8
895-3 25 kb 1435 °C: cpx, ilm; $Mg'(liq) = 0.30$	31.15	19.7	5.0	.3	28.6	7.01	.28	6.81	.6	1.0	100.5
1195-1 30 kb 1500 °C: ol; $Mg'(liq) = 0.51$	29.3	21.8	5.56	.47	19.6	11.5	.21	10.1	.27	1.02	100.4
Model VHT Source	41.7	2.70	1.48	.66	17.9	33.0	.19	2.41	.003	.32	

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Fig.1 Projection from Wo (wollastonite) component of melts generated during polybaric fractional fusion of VHT source (Table 1). Open squares are instantaneous melt compositions; solid squares are pooled melts. Melting begins at 40 kb; last melting episode at 8 kb. 1 atm liquidus boundaries are drawn for VHT glass compositions.

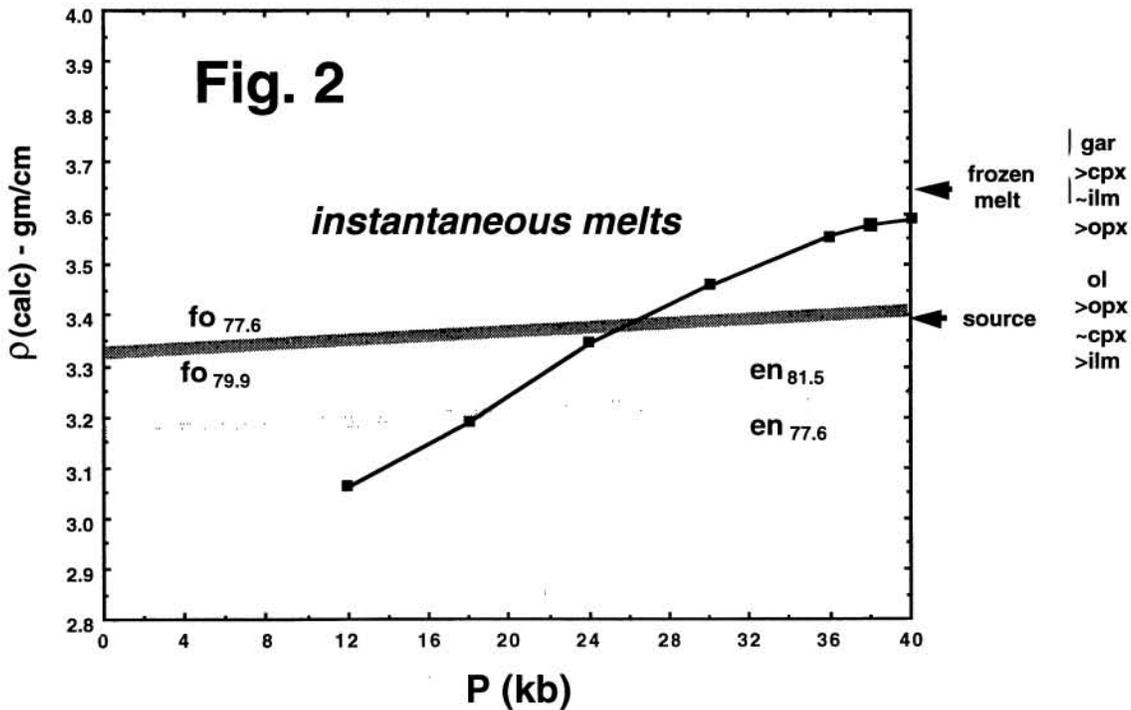
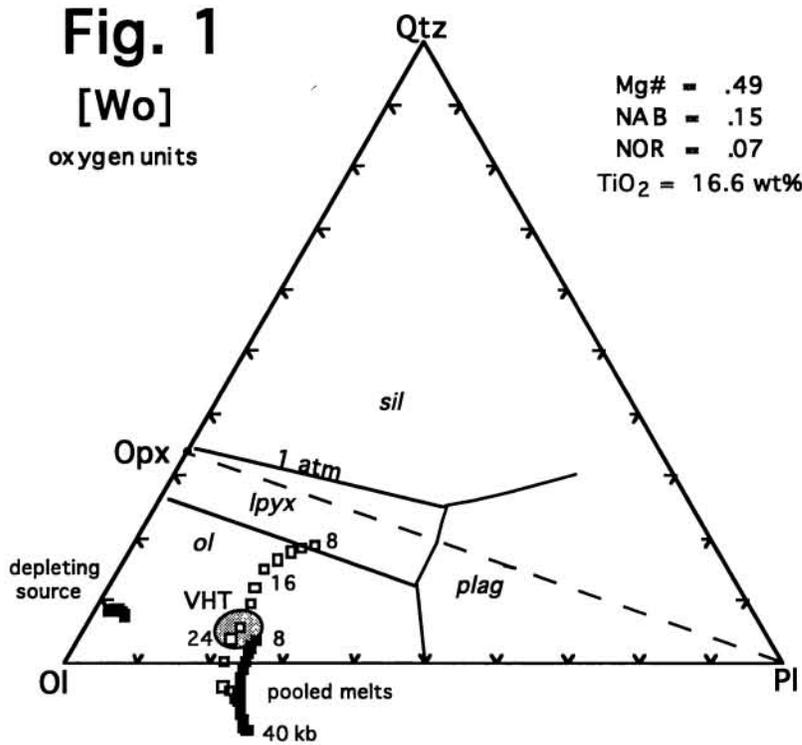


Fig. 2 Calculated densities of instantaneous melts versus pressure. Olivine and pyroxene density curves from [2].