NEW OBSERVATIONS ON POLYGONIZED LUNAR DUNITES; Ursula B. Marvin, Beth B. Holmberg, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138, and Marilyn M. Lindstrom, NASA Johnson Space Center, Houston, TX 77058.

In a previous report Marvin *et al.*, (1989), described the textures and mineral compositions of three dunite clasts in thin sections of Apollo 15 regolith breccia 15295, collected near the LRV at Station 6, and black-and-white rock 15445 from the inner rim of Spur Crater at Station 7. We now have recovered a polygonized dunite from soil sample 15313 collected on the rim crest of Spur Crater. The dunite particle was analyzed by INAA before being made into thin section 15313,17.

All of the dunite clasts are oval with long axes ranging from 1.25 to 4 mm. Olivine, in polygonal grains 30 to 115 µm across, makes up 96 to 99% of each clast. Variations in modal and mineral compositions are indicated in Table 1.

Although the clasts are small and rare, these dunites are of special interest because their compositions and textures show certain contradictory characteristics which bear on their possible mode of origin. The olivines are Mg-rich (Fo_{88-93}) with 0.0-0.2 wt. % CaO; sparse 2-15 µm-grains of accessory Fe-metal contain 33-68 wt.% Ni and 1.0 to 2.3 wt.% Co. Pyroxenes, mainly En >80 Wo <5 but also augites, occur in minute <20 µm-grains scattered through the olivine. These mineral assemblages are consistent with derivation from a deep-seated, ultramafic source (e.g. Albee *et al.*, 1974; Prinz *et al.*, 1973). However, three of the dunite clasts show minute interstices between olivine grains that are filled with plagioclase, chiefly bytownite ($Ab_{6-26}Or_{0.1-1.5}$) which belongs in more evolved rocks.

The polygonized textures and essentially uniform olivine compositions suggest a history of subsolidus metamorphism, but open interstices are not expected in granoblastic rocks. A cumulate origin would be acceptable, except for the very small grain sizes of the olivines. There remains the possibility that polygonization was induced by shock, as it apparently was in some ureilites. Evidence of shock is provided by the presence in three of the clasts of small patches of "wormy-looking" arrays of dendritic Mg-Al-chromites in augite.

The newly discovered dunite (Clast D, 15313,17) has the most complex mineral assemblage. In addition to interstitial bytownite, this clast has a small zone where well-developed grains of feldspar poikilitically enclose minute olivine grains. Both minerals are of the same composition as their counterparts in the rest of the clast. Opaques, chiefly Mg-Al chromium spinels intergrown with troilite and Fe-Ni-Co metal, make up about 3% of the mode. The spinels are picotite and chrome-pictotite with Mg/Mg+Fe 0.50 to 0.64 and Cr/Cr+Al 0.46 to 0.69. We found two small patches of apatite in these opaque assemblages.

The bulk analysis of Clast D is listed in Table 2 along with analyses of three other lunar dunites. Although the major element analysis is incomplete, the sample shows lower Fe and higher Na contents than the dunites described earlier. This is consistent with the higher MgO in the olivine and the presence of interstitial bytownite. While Sc is in the range of other dunites, Cr, Co, and Ni are distinctly higher. The Ir content of 3 ppb is indicative of meteoritic contamination, but the metal grains we analyzed are much too well-crystallized and rich in Ni and Co to derive from a meteoritic source. The REE values are more than ten times higher than in lunar dunite 72417 (Laul and Schmitt, 1975) and have a negative Eu anomaly suggestive of prior plagioclase fractionation. The overall REE pattern is KREEP-shaped (Figure 1) and appears to reflect incorporation of about 2% of a KREEP component, which we would expect to find in phosphate minerals. However, the scarce phosphates we have identified make up <0.1% of the mode, and they are apatites that sum to about 100 wt. % of oxides, not counting any REE. As shown in Figure 1, the REE concentrations are within the range of five Apollo 14 dunites (Lindstrom *et al.*,1984; Neal *et al.*, 1988), but are lower than all but a single sample, 14304,160 which shows a dramatic HREE enrichment due to the presence of zircon.

The mineral components and bulk composition of the dunite clasts strongly suggest a two-stage history in which deep-seated dunitic fragments have been projected to shallower levels where they were injected with small amounts of a liquid characterized by Na_2O and a KREEP component. The polygonized texture of the olivine may have been formed by a shock event--possibly the one that excavated the Imbrium Basin.

References: Albee, A.L., Chodos, A.A., Dymek, R.F., Gancarz, A.J., Goldman, D.S., Papanastassiou, D.A., Wasserburg, G.J. (1974) *Lunar Science V*:3-5. Laul, J.C. and Schmitt, R.A. (1975), *Proc. Lunar Sci. Conf. 6th*, 2:1232-1254. Lindstrom M.M.,Knapp, S.A., Shervais, J.W., and Taylor, L.A. (1984), *Proc. Lunar, Planet. Sci. 15th* JGR 89:C41-49. Marvin, U.B., Holmberg, B.B., and Lindstrom, M.L. (1989) [Abs.] *Meteoritics* 24:299. Neal, C.R., Taylor, L.A., Patchen, A.D., and Lindstrom, M.M., *Lunar Planet. Sci.; XIX*: 837-838. Prinz, M, Dowty, E, Keil, K., Bunch, T.E. (1973) *Science* **179**:74-76.

Table 1. Polygonized Dunites

PTS	15295,40 Clast A	15445,146 ,147 Clast B	15445,135 Clast C	15313,17 Clast D
Olivine (vol%)	99	98	99	96
Fo	88-89	85-90	87-88	90-93
CaO (wt%)	0.02-0.15	0.05-0.24	0.08-0.19	0.0-0.17
Plagioclase (vol%)	n.d.	<1	<1	~1
Ab		12-26	10-14	6-19
Or		0.3-1.5	0.2-1.0	0.3-1.0
Pyroxene	tr	tr	n.d.	tr
En	46-53	85-61		87-49
Fs	6-5	14-16		9-4
Wo	48-42	1-23		4-47
Fe Metal (vol%)	tr	tr	n.d.	~1
Ni (wt%)	40-49	33-38		38-68
Co (wt%)	1.7-3.0	2.0		1.0-2.3
Troilite (vol%)	tr	tr	tr	<1
Rutile	tr	tr	tr	n.d.
Ilmenite	n.d.	tr	n.d.	n.d.
Mg-Al-Chromite (vol%)	tr	tr	tr	~2
Apatite	n.d.	n.d.	n.d.	tr

n.d.= not detected tr=trace

Table 2. Lunar Dunites

	15313,17	72417[1]	14321,1411[2]	14303 14304[3]
SiO_2 wt %		39.8		40-41
TiO_2		0.03	0.08	0.06-0.15
Al_2O_3		1.3	0.56	0.47-2.0
FeO	9.31	11.9	11.6	11.3-16.5
MgO		45.5	53.7	40-46
CaO	0.70	1.1	n.d.	0.45-1.1
Na_2O	0.0606	0.013	0.023	0.01-0.02
K_2O	0.0095	0.002	n.d.	n.d.
Sc ppm	4.9	4.3	5.0	2.8-6.8
Cr	8680	2330	522	550-1680
Co	120	55	61	37-60
Ni	2730	160	70	140-220
Ba	17	4.1	24	11-34
La	2.12	0.15	5.11	1.3-6.8
Hf	0.88	0.10	0.93	1.0-16
Ir (ppb)	3.1 ± 0.7		<2	<2
Mg/Mg+Fe	91	87	89	81-88

1) Laul & Schmitt (1975) 2) Lindstrom, et al (1984)
3) Neal, et al (1988) and unpublished data n.d.= not detected

Figure 1. REE in Dunites