ORIGIN OF LUNAR HIGH TITANIUM ULTRAMAFIC GLASSES: A HYBRIDIZED SOURCE?

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Introduction: Two new hypotheses for the origin of the lunar high-Ti ultramafic glasses are considered in this study. These new models are motivated by the results of experiments on a model hybridized lunar magma ocean cumulate composition. These models are also motivated by the failure of current models to adequately account for the processes that lead to the origin of these unique lunar ultramafic magmas.

Experimental Methods and Results: The near liquidus phase relations of a model hybrid source composition were determined in synthesis experiments over the pressure range of 1 to 2 GPa. The experimental liquids contain as much as 10 wt % TiO_2 however, the compositions are too CaO rich and do not plot along the lunar glass trend of [1] (Figure 1). Melting of the model hybridized lunar mantle source cannot produce the TiO_2 contents observed in the Apollo red and black glasses and only manages to produces liquids that match the lowest TiO_2 content orange glasses (Figure 1).

In the first model we propose that the observed compositional variability at the high-Ti end of the glass spectrum is created by melting of compositionally heterogeneous source materials produced during the late stages of magma ocean crystallization (Figure 1). The lunar hybridized source composition that we have investigated can produce the major element compositional characteristics of the Apollo 17 orange glass and is saturated with olivine and orthopyroxene as residual phases in the source.

Models of high-Ti glass generation that include fractional crystallization and/or melting involving these two

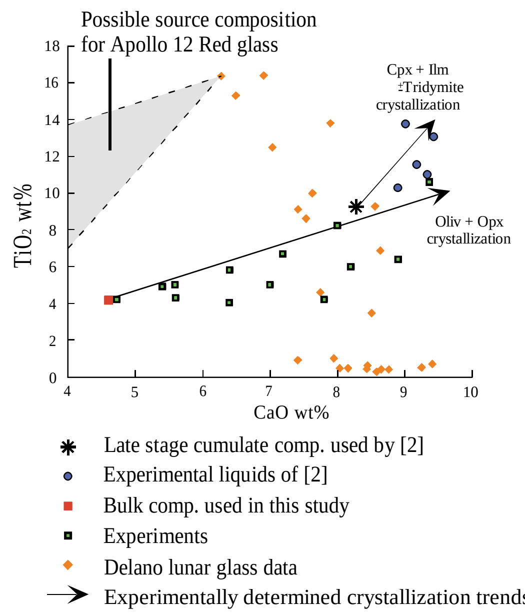

Figure 1. Lunar and experimentally produced glass composition data. The lunar glasses display a trend of increasing TiO_2 content with decreasing CaO content. Experimental glasses reach a maximum TiO_2 content of 10 wt% but are more CaO rich than the Lunar glasses.

phases is an attractive possibility because all lunar ultramafic melts show evidence of high pressure multiple saturation with these phases. However, crystallization of these phases in the proportions indicated from high pressure experimental results will not produce the entire spectrum of high-Ti glasses. Perhaps the compositional variability is caused by heterogeneity in the phase proportions stored as late-stage cumulate residues.

In the second model, low degree partial melts of the hybridized magma ocean source are segregated during partial melting and sink into and interact with underlying hotter olivine + orthopyroxene cumulates, giving rise to the compositional spectrum observed in the high-Ti ultramafic glasses. In this model, the Apollo 17 high-Ti orange glass is produced by the highest degree of melting of the hybridized source. Higher-Ti ultramafic glasses (e.g. Apollo

15 red and Apollo 14 black glasses) are produced by smaller degrees of melting of the hybridized source when olivine + orthopyroxene + clinopyroxene are still present as saturating phases.

References: [1] Delano J.W. (1986) *J. Geophys Res. v. 91*: D201-D213. [2] Van Orman, J.A. and Grove, T.L. (2000) *Meteoritics v. 35*: 783-794.