

TOWARD DEVELOPING A GARNET LHERZOLITE SATURATION MODEL FOR LUNAR LOW-TI, ULTRAMAFIC GREEN GLASS COMPOSITIONS. J. A. Barr¹ and T. L. Grove¹, ¹Massachusetts Institute of Technology, 77 Mass. Ave, Cambridge, MA, 02139; jaybarr@mit.edu

Introduction: The petrogenesis of the low-Ti lunar ultramafic glasses is critical to the understanding of volcanic processes on the Moon. Popular petrologic models developed to explain the formation of these glasses involve high pressure melting of a variety of sources, including primordial, garnet bearing, lunar mantle and depleted lunar magma ocean (LMO) cumulates [1,2,3,4]. Following the high pressure melting some of models involve continued, polybaric, melting and pooling of the melts at shallow depths [4,5] and others involve deep melts ascending to shallow depths where they interact with overturned LMO cumulates [1,2,3]. Members of this later class of models vary in their interpretation of the formation of the original, deep melts; from remelting of depleted magma ocean cumulates, to melting of primordial, garnet bearing, lunar mantle, previously unaffected by LMO processes. To fully evaluate these different scenarios, petrologic melting models must be developed for all possible lunar mantle materials, including garnet bearing lithologies.

Motivation: Geochemical evidence indicates melts of a garnet-bearing, primordial lunar mantle have contributed to the formation of some lunar ultramafic glasses [3], however experimental studies of the lunar ultramafic green glasses indicate that the compositions are not saturated with garnet bearing lithology over expected pressure ranges [1,6,7]. These experimental studies indicate that ultramafic green glasses were last in equilibrium with an olivine + orthopyroxene assemblage at ~2.4 to ~1.3 GPa [1,2,7]. This range in pressures has been explained by allowing deep, hot melts to assimilate LMO cumulates over a range of pressures, giving rise to the chemical trends found in the ultramafic glass compositions [8]. Because of the interaction with LMO cumulates, determining the origin of the original parental melts cannot be done using traditional inverse experimental petrologic techniques.

Estimating garnet saturated melts of a lunar mantle: A recent study of terrestrial mantle melting has produced a model to estimate garnet saturated peridotite melts [9]. This model was used to investigate the possible relationship of melts in equilibrium with a garnet and the green glass compositions of Apollo 15 Group C [7]. The results of this study presented evidence that the predicted garnet saturated melt compositions could be related to the Apollo 15 green glasses of Group C, as defined by [8]. However, they also found

that the predicted compositions derived from the model of [9] were not sufficiently calibrated for the extreme compositions of the lunar ultramafic glasses. More experimental work is needed to extend the predictive model calibration to include lunar compositions and is the focus of the current study.

Preliminary results: This study uses the algorithm of [9] as a starting point to predict garnet lherzolite saturated melt composition based on the composition of Group C green glasses of Apollo 15. These calculated melts are then investigated in the laboratory to determine the true multiple-saturation behavior. Experiments produced liquids saturated with olivine + clinopyroxene + garnet near the liquidus at 2.6 GPa, missing co-saturation with orthopyroxene. Since a primordial lunar mantle would be expected to be a garnet lherzolite, orthopyroxene is a crucial phase.

Previous phase equilibrium experiments of [7] and [2] showed that the Apollo 15, Group C green glasses are saturated with orthopyroxene on the liquidus, becoming co-saturated with olivine and eventually low-Ca clinopyroxene with decreasing temperature. In an effort to get the garnet-saturated liquid to also saturate with orthopyroxene, the two compositions were mixed to produce a hybrid melt that was 50% actual green glass composition and 50% estimated garnet lherzolite saturated composition. This melt was then used in phase equilibrium experiments, and was found to produce olivine + clinopyroxene + orthopyroxene near the liquidus at 2.6 GPa and 1520°C. However, at 1500°C and 2.6 GPa, this saturation changes to olivine + clinopyroxene + garnet. This implies saturation with all the requisite phases at 2.6 GPa and ~1510°C. When this bulk composition is then compared to the compositions predicted from the model of [9] for a range of pressures, it closely resembles the composition predicted to be multiply-saturated at 2.8 GPa.

These preliminary results suggests that the current garnet lherzolite saturation model of [9] can predict analog lunar melt compositions that saturate with a garnet lherzolite lithology, but does not accurately estimate the pressures and temperatures of these melts. Further work will attempt to accurately calibrate the saturation model for lunar compositions so melt compositions can be calculated to be used in mixing models to evaluate petrologic models for the formation of the lunar ultramafic green glasses.

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