GABBROIC VS. CUMULATE EUCRITES: EXTENDING THE DIVERSITY OF EUCRITIC LITHOLOGIES. A. Patzer and H. Y. McSween, Department of Earth and Planetary Sciences, University of Tennessee, 1412 Circle Dr., Knoxville, TN 37996 (apatzer@utk.edu).

Introduction: Eucrites are part of the howardite-eucrite-diogenite (HED) suite of meteorites. Two basic subgroups have been recognized: basaltic and cumulate. Cumulate eucrites are plutonic rocks (coarse-grained equigranular) and primarily made of anorthitic plagioclase (An_{90-96}) and MgO-rich pyroxene (En_{46-65}). Basaltic eucrites are defined by extrusive, i.e., fine- or very fine-grained, textures and contain pyroxene that is more FeO-rich ($En_{<46}$) and plagioclase that is more sodic ($An_{<90}$) than their cumulate equivalents [e.g., 1].

Howardites are fragmental breccias and essentially composed of eucritic and diogenitic debris. Just recently we showed that some howardites contain symplectic clasts with genetic ties to highly differentiated cumulate eucrites [2]. The assumed cumulate origin of those highly evolved eucrites was mainly based on grain size. Coarse-grained plagioclase associated with the newly discovered symplectic assemblages was generally less calcic than cumulate feldspar but also showed some overlap (An_{81-93}).

Here, we present additional data from our suite of new Antarctic howardites focussing on a medium- to coarse-grained eucritic rock type that exhibits a basaltic bulk composition but has the lithological distinction of containing interstitial olivine.

Results: *LAP 04838.* LaPaz Ice Field (LAP) 04838,19 is a bimodal sample and consists of coarse-grained eucrite and howardite. The coarse-grained portion is composed of plagioclase, pyroxene, and some silica as well as minor amounts of fine-grained interstitial olivine, occasional ilmenite, and trace amounts of troilite. Olivine is distributed heterogeneously, ranging from 0 to about 10 area% in a given 1 x 1 cm frame (Fig. 1a). In addition, we detected a single 1 mm-sized coarse-grained pyroxene clast within the howardite portion that also contains plagioclase and significant amounts of interstitial olivine (Fig. 1b).

MIL 07007. Miller Range (MIL) 07007,8 contains a large number of monomineralic fragments, the majority being orthopyroxene. Polymineralic clasts are rare and include one 0.98 mm-sized coarse-grained fragment (Fig. 2). It is made of pyroxene (~80 area%), plagioclase (~10 %), and interstitial olivine (~10 %).

The clasts of interest all show a bulk eucritic mineralogy, grain size of >0.5 mm, and minor fine-grained olivine. Feldspar analyses yield 79-89 mol% anorthite. Pyroxenes contain from 28 to 41 mol% enstatite and – in the case of LAP 04838 – mostly exhibit pigeonite or augite compositions; orthopyroxene (Wo_4) is sparse. Pyroxene in the clast from MIL 07007 displays 1-2 µm-sized, densely-spaced exsolution lamellae and a compositional range of $En_{29-35}Fs_{54-62}Wo_{9-13}$ (defocused beam mode). Olivine mostly occurs as chains of distinct small grains. Occasionally, it forms thin veinlet fillings and may be associated with plagioclase. Olivine compositions vary from mg# 14-27 but are significantly more uniform within a single fragment (LAP 04838: mg# 17-24 for the coarse-grained region and mg# 27 for the isolated clast; MIL 07007: mg# 14-15).

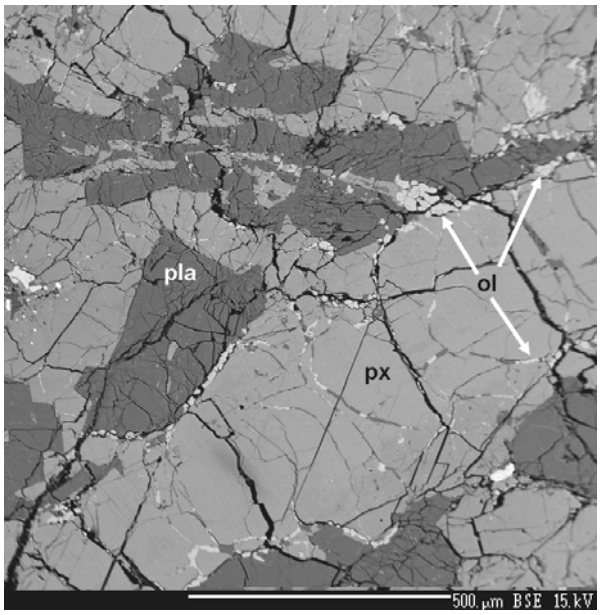

Fig. 1a. Back-scattered electron (BSE) image of a detail within the coarse-grained eucrite portion of LAP 04838,19 (pla = plagioclase, px = pyroxene, ol = olivine).

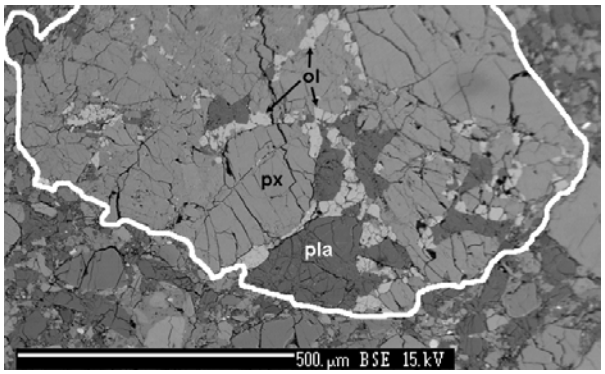

Fig. 1b. BSE image of an isolated coarse-grained eucritic clast in the howardite portion of LAP 04838,19 showing considerable amounts of fine-grained interstitial olivine (abbreviations as in Fig. 1a).

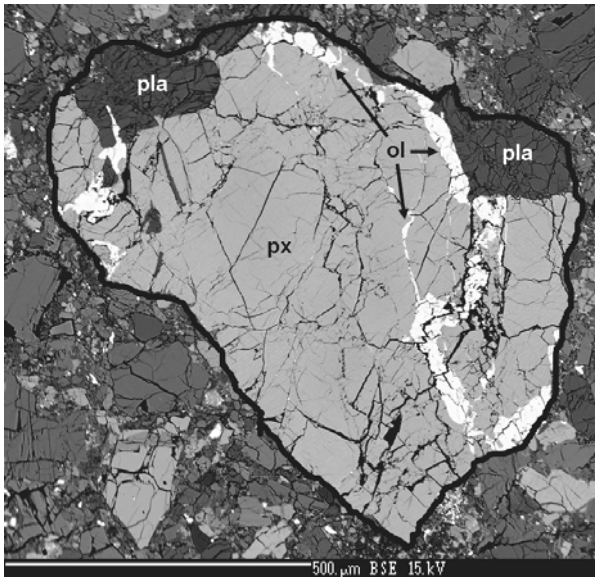

Fig. 2. BSE image depicting the polymineralic fragment of interest in MIL 07007,8 (abbreviations as in Fig. 1a).

Discussion: Feldspar and pyroxene compositions in the clasts investigated match those of basaltic eucrites (Fig. 3), though anorthite contents in plagioclase may get very close to those found in cumulate eucrites.

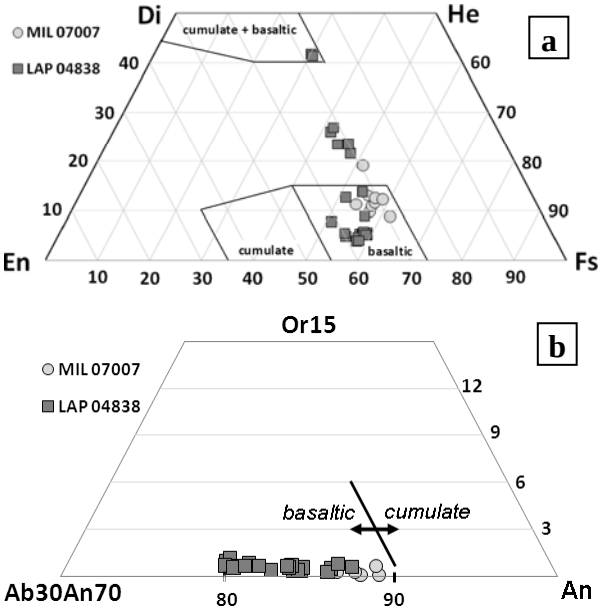

Fig. 3. Quadrilateral diagrams illustrating the compositions of pyroxene (a) and plagioclase (b) in clasts selected from howardites LAP 04838 and MIL 07007. Enstatite (a) and anorthite (b) contents match those of basaltic eucrites.

Olivine turned out to be relatively FeO-rich (for comparison: diogenitic olivine exhibits mg# 61-78 [1]). Judging from its very fine-grained interstitial appearance, this phase most likely precipitated after the main constituents plagioclase and pyroxene had crystallized. Precipitation took place into pre-existing interstices as well as along grain boundaries, seemingly while the system still allowed minor movement of the coarse-grained silicates. The potential source of olivine in this scenario would be primary mesostasis. Alternatively, a secondary late-stage liquid might have reentered the intrusive body after cooling and filled in pore space and fine cracks that arose from cooling contraction, draining of intergranular primary liquid, and/or deformation.

Conclusions: Common attributes of the lithology introduced here and of that described recently [2] are their coarse-grain size and eucritic provenance. Major element concentrations of plagioclase and pyroxene mostly match those of basaltic eucrites but also show overlap with the compositions of known cumulate eucrites. Distinctive features include the occurrence of minor fine-grained olivine on one hand and symplectic assemblages on the other. Based on this set of common and distinctive properties, we suggest that a third class of eucrites exists on the HED parent body: *gabbroic eucrites*, featuring a basaltic bulk composition but intrusive (i.e., medium- to coarse-grained) textures. These gabbroic eucrites can be further subdivided into an olivine-bearing lithology and a symplectite-bearing kind. Clearly, the latter is significantly more differentiated than the former. Yet, both types may well be genetically related and simply reflect different proportions and evolutionary stages of mesostasis: The olivine-bearing lithology retained (or regained) very small amounts of relatively FeO-rich mesostasis while the symplectite-bearing kind evolved longer and undisturbed with relatively large amounts of mesostasis, culminating in the precipitation of metastable pyroxferroite.

The occurrence of gabbroic eucrites on the HED parent body is also relevant to the DAWN mission, as HEDs are believed to originate from Vesta and the spacecraft's geochemical data may be capable of distinguishing different lithological terrains on the asteroid [e.g., 3].

References: [1] McSween H. Y. et al. (2010) *Space Sci. Rev.*, doi: 10.1007/s11214-010-9637-z. [2] Patzer A. and McSween H. Y. (2011) Workshop on Formation of the First Solids in the Solar System, held November 7–9, 2011 in Kauai, Hawaii. LPI Contribution No. 1639, p.9002. [3] Zuber M. T. et al. (2011) *Space Sci. Rev.*, doi: 10.1007/s11214-011-9806-8.