EXPLORING THE RELATIONSHIPS BETWEEN THE APOLLO 17 MG-SUITE SAMPLES IN SEARCH OF A CO-MAGMATIC ORIGIN. D. F. Astudillo Manosalva[1] and S. M. Elardo[1], [1]The Florida Planets Lab, Department of Geological Sciences, University of Florida, Gainesville, FL 32611, USA. daniel.astudillo@ufl.edu.

Introduction: The origin of the magnesian-suite (or Mg-suite) of lunar highlands rocks has been debated since they were first discovered in the early 1970s, and although they have been thoroughly studied ever since, questions remain regarding their origin. The Mg-suite is a group of plutonic crustal rocks defined by its very high Mg# in mafic minerals, interpreted to be a result of early magmatism during or after the lunar magma ocean solidification. Several studies have focused on the composition, origin, evolution and dating of these samples, however, there are still gaps in the data collected from these samples that could be used to further address their origin.

The largest and most pristine Mg-suite samples were retrieved by the Apollo 17 mission from the Taurus-Littrow valley and present many textural similarities among themselves, such as grain sizes, late entrapment phases, and disequilibrium textures. Some of these similarities are suggestive that there might be a co-magmatic origin for many samples which means that some bias might be present within the sample collection and research. Most of the samples have been studied individually and interpreted individually[1–4]. Therefore, if a co-magmatic origin exists for some of these samples, a certain degree of bias may be present in interpretations. To find whether this is the case, we are currently revisiting a large subset of Mg-suite thin section samples from Apollo 17 to obtain new chemical data of major, minor, and trace element compositions with focus on inter-sample relationships. With these data, it will be possible to perform inversions that will shed light over the nature of the source melt that formed these rocks, such as it has been previously done ([1,5]), and together with a detailed comparison of the textures and chemistry of the rocks we will be able to identify shared primary and secondary processes that will allow us to assess whether these samples share a co-magmatic origin.

Methods: The work will be carried out using different thin sections from 20 samples of Apollo 17, encompassing the whole range of Mg-suite rocks that include dunites, troctolites, norites, and gabbronorites. Textural analysis is performed via optical microscope and back scattered electron (BSE) imaging in both scanning electron microscopy and electron-probe microanalysis (EPMA). Analysis of major and minor elements in minerals is done using a Cameca SXFive FE EMP at the University of Florida at 15 kV and 20 nA. Trace elements will be obtained through laser ablation inductively coupled plasma mass spectrometry, mainly on pyroxene and plagioclase in the larger samples. Compositional inversions to calculate parental melt compositions will be carried out using trace element partition coefficients that are appropriate for a lunar environment [6–9].

Mineralogy and textures: There is a very wide range of textures in all samples and distinguishing the primary textures from shock and metamorphic textures can be difficult. Almost all samples are finely brecciated clasts within lunar breccias. Exceptions to these are well known samples like dunite 72415, troctolite 76535, and norites 78235 and 72255. All samples have various degrees of shock, except for 76535. One of the textural features that are common to many samples are chromite/two-pyroxene symplectites, appearing in dunite 72415, troctolites 73146, 73235, 76535, and in norite 78527. The formation of these symplectites has been largely debated, with the most current theory being a reaction between olivine and plagioclase where melt is involved [3]. Another common occurrence among the samples is that of evolved phases trapped within crystallographic edges of the main crystals, usually entrapments of silica with phosphates, troilite, Fe-Ni metal, and/or chromite, but similar entrapments of clinopyroxene and K-feldspar + K-rich melt have been found in norites. Apatite has been found filling cracks in dunite 72415 and troilite has been found the same way in troctolite 73535 and norite 72225. Clinopyroxene often contains exsolution lamellae of orthopyroxene in troctolite 73235, and can be found in disequilibrium as crystalline remnants within orthopyroxene in troctolites and norites. Exsolution lamellae of chromite in orthopyroxene can be found abundantly in norite 72225 and can be found on the orthopyroxene lamellae of troctolite 73235. Both of these samples also present an assemblage of armalcolite ± chromite ± rutile ± ilmenite ± loveringite ± baddeleyite ± zircon. Apatite is the dominant phosphate phase for dunite 72415, troctolites 73235 and 73416, and norite 78535, whereas merrilite is the dominant phase in most other samples where it is present.

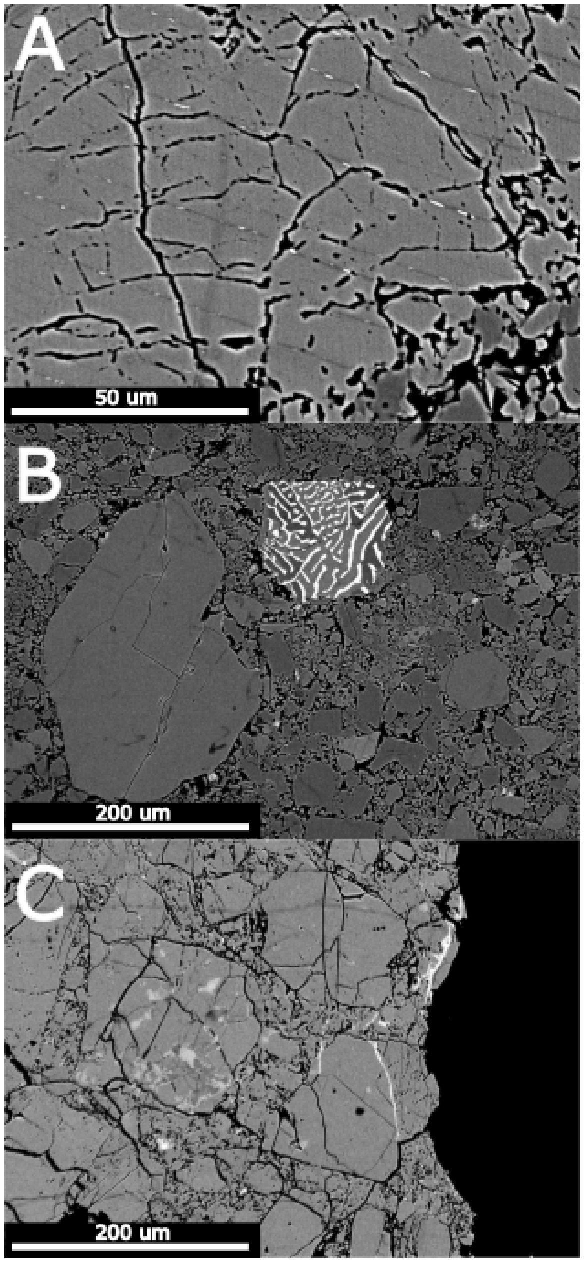

Figure 1: BSE images showing A) clinopyroxene in troctolite 73235 with orthopyroxene lamellae, which in turn have chromite exsolution lamellae. B) Plagioclase crystal and chromite symplectite from troctolite 73235. C) Apatite filling breccia cracks on dunite 72415.

Initial chemical results: Most of our results so far agree with previous reports, (i.e. [1, 5], [10–12]). Measurements are consistent along most minerals within a sample, with only very slight zonations in plagioclase and olivine in a few samples. An interesting observation is in the difference between the Mg# of clinopyroxene and other mafic minerals. We have also identified common evolutionary trends such as an increase in the Ti contents of chromites towards more evolved samples, besides the mol An% in plagioclase vs Mg# in mafic minerals that is one of the main features of the Mg-suite. We have also identified the mineral loveringite as part of the armalcolite + rutile + ilmenite assemblages, a mineral that has previously been recognized as a Ca-Zr-armalcolite [14].

Discussion: We can find some similarities between some samples that might suggest that they might have shared some processes in their formation. The occurrence of chromite symplectites in samples of dunite, troctolite, and norite not only indicates the common presence of the phases involved in their formation, but might also indicate that the physical conditions at which they occur are the same or very similar for all of them. The presence of silicate-rich entrapments and the presence of phosphates is common in norites, and similar assemblages have been seen in troctolite 76535 and dunite 72415, suggesting similarities in their parental melts. The presence of chromite exsolution lamellae in orthopyroxene suggest that troctolite 73235 and norite 72225 might have had similar temperature-pressure conditions, including a similar cooling rate. All of these could be similarities found between different stages of a mafic layered intrusion. The complete chemical analysis of all samples and its compositional inversion will provide new data that could further evidence this co-magmatic origin In addition, findings based on trace phases in these rocks might provide new information about the evolution of these rocks.

References: [1] Papike, J. J., *et al.* (1996) *Geochim. Cosmochim. Acta* 60, 3967–3978. [2] Shearer, C. K., *et al.* (2005) *Geochim. Cosmochim. Acta* 69, 3445–3461. [3] Elardo, S. M., *et al.* (2012) *Geochim. Cosmochim. Acta* 87, 154–177. [4] Shearer, C. K., *et al.* (2015) *Am. Mineral.* 100, 294–325. [5] Papike, J. J., *et al.* (1994) *Am. Mineral.* 79, 796–800. [6] Sun, C., *et al.* (2012) *Contrib. Mineral. Petrol.* 163, 807–823. [7] Yao, L., *et al.* (2012) *Contrib. Mineral. Petrol.* 164, 261–280. [8] Sun, C., *et al.* (2013) *Geochim. Cosmochim. Acta* 119, 340–358. [9] Sun, C., *et al.* (2017) *Geochim. Cosmochim. Acta* 206, 273–295. [10] Dymek, R., *et al.* (1975) *LPSCVI*, 301–341. [11] Warren, P. H. (1993) *Am. Mineral.* 78, 360–376. [12] Papike, J. J., *et al.* (1998) *Rev. in Mineral. Geochem.36,* 5-1-5–234. [13] Pearson, D. G., *et al.* (2014) in *Treatise on Geochemistry (Second Edition)*, 169–253. [14] Zhang, A.-C., *et al.* (2020) *Am. Mineral.* 105, 1021–1029. **Acknowledgements**: The authors acknowledge support from NASA Solar System Workings grant 80NSSC19K0752 and UF.