PINK-SPINEL ANORTHOSITE FORMATION: CONSIDERATIONS FOR A FEASIBLE PETROGENESIS. L. A. Taylor[1] and C. M. Pieters[2]; [1] Planetary Geosciences Institute, Dept. of Earth & Planetary Sciences, University of Tennessee, Knoxville, TN 37996, lataylor@utk.edu ; [2] Dept. of Geological Sciences, Brown University, Providence, RI 02912.

Introduction - The Moon Mineralogy Mapper, a reflectance spectrometer aboard the Chandrayaan-1 Indian lunar orbiter in 2008-2009, made several major scientific discoveries. Most notable was the first report of direct evidence for OH in lunar regolith [1]. In addition, discovery of an entirely new lunar lithology, *Pink-Spinel Anorthosite* (PSA) [1-3], in the regolith of the Moscovience Crater on the farside has renewed excitement in lunar petrology, specifically in the origin of the highlands. This study reviews the petrogenesis of the highlands and focuses on the origin of the PSA and other unusual highland lithologies.

Constraints on the formation of Pink-Spinel Anorthosite – Certain criteria need to be met in order to explain the genesis of PSA. For example, the PSA must: 1) consist of ~20-30 % pink spinel with <5 wt% mafic minerals; 2) have <10 wt% FeO [3]; 3) not be a crystallization product of the Lunar Magma Ocean (LMO) – i.e., not be directly associated with ferroan anorthosite (FAN) formation; 4) have Hi-Mg#, low-FeO Melt = non-mare; and 5) not have formed with the Hi-Mg suite – i.e., too-high Mg#; too much mafic phases – FeO. The conclusion from these considerations is that an unusual origin is required for PSA formation, with low-total FeO content, high MgO, and mostly anorthite.

Highlands Formation - Warren [4] presented a fine review of the origin of the LMO and the overall origin of the highlands of the Moon. The equilibrium and fractional crystallization of the LMO by Snyder et al. [5-6] gave a scenario that addressed the general origin of the mantle and the ferroan anorthosites (FANs) of the proto-highlands. However, the chemistry of the plagioclase floatation, with its minor attached mafic phases, in spite of the modeling of Warren [7], has not been adequately explained. Indeed, the FeO contents of lunar plagioclase are not that which are expected considering its LMO origin, but has instead undergone extensive re-equilibration [8]. The petrogenesis of the high-Mg suite and the gabbro/norite/alkaline suites has been attributed to post-FAN interactions between the initial FAN and intrusions of mantle-derived magma, carrying a signature of the late-stage LMO urKREEP [4]. The nature of these interactions have only recently been addressed.

Recent Experimentation - The classic, detailed, well-designed, and in-depth experimental study by the Brown University petrologists [9] presented a case for the assimilation-dissolution of plagioclase by a picritic magma. This study demonstrated the feasibility of the possible formation of many secondary highland lithologies. However, using the forsterite-anorthite phase

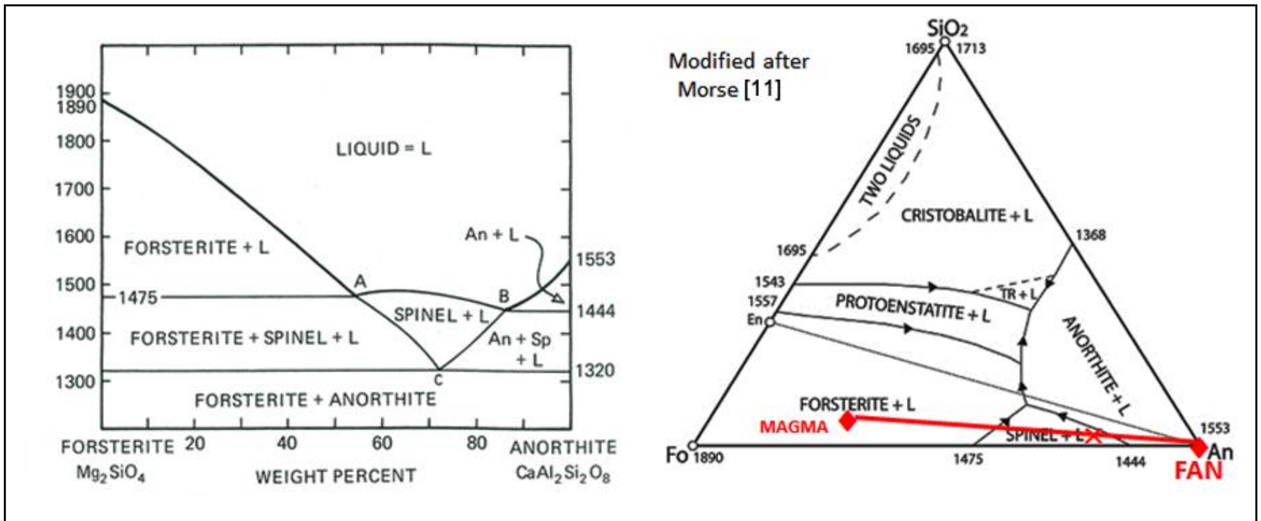

Figure 1. Intrusion of low-FeO magma (♦) into highland crust, represented by FAN. The magma will assimilate a portion of the **FAN** plagioclase such that the composition at that exact site will be in or near the spinel-primary field (e.g., **X**). Crystallization will result in pink spinel anorthosite (PSA).

diagram determined by [10], an explanation was made for the formation of hercynitic spinel $(Mg,Fe)Al_2O_4$ lithologies, within the Fo-An-SiO_2 pseudo-ternary. Subsequent studies by Ganskow et al. [12] and Prissel et al. [13], addressing variations of the assimulating magma, again by the Brown experimental petrologists, have taken this interaction of highland plagioclase with various melts to a more sophisticated level. Indeed, Gross et al. [14] and Gross and Treiman [15] used these experimental studies to explain the occurrence of a hercynitic spinel – anorthite lithology in lunar meteorite ALH 81005, with implications for the formation of PSA. The experimental compositions used would account for formation of spinel troctolites, and even some spinel anorthosites.

Conclusion - In principle, the assimilation of the anorthositic crust by an intruding magma of typical lunar composition would appear feasible for the formation of PSA, except for the composition of the pink spinel that is formed – i.e., it will contain too much FeO. The composition of the intruding magma must have a reasonably hi-Mg# - e,g,, Mg# 60 – but a low-total FeO – ~10 wt%. This is not a common composition for any of the known basalts, EXCEPT for some of the Very-High-Potassium (VHK) basalts from Apollo 14. We propose that the PSA could have formed by the intrusion of a VHK-like basaltic magma into a highland anorthosite, with some assimilation of the highland plagioclase. An accompanying abstract by Pieters et al. (this volume) further addresses this type of interaction between magmas and highland rocks to form the PSA, as well as other unusual lunar highland rocks.

References - [1] Pieters, C.M. et al., (2009) *Science 96,* 500; [2] Pieters, C.M. et al., *LPSC 42*; [3] Pieters et al., (2011) *JGR 116*; [4] Warren, P.H., (1985) *Ann. Rev, Earth Planet. Sci. 13*, 201; [5] Snyder, G.A., et al. (1992) *GCA 56*, 3809; [6] Snyder, G.A., & Taylor, L.A. 1993, *Nat. Inst. Polar Res.,*6246; [7] Warren, P.H. (1990) *Amer. Mineral. 56*, 3809; [8] Taylor, L.A. (2009, *LPSC 41*; [9] Morgan, Z., et al. (2006) *GCA 70*, 3477; [10] Osborn, E.F., & Tait, D.B. (1952) *Amer. Jour. Sci. Bowen Vol*., 413; [11] Morse, S.A. (1994) Basalts and Phase Diagrams, Springer-Verlag, 132 + 162; [112] Ganskow, G. et al. (2011) *Fall AGU* 1695; [13] Prissel, T.C., et al. (2012) *LPSC 43*, #2743; [14] Gross, J. et al. (2011) *LPSC 42*, #2620; [15] Gross, J., & Treiman, A.H. (2011) *JGR 116*, E10009.