THE NORTHWEST AFRICA 5744 GROUP: A GLIMPSE INTO SCHRÖDINGER-LIKE LITHOLOGIES?

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Introduction: The Schrödinger basin on the lunar farside has been identified in multiple studies to be a high-priority target for robotic and/or human exploration (e.g., [1-4]). Missions to Schrödinger could address as many as seven of the eight science concepts outlined by the US National Research Council [2,5].

Schrödinger basin is geologically complex, containing impact lithologies, crustal lithologies uplifted from ~20-30 km, mare lava flows, and a pyroclastic vent [6-7]. Spectral [6] and photogeologic [6,8] studies reveal large outcrops of anorthosite and Mg-suite olivine-bearing rocks that may be described as troctolitic and noritic [6,9].

Those types of Mg-suite rocks are poorly represented in the returned Apollo sample collection, consisting of <1% of the total sampled mass [10-11]. Many of the Apollo Mg-suite samples are also rich in K, rare earth elements, and P (KREEP) [12], which is a dominant chemical component on the lunar nearside, but is not found on the farside [13]. Lunar meteorites, representing a more random sampling of the lunar surface, include material outside the Procellarum-KREEP terrane [13-14]. Here we present new data from a group of KREEP-poor, troctolitic lunar meteorites, the Northwest Africa (NWA) 5744 group (including NWA 8687) [15-17], that may be petrologically similar to lithologies observed in Schrödinger basin.

Methods: One polished thin section of NWA 5744 and two polished thin sections of Northwest Africa (NWA) 8687 were examined with a petrographic microscope and X-ray mapped using a JEOL field emission scanning electron microscope at Johnson Space Center (JSC). Mineral compositions were obtained using the JSC Cameca SX-100 electron microprobe (15 kV, 10 to 20 nA), using well-characterized mineral, glass, and metal standards.

Results and Discussion: NWA 5744 is classified as an anorthositic troctolite breccia with a granulitic texture [15]. Proportions of major minerals, especially pyroxene, seem to vary by several percent between pairs [15-17] and even between thin sections of a single sample (~12 to ~18% in NWA 8687). Texturally, NWA 5744 and NWA 8687 are similar: anhedral to subhedral olivine, 10 to 200 μm long, is surrounded by homogenous plagioclase matrix (Fig. 1, 2). Anhedral pyroxene is usually small (~5 to 80 μm), unevenly distributed, and often associated with olivine [15] (Fig.2).

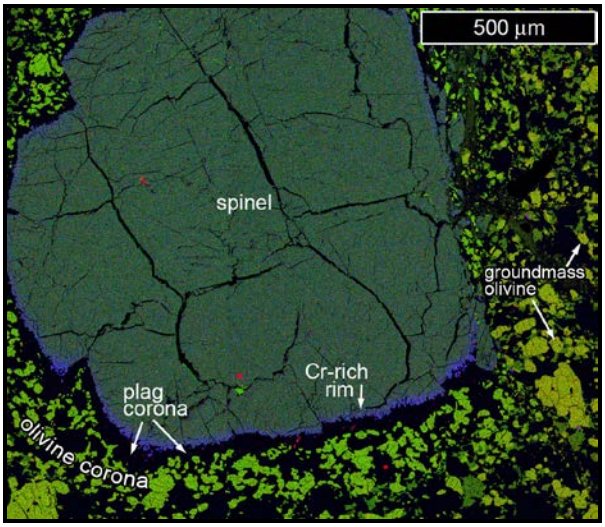

Figure 1. X-ray map of pleonaste spinel phenocryst in NWA 5744. Mg=G, Fe=R, Cr=B. This spinel is largely homogenous with a symplectitic Cr-rich rim and coronas of plagioclase (black) and olivine (bright green), respectively. More Fe-rich groundmass olivine appears yellowish compared with the more Mg-rich corona olivine.

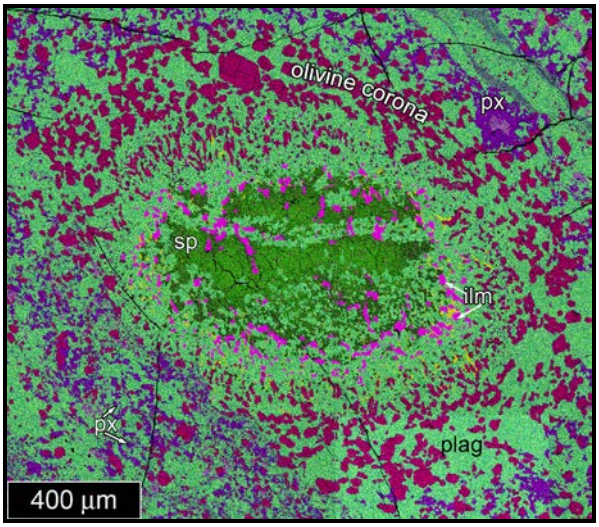

Figure 2. X-ray map of pleonaste spinel phenocryst in NWA 8687. Note the color scheme is different than that in Fig. 1 to emphasize different mineralogy. Plagioclase is pale green, pyroxene is purple, olivine is red, ilmenite is pink, phosphate is yellow, and spinel is dark green. The darker areas of the spinel contain more Cr. TiO_2 content is a constant ~1 %.

Rare low-Ca pyroxene phenocrysts up to ~300 μm in size contain exsolved high-Ca pyroxene. Plagioclase grains (~100 to 1000+ μm), both angular and rounded, are evenly distributed throughout the meteorites [15].

Some of the larger plagioclase grains enclose small olivine crystals [15]. Nearly all the plagioclase in both samples has been converted to maskelynite. Both samples contain multiple impact melt veins, though NWA 5744 is particularly glass-rich. It has one ~20mm-long transparent impact glass vein up to ~2 mm wide as well as several thinner veins.

	NWA 5744	NWA 8687	NWA 10401	*trocs*	*sp trocs*	*nor*	*gab nor*
Ol Fo	71-89	74-76	79-84	*83-89*	*78-92**	*71-74*	*68-71**
g.mass	71-76						
rims	76-83						
xenocr	82-89						
Plag An	94-98	95-98	92-97	*94-96*	*92-97*	*83-95*	*83-96**
En	46-77	48-77	49-84				
Fs	13-20	10-20	7-19				
Wo	3-41	3-42	2-44				
opx Mg#	83-89	78-80		*85-91*	*84-91**	*73-84*	*64-78**

Figure 3. Compositions of major minerals in NWA 5744, NWA 8687, and NWA 10401 [16] compared with Apollo Mg suite rocks (troctolites, spinel troctolites, norites, and gabbronorites) [12]. *indicates a single outlier with a substantially different range has been omitted for clarity.

Major mineral chemistry. Chemical data for major minerals in NWA 5744 and NWA 8687 are summarized in Fig. 3. Olivine, pyroxene, and plagioclase in NWA 8687 are quite homogenous and overlap with ranges reported for NWA 10401 [16] as well as Apollo norites and spinel troctolites [12]. Olivine and pyroxene in NWA 5744 are more variable. A single zoned ~3 mm olivine xenocryst is more Mg-rich (Fo_{82-89}) than the common groundmass olivine (Fo_{71-76}). The xenocryst is surrounded by a rim of smaller, slightly Mg-enriched olivine crystals (Fo_{76-83}), indicating the xenocryst is not in equilibrium with the surrounding material. A similar corona of Mg-enriched olivine (Fo_{76-83}) surrounds a large spinel in NWA 5744 (Fig. 1). However, the olivine corona around the NWA 8687 spinel has the same Mg content (Fo_{74-76}) as other olivine in the sample, despite the dramatic reaction occurring around the spinel (Fig. 2). Excluding the xenocryst, the range in Fo content in NWA 5744 is similar to that among Apollo norites. Given the relatively high proportion of pyroxene present (~17 %), this particular sample of NWA 5744 might be better described as a spinel-bearing noritic lithology [9].

Spinel-group minerals. Both NWA 5744 and NWA 8687 contain spectacular >1 mm long pleonaste spinel (Figs. 1, 2, 4). The pleonaste in NWA 5744 is pink in plane polarized light and has a Cr-rich symplectitic rim very similar to a spinel reported in another pair, NWA 10401 [18] (Fig.1). The Cr-rich rim (~12 wt.% Cr_2O_3) is also enriched in TiO_2 relative to the core (0.02 % vs. 0.45 % TiO_2).

The large pleonaste in NWA 8687 is deep red in plane polarized light and has a unique reaction texture (Fig. 2) with plagioclase and olivine coronas, as well as opaque minerals including ilmenite. Both samples also contain chromite. Spinel-group mineral chemistry from NWA 5744 and 8687 is compared with Apollo spinel-group mineral data in Fig. 4. Pleonaste compositions in NWA 8687, 5744, and 10401[18] overlap the Apollo spinel troctolite field, but extends to higher Cr#s.

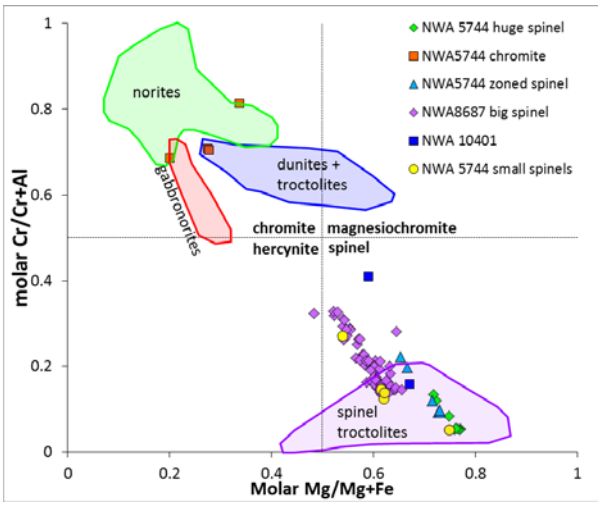

Figure 4. Mg# vs Cr# for spinel-group minerals in NWA 5744, NWA 8687, and NWA 10401 [18]. Fields from [12].

Conclusions: The spinel- and olivine-bearing NWA 5744 group meteorites differ from Apollo samples in interesting ways [15-16,18] and may represent farside crustal intrusives now exposed, for example, in places such as the Schrödinger basin.

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