UNIQUE PINK SPINEL SYMPLECTITE ASSEMBLAGE IN NORTHWEST AFRICA (NWA) 10401: BREAKDOWN REACTION THROUGH SOLID-STATE DIFFUSION AND POTENTIAL RELATION TO APOLLO 17 SAMPLES. J. Gross[1,2,3], T.C. Prissel[1], R.L. Korotev[4], S.W. Parman[5]. [1]Rutgers University, Piscataway, NJ 08854; [2]American Museum of Natural History, New York, NY 10024; [3]Lunar and Planetary Institute, Houston, TX 77058; [4]Washington University, Saint Louis, MO 63130; [5]Brown University, Providence, RI 02912; jgross@eps.rutgers.edu

Introduction: The lunar crust provides a record of planetary formation, early evolutionary processes, and contains a wealth of information about the origin and evolution of the Earth-Moon system [e.g., 1-4]. Lunar meteorites provide a random sampling of the lunar surface and are presumably representative of the whole lunar surface [5]. Lunar meteorite NWA 10401 is an anorthositic troctolite with a granulitic texture and is unique among feldspathic meteorites in that it could represent a KREEP-free Mg-suite rock [6]. It also contains chromites and pink (Mg,Fe)-Al spinel (Fig. 1). Pink spinel is rare in lunar rocks and is an important possible indicator of parental melt compositions and crustal assimilation processes [e.g., 7-10]. The spinel in NWA 10401 is unique because of its large grain size and texture. It dispays a symplectitc intergrowth zone of Cr-rich spinel and plagioclase around its entire rim followed by a plagioclase-zone and an olivine-zone (Fig. 2) that can be described as coronas. Symplectite assemblages of Cr-spinel and two-pyroxenes along relict olivine-olivine grain boundaries have been previously described in Apollo 17 Mg-suite rocks [10-12]. However, the symplectite assemblage in NWA 10401 is distinct as it is mantled by plagioclase and olivine coronas and lacks pyroxene. Here we investigate the petrology and mineral chemistry of the spinel-plagioclase-olivine symplectite assemblage in NWA 10401 in order to place constraints on its origin and formation, as well as any connection to a KREEP-free Mg-suite parental melt.

Analytical Methods: In this study, we analyzed a thick section piece of NWA 10401 that contains a large spinel grain (1.1 mm). All minerals were analyzed using the electron microprobe (JEOL 8200) at Rutgers University. Beam conditions were 15kV accelerating voltage, 25 nA beam current, 1μm beam diameter (olivine, pyroxene, spinel) and 10 nA beam current, 2μm beam diameter (plagioclase).

Texture, Petrography, and Mineral Chemistry: NWA 10401 is an anorthositic troctolite with a granulitic texture and is composed of single mineral grains and mafic clasts set in a granular coarse grained matrix composed mainly of Ca-bearing plagioclase (converted into maskelynite, however, hereafter refered to as plagioclase) (59-65%), olivine (23-26%), pyroxene (clinopyroxene and orthopyroxene) (12-15%), glass, and accessory phase chromites, spinel, and metal. It has been suggested that this rock could represent a KREEP-free Mg-suite rock [6].

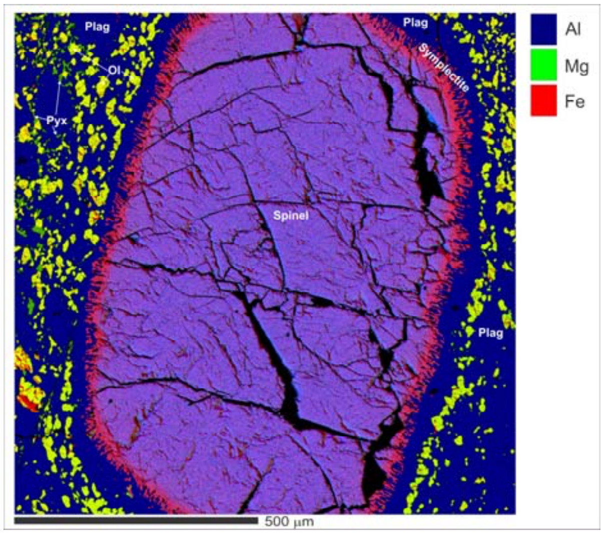

Figure 1: *BGR (Blue-Green-Red) map of the symplectitic textured spinel grain in NWA 10401. Al = blue; Mg = green; Fe = red. The symplectitic rim of the spinel grain is enriched in Fe and Cr.*

Spinel and Symplectitic Intergrowth Zone: A euhedral single pink spinel grain is found in this section with a large grain size of 1.1 mm. Compostitionally, the spinel is homogenous with $Sp_{83}Chr_{16}Ulv_{1}$ and Mg# [molar Mg/(Mg+Fe+Mn)] = 0.67 and Cr# [molar Cr/(Cr+Al+V)] = 0.16. Around the entire rim the spinel dislays sypmlectitic intergrows of plagioclase and vermicular Cr-enriched spinel with a composition of $Sp_{69}Chr_{22}Ulv_{9}$ (Fig.1) (Mg# 0.59 and Cr# 0.41). Outward from this symplectitic intergowth zone a plagioclase (olivine-free) zone is situated and beyond that an olivine-rich zone. Both zones re-trace the original euhedral spinel cystal faces (Figs. 1, 2).

Plagioclase-zone: Plagioclase in this zone (Fig. 2) is calcic with a composition of $An_{98.2}Ab_{1.7}Or_{0.05}$, whereas plagioclase in the matrix (away from the spinel) is slightly more albitic with a composition of $An_{96.6}Ab_{3.0}Or_{0.1}$. Large (0.2-0.8 mm), anhedral, single plagioclase grains can be found in the matrix with a compositional range of An_{92-96}.

Olivine-zone: The olivine in the olivine-zone are anhedral in shape with individual grain sizes ranging from < 10 μm up to ~ 40 μm, forming a ring around the plagioclase-zone tracing the original euhedral spinel crystal faces (Fig.1,2). Compositionally, the olivine in this zone are more Mg-rich with an average Fo# [molar Mg/(Mg+Fe)] of 79 compared to the granular matrix olivine with an average Fo# of 76.

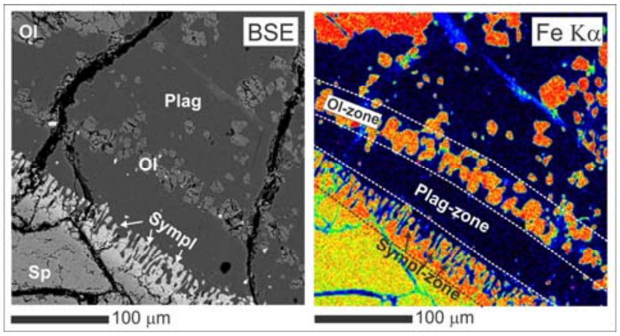

Figure 2: *Symplectic rim of spinel with plagioclase (olivine-free) zone and olivine-plagioclase rim outlining the original spinel grain boundary.*

Origin, Formation History, and Implications: Spinel-bearing rock fragments in Apollo samples (e.g., 67435) retain great textural evidence of plutonic igneous crystallization in which spinel was a cumulate phase [13]. Such spinel-bearing rock fragments suggested that the Moon contains spinel-bearing igneous cumulates near or below its crust-mantle boundary [e.g.,13-15]. The spinel grains in these rock fragments are smaller in size but are comparable in shape to the spinel in NWA 10401. In fact, the spinel grain in NWA 10401 represents the largest spinel grain reported in lunar material to our knowledge. Its size, euhedral grain shape, and homogenous composition indicates that it originated from a slowly cooled parental melt and could have an origin similar to the cumulate spinel in 67435. However, the formation history of the symplectitic intergrowth zone, the plagioclase-zone and the adjacent olivine-zone is unclear and indicates that the spinel was in disequilibrium.

The plagioclase-zone and olivine-zone tracing the spinel in NWA 10401 can best be described as a double corona. Such coronas around pink spinel have been described previously in Mg-suite Apollo samples 76055 and 72355 [14,16]. Interestingly, the pink spinel in those samples is very smilar in compositon to the spinel in NWA 10401 (Mg# 0.67-0.45; Cr# 0.02-0.1 for the pink spinel and Mg# 0.59-0.42; Cr# 0.15-0.32 for the Cr-enriched rim) and is also mantled by a plagioclase (olivine-free) corona. Similar to NWA 10401, the plagioclase in contact with the spinel in 76055 and 72355 is also more calcic (An_{95}) and zones outward to become more albitic (An_{88}) [14,16]. Additionally, the bulk composition of Mg-suite samples 76055 and 72355 is similar to that of NWA 10401 with the distinct difference that NWA 10401 contains virtually no KREEP component, suggesting a relationship. However, at this point it is unclear how and if NWA 10401 (KREEP-free Mg-suite) and Apollo 76055 and 72355 (KREEP-rich Mg-suite) are related.

Double coronas are common in terrestrial high-grade, dry, metamorphic rocks in which the lack of water keeps the reaction from running more readily to completion [17]. They are formed as conditions continue to change to the extent that either the core mineral or the matrix mineral is no longer stable adjacent to the first corona (in this case olivine). In the case of NWA 10401 this could mean that its parental melt composition became more An rich, moving away from the Ol-Plag joint into the An-field in the Ol-An-Qtz liquidus diagram (e.g. through the assimilation of anorthositic crust of an intruding KREEP-free Mg-suite melt parental to NWA 10401) to the point that olivine becomes unstable. However, resorption of these olivine would be expected, but this is not observed. Alternatively, the different coronas could have formed at the same time through diffusion in a solid state. In this scenario the spinel grain would represent a xenocryst that became unstable (e.g. pressure change). Each corona represents different diffusion fronts or gradients. Al and Mg diffuses away from the spinel to form Mg-rich olivine and more An-rich plagioclase compared to the more Fe-rich olivine and the more albitic plagioclase in the matrix. The diffusion rate of $D_{Al} << D_{Mg,Fe}$ which could explain why the olivine corona is the furthest out and the plagioclase corona is closest to the spinel. The remaining spinel would become enriched in a Cr-component at the reaction zone, which explains the chromite enriched symplectitic rim around the Mg-Al spinel core. Further study of these samples will help us place constraints on its formation history and potential connections (if any) between the different types of Mg-suites.

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