PINK SPINEL ANORTHOSITE (PSA) CLASTS IN LUNAR DIMICT BRECCIA NORTHWEST AFRICA (NWA) 15500: EVIDENCE FOR A PETROGENETIC LINK BETWEEN PSA AND MG-SUITE D. Sheikh[1], A. Ruzicka[1], M. Hutson[1], and C. Zlimen[2], [1]Cascadia Meteorite Laboratory, Portland State University, Department of Geology, Portland, OR 97239, USA (dsheikh@pdx.edu), [2]Minnesota Meteorites, LLC, St. Paul, MN 55119, USA.

Introduction: The initial discovery of pink spinel anorthosite (PSA) by the Moon Mineralogy Mapper (M^3) spectrometer in the Moscoviense region [1], and subsequent identification on nearside and farside regions of the lunar surface through additional remote sensing [2] have sparked considerable discussion surrounding 1) the enigmatic chemical nature of PSA and 2) the role of PSA in the grand scheme of LMO differentiation and lunar crustal evolution. Petrogenetic models established from experimental studies have provided constraints into hypothetical formation mechanisms of PSA, which include crystallization from troctolitic melts formed by basin forming impacts [3], formation as cumulates in the deep crust at high pressures from basaltic precursors [4], or magma-wallrock interactions involving assimilation of anorthositic crust into picritic or Mg-suite parental melts at shallow [5] to moderate crustal depths [6-7]; there is no clear consensus yet into the petrogenesis of PSA [8].

Having complementary "ground truth" PSA samples alongside experimental and reflectance spectra data would ultimately provide additional constraints into the petrogenesis of PSA, however, bonafide PSA material that is both 1) spinel-rich and 2) contains <5 vol. % olivine + pyroxene has not yet been identified in either Apollo/Luna samples or lunar meteorites [5-11]. Here, we report on 4 PSA clasts found within Northwest Africa (NWA) 15500, a recently classified lunar dimict breccia comprised of two distinct (but genetically related) lithologies: Lith A- Mg-suite-rich fragmental breccia, Lith B- troctolitic melt rock (Fig. 1).

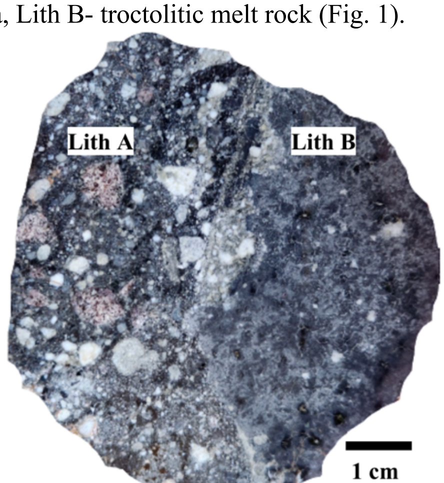

Fig. 1: *Hand specimen image of NWA 15500 stone with lithologies A and B outlined. Scale bar displayed.*

Results: Pink spinel anorthosite clasts C1-C4 (Figs. 2-3) appear angular in texture and are comprised primarily of unzoned, irregularly fractured subhedral spinel grains (grain size range ~50-350 μm) with modal volume abundances of ~36%, ~51%, ~59%, and ~43%, respectively. Plagioclase is observed as both fractured and smooth grains (smooth grains labeled as maskelynite), although their relative abundances vary between PSA clasts. Apart from C4, C1-C3 are devoid of mafic phases; C4 contains unzoned, anhedral olivine grains that comprise ~5 vol. % in modal abundance.

Compositional data for individual spinel grains from each clast are displayed in Figure 4; all spinel grains have compositionally uniform Cr# (with slight variances in Mg#) and plot within the shaded region representing spinel compositions from pink spinel troctolites (PST) [6,12]. Of notice, spinel grains from all clasts plot close to, but not within, the shaded region representing estimated PSA spinel compositions based off M^3 remote sensing data [1,6,13]. For clasts C1-C4, plagioclase is anorthitic in composition (An94.5-95.5, An94.9-97.0, An96.9-97.4, and An96.4-96.9 respectively). Olivine grains from clast C4 are magnesian in composition (Fa7.5-7.8); combined with the spinel data, applying the Ol-Sp geothermometer equation from [14] yields an estimated equilibration temperature for C4 of ~1125°C.

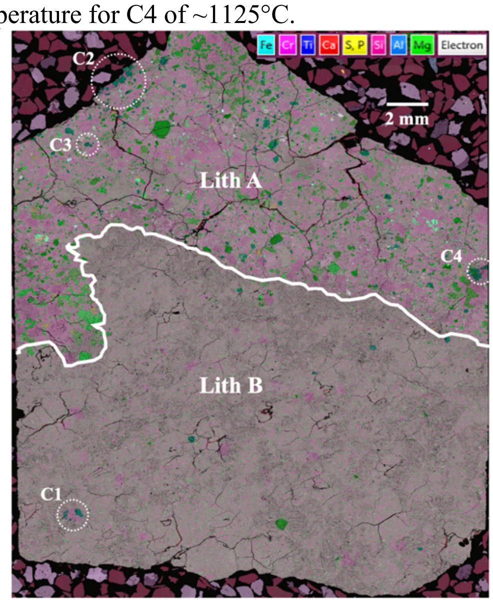

Fig. 2: *False color EDS+BSE chemical map of NWA 15500. Both lithologies and selected clasts outlined and labeled. Element key and scale bar displayed.*

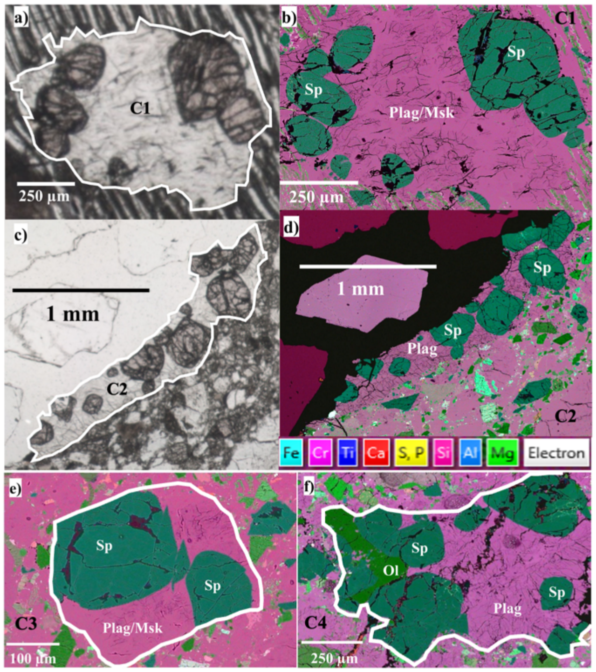

Fig. 3: *Transmitted PPL images of PSA clasts C1-C2 (a and c), and false color EDS+BSE chemical maps of PSA clasts C1-C4 (b, d, e, and f). Clasts outlined with mineral phases labeled (Plag=plagioclase, Msk=maskelynite, Sp=spinel, Ol=olivine). Element key and scale bar displayed.*

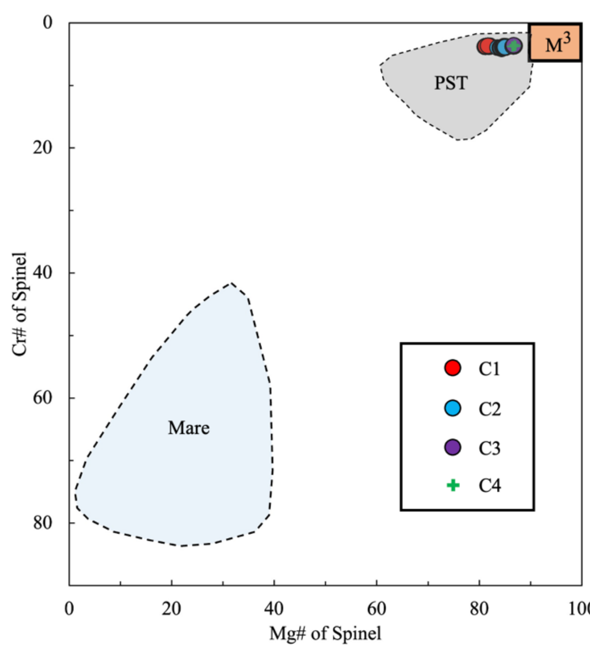

Fig. 4: *Spinel Mg# (Mg/(Mg+Fe)*100) vs. Cr# (Cr/(Cr+Al)*100) for spinel grains from PSA clasts C1-C4. Shaded regions indicate spinel compositions from mare samples, pink spinel troctolites (PST), and from pink spinel anorthosites estimated by remote sensing using M^3 data [1,6,13].*

Discussion: The prevalence of Mg-suite lithic and mineral clasts/fragments scattered throughout NWA 15500 in close proximity to the PSA clasts analyzed in this study raises the question of whether the PSA clasts are genetically related to Mg-suite lithologies (i.e. pink spinel troctolites). Evidence for a potential petrogenetic relationship includes: 1) textural and compositional similarity of PSA spinel in clasts C1-C4 to PST [7,12], 2) compositional similarity of PSA plagioclase in clasts C1-C4 and olivine in C4 to PST [12], similar equilibrium temperature and lack of significant sub-solidus re-equilibration for clast C4 (~1125°C) to that of PST [7]. In summary, this evidence points to PSA as representing an Mg-suite lithology forming alongside PST from magma-wallrock interactions involving assimilation of anorthositic crust into Mg-suite parental melts at shallow to moderate crustal depths (albeit requiring a higher degree of assimilation than PST, potentially involving crystal settling of spinel cumulates as well) [6-7].

To explain compositional discrepancies between spinel from these PSA clasts and the estimated M^3 PSA, two possibilities exist: 1) M^3 PSA formed from either a distinct Mg-suite parental melt or by a different mechanism (i.e. impacts), or 2) the PSA compositional range estimated from M^3 data is greater than predicted, owing to analytical uncertainty [8,13] and bias in identifying the PSA spinel signature in the reflectance spectra, as an increased Fe-content within spinel can mask the PSA spinel signature [6]. Nonetheless, the petrogenetic relationship between PSA clasts in NWA 15500 and Mg-suite lithologies together with the identification of PSA on nearside and farside regions supports ideas [6-7] that suggest Mg-suite plutonism may have been globally distributed on the Moon.

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References: [1] Pieters C. M. et al. (2011) *JGR, 116,* 1-14. [2] Pieters C. M. et al. (2014) *AM, 99,* 1849-1859. [3] Treiman A. H. et al. (2019) *AM, 104,* 370-384. [4] Herzberg C. T. and Baker M. B. (1980) *Proc. Conf. LHC,* 113-132. [5] Gross J. and Treiman A. H. (2011) *JGR, 116,* 1-9. [6] Prissel T. C. et al. (2014) *EPSL, 403,* 144-156. [7] Prissel T. C. et al. (2016) *AM, 101,* 1624-1635. [8] Gross J. et al. (2014) *AM, 99,* 1849-1859. [9] Wittmann A. et al. (2019) *MaPS, 54,* 379-394. [10] Simon S. B. et al. (2022) *JGR, 127,* 1-19. [11] Xie L. F. et al. (2022) *MetSoc 85,* abstract #6071. [12] Shearer C. K. et al. (2015) *AM, 100,* 294-325. [13] Jackson C. R. M. et al. (2012) *LPSC 43,* abstract #2335. [14] Jianping L. et al. (1995) *CJG, 14,* 68-77.