AN "UNCOLLECTED" MEMBER OF THE MG-SUITE: MG-AL PINK SPINEL ANORTHOSITES AND THEIR PLACE ON THE MOON. T.C. Prissel[1], S.W. Parman[1], J.W. Head[1], C.R.M. Jackson[1], M.J. Rutherford[1], P.C. Hess[1], L. Cheek[1], D. Dhingra[1], and C.M. Pieters[1]. [1]Department of Geological Sciences, Brown University. Providence, RI 02912 USA. (Tabb_Prissel@Brown.edu)

Introduction: The discovery of Mg-Al "pink" spinel anorthosite (PSA) [1,2] has renewed an interest in spinel-bearing lithologies on the Moon. Recent work suggests such rock types likely formed from melt-rock interactions and represent a widespread, low volume constituent of the the lunar crust [e.g. 3, 4]. Indeed, as M^3 (Moon Mineralogy Mapper) data continues to be processed, spinel "sightings" are ever increasing [5, this conference].

Spectral evidence suggests that currently observed spinel lithologies have very high Mg#'s (Mg/(Mg + Fe) ~ 90 or greater) [1, 2, 6]. In the present study we show that only spinels by Mg-suite parental liquids (MgPL) with anorthite have Mg#'s high enough to match the spectral observations [3]. Therefore, high Mg# PSA may represent an "uncollected" member of the Mg-suite of lunar rocks (that is, not returned during Apollo or Luna missions).

Additionally, the spinel stability field is highly pressure dependent. Therefore, the depth of formation is constrained by the presence or absence of spinel. Here, we have conducted a series of experiments to constrain the pressures necessary for spinel formation during melt-rock reactions on the Moon.

Experimental Set Up: Starting compositions were modeled after an MgPL [7] and Apollo 15C green glass (A15GG) [8] and synthesized using reagent grade oxides. Thin (~ 5mm outer diameter) graphite "sleeves" with a fixed bottom and open top were machined to house the synthesized basaltic powders juxtaposed against sintered pure anorthite. This package was then completely surrounded by carbon-graphite powder, all packed and sealed within an outer Pt capsule (Fig. 1).

This method is a modification of our previous setup, where confining pressures were not precisely known in the lowest-P runs. This was due to the use of thick-walled (~1.5mm) and capped graphite crucibles which remained largely intact after quench and suggested that the sample pressure was lower than the confining pressure. The thin graphite sleeve in combination with the graphite powder appears to have remedied this issue.

Experiments were run at or near the liquidus temperatures of the basalts (1400 ^oC) and over a pressure range of 0.5kbar-10.5kbar pressures. Lower pressure experiments were performed in an internally heated pressure vessel (IHPV) following the set up described above. 8-10.5kbar pressure experiments were carried out using a piston cylinder apparatus following procedures of [3].

Post-experiment, graphite sleeves appear both cracked and crushed into several pieces indicating that the sample pressure equaled the confining pressure. Contact with the outer Pt capsule (which would result in Fe-loss from the melt) was prevented by the encapsulating graphite powder.

Results: Melt-rock reactions between MgPL + anorthite produced Mg-Al spinel over our entire experimental pressure range. Spinel compositions in these experiments were consistent with spectral constraints from M^3 (Mg#'s > 90) and experimental assemblages are consistent with a ~ mafic free lithology (another key petrological constraint from the spectra). Experiments reacting A15GG + anorthite also produced Mg-Al spinels over the entire pressure range, but spinel compositions were inconsistent with observations from M^3 (Mg#'s ~ 75). However, previous A15GG + anorthite experiments using thick-walled graphite capsules did not produce spinels at 0.5 kbar pressures. This implies that 0.5kbar pressure is approaching the lower limit of the spinel stability field with respect to the A15GG composition during melt-rock reactions with anorthite.

Implications: The compositions of spinel in our experiments strongly implies that spinels observed by M^3 were produced by liquid compositions parental to the Mg-suite. Because MgPL + anorthite produced spinels over the entire experimental pressure range, we cannot place pressure constraints on the formation of high Mg# PSA at this time. However, if lower Mg# PSA are detected on the lunar surface, depth of forma-

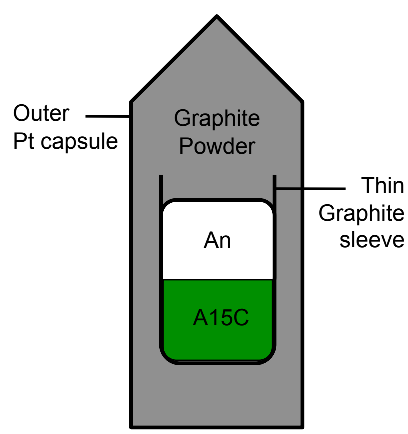

Fig. 1. New experimental design implementing a thinner walled graphite sleeve open to graphite powder to reduce any difference between sample pressure and the confining pressure of the experiment.

tion constraints may be applied. For instance, the absence of spinel in previous A15GG + anorthite experiments at 0.5kbar suggests formation depths greater than ~ 10km within the crust.

Other liquids of interest known to have come into contact with the lunar crust are the Low-Ti Apollo 15 yellow glass (A15YG) and High-Ti Apollo 15 red glass (A15RG) compositions [8]. Preliminary experiments using the techniques reported here of A15RG + anorthite suggest that Mg-Al spinels produced during this reaction may be scarce, if present at all on the near side of the Moon due to the thinness of the crust [9] (no spinel was produced at pressures up to ~ 2kbar).

However, the A15RG experiments were intended to quantify the compositional effects associated with reacting lower Mg# liquids with anorthite and did not vary temperature from A15GG and MgPL experiments. Therefore, the absence of spinel in A15RG experiments may be due to **1)** compositional effects preferentially lowering the stability of spinel as a function of pressure or **2)** the high temperature of the experiments (1400 ^{o}C) was above the stability field of spinel in this system. Presently, we are running experiments to differentiate between 1) and 2).

Conclusions: Experimental results suggest that high Mg# PSA may be an "uncollected" member of the Mg-suite. Additional lower Mg# spinel anorthosite lithologies may also exist within the lunar crust, but are likely constrained to deep crustal origins. With current and future work, we hope to provide a crustal cross section detailing the possible locations and compositions of PSA on the Moon.

References: [1] Pieters C.M. et al. (2011) *JGR, 116.* doi:10.1029/2010JE003727 [2] Dhingra D. et al. (2011) *GRL, 38.* doi:10.1029/2011GL047314 [3] Prissel T.C. et al., (2012) LPSC 43, 2743. [4] Gross J. and Treiman A.H. (2011) *JGR, 116.* doi:10.1029/2011JE003858 [5] Pieters C.M. et al., (2013) LPSC 44, #### [6] Jackson C.R.M. et al., (2012) LPSC 43, 2335 [7] Longhi J. et al. (2009) *Geochim. Cosmo. Acta, 74.* 784-798 [8] Delano J.W. (1986) *JGR, 91.* D201-D213 [9] Wieczorek M.A. et al., (2012) *Science-xpress,* 10.1126/science.1231530.