THIRD OF A KIND – IMPACT MELTED LUNAR GRANULITIC BRECCIA METEORITE DHOFAR 1766. Axel Wittmann[1], Randy L. Korotev[1], and Bradley L. Jolliff[1], [1]Department of Earth & Planetary Sciences, Washington University in St. Louis, One Brookings Drive, Saint Louis, MO 63130, wittmann@levee.wustl.edu.

Introduction: In 2011, Dhofar (Dho) 1766, a 262 g stone was collected in Oman. It has a reddish exposure surface with ~5 mm yellowish to grey, partly melted clasts embedded in a flow-textured, vesicular groundmass (Fig. 1). We present initial geochemical and petrographic data or Dho 1766 that are aimed at understanding the petrogenesis of lunar granulites.

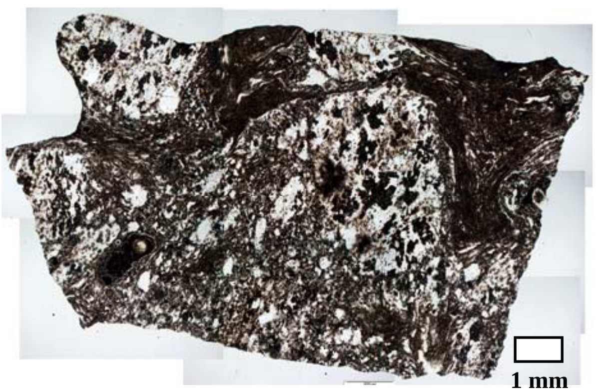

Fig. 1. Thin section of Dhofar 1776, plane polarized light.

Samples & Methods: We analyzed two ~1 cm^2 petrographic sections of Dho 1766 microscopically and with the Jeol 8200 E, and determined trace element concentrations of twelve 22–34-mg subsamples by INAA following the procedure outlined by [1].

Results: *Petrography.* Dho 1766 has the flow texture of an impact melt rock that entrained and assimilated 5 to <0.5 mm clasts of variably feldspar-rich rocks. The impact melt groundmass is composed of felty plagioclase ($An_{91–95}Or_{0.1–0.3}$, n=13) with <10 µm skeletal pyroxene ($En_{55}Wo_{24}$) filling interstices, and up to 50 µm, zoned, subhedral olivine ($Fa_{11–16}$, n=3). Rounded, ~100 µm domains in the impact melt groundmass have ophitic textures of anhedral olivine ($Fa_{11–16}$, n=14) overgrown with minor augite ($En_{40–49}Fs_{15–34}Wo_{21–45}$, n=6 and $En_{13}Wo_{34}$) that poikilitically encloses acicular plagioclase ($An_{78–90}Or_{0.1–0.2}$, n=5), silica-rich mesostasis (92–97wt% SiO_2; n=2) and rare, up to 30 µm, euhedral armalcolite crystals (up to 0.4 wt% ZrO_2). Ilmenite (with 3.3–9 wt% MgO) is in places intergrown with armalcolite or forms acicular crystals in the impact melt matrix. Accessory, round <10 µm troilite grains are occasionally intergrown with minute taenite and tetrataenite grains (36.5–63.5 wt% Ni and 1.2–1.5 wt% Co, n=5). Granular, 30 to 250 µm chromian spinel indicates variable degrees of decomposition and recrystallization to <1–10 µm zoned, variably Mg, Fe, Cr and Ti-rich crystals (Fig. 2) with interstitial spaces empty or filled with feldspathic material ($An_{77–96}Or_{0.2–0.3}$, n=2). Abundant vesicles in the impact melt, some of them round, others elongated, are hollow or more typically, filled by secondary $CaSO_4$; $SrSO_4$ and rare $BaSO_4$ occur as ~5 µm crystals. A few >100 µm Ø vesicles are filled with Mg-rich phyllosilicate (talc?) that is rimmed by $SrSO_4$.

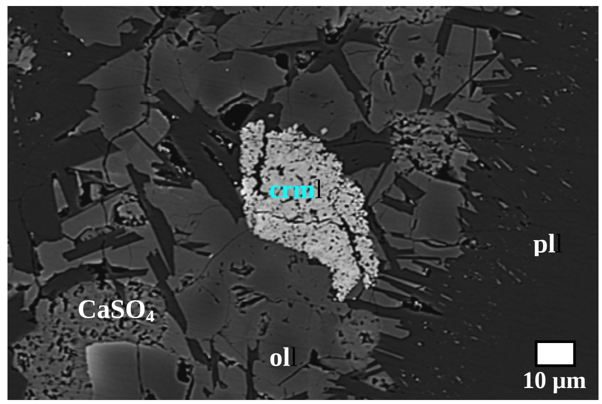

Fig. 2. Granular chromian spinel (crm) in Dhofar 1776, ol-olivine, pl-plagioclase; back-scattered electron image.

Entrained clasts are strongly assimilated into the melt matrix but EDX-compositional mapping reveals plagioclase clasts with variable Na_2O contents ($Ab_{4–6}Or_{0.1}$, n=10 and $Ab_{8–14}Or_{0.2–0.7}$, n=6). Some fractured, unzoned olivine ($Fa_{13–31}$, n=12) may also be relict clasts. Polycrystalline clasts that are frequently >1 mm are composed of assemblages similar to those of the impact melt groundmass: recrystallized plagioclase, olivine, and ophitic domains of plagioclase poikilitically intergrown with zoned olivine, augite, SiO_2-rich mesostasis ± ilmenite. The shapes of these ophitic domains suggests they may have been poikilitic pyroxene that are features of some granulitic rocks.

Bulk trace element composition. Dho 1766 is highly feldspathic (low FeO; Fig. 3) with low concentrations of incompatible elements [2]. The most unusual compositional aspects are that concentrations of the plagiophile elements Na and Eu are twice that of most other lunar meteorites of similarly low Sm concentration [2], (Fig. 3), reflecting the Na-enriched plagioclases (Ab_{8-14}). Compositionally, the meteorite is all but indistinguishable from granulitic breccia Dho 733 [1–3], the only lunar stone that was found within 15 km of Dho 1766. Therefore, we infer that Dho 1766 and Dho 733 are paired.

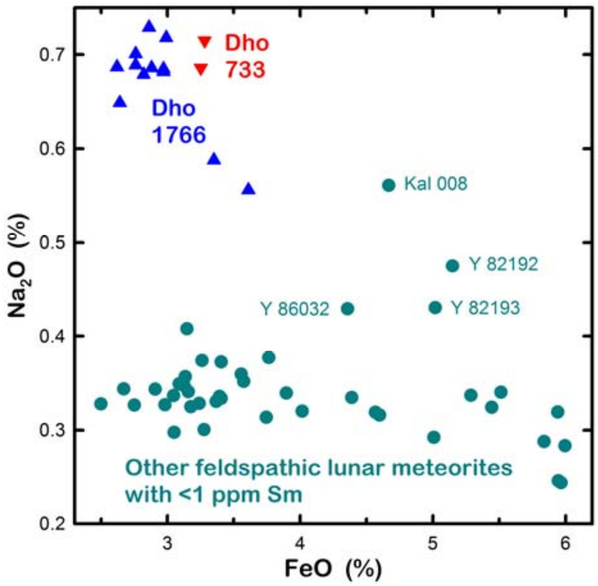

Fig. 3. Dho 733 and 1766 are distinct in having concentrations of Na (and Eu) about twice that of other feldspathic lunar meteorites. The triangles represent small subsamples of Dho 733 and 1766; the green circles each represent other named stones.

Discussion: Dho 1766 is a clast-rich impact melt rock. This classification is corroborated by clasts of granular textured chromite crystals (Fig. 2), which formed as a result of decomposition and subsequent recrystallization of chromite at temperatures >1635°C [4]. Similar granular textured chromite clasts have been used to identify impact melts in eucrite and lunar meteorites [5,6]. Moreover, Dho 1766 appears to be an impact-melted variety of Dho 733, which shares its compositional characteristics [1–3], and is a plausible precursor for the relict clasts in Dho 1766. However, the remelting of the sodic magnesian granulitic breccia material of Dho 733 produced a wider range of mineral compositions in Dho 1766. Most notably, no low Ca pyroxene is retained and olivine ($Fa_{11–31}$) reaches to far more magnesian compositions than the precursor crystals in Dho 733 ($Fa_{23–30}$; [3,7]).

Birds of a feather. At least two other assemblages of impact melted granulitic breccias are known: Apollo sample 15418 [8,9], and the paired stones Dho 026/457–468/1669 [6,9,10]. Thus, the occurrence of at least three partly impact melted granulitic breccias among lunar samples suggests they are not unusual. On the contrary, the ubiquity of granulitic rock fragments in polymict lunar breccias suggests granulites are common near-surface lithologies on the Moon [11], which frequently become impact melted.

Petrogenesis of granulitic lunar impact melts. If some lunar granulitic rocks are impact melts that cooled slowly in voluminous impact melt sheets [12], it is plausible that their impact-excavation would produce impact-melted "granulites". Consequently, Dho 733 may be derived from a granulite terrain that was the upper, clast-rich part of an impact melt sheet on the Moon. An impact into this melt sheet produced suevite-like ejecta deposits. Because Dho 1766 cooled slow enough to induce pervasive recrystallization of granulite target rock clasts, a moderately thick suevite-like breccia deposit in the crater or proximal to it was the probable petrologic setting from which Dho 733 and Dho 1766 were sourced. This assumption is based on studies of large terrestrial impact craters. For example, a 100 m thick suevite deposit in the 180 km Ø Chicxulub crater is pervasively recrystallized and contains granular textured zircon crystals [13] that indicate an analogous thermal regime to the granular chromite clasts in Dho 1766. This setting also accounts for the low content of noble gas nuclides in Dho 733 that suggests shielding from cosmic-rays on the Moon [14]. An impact into these suevite-like deposits ~1.8 Ma ago [14] launched Dho 733 and Dho 1766 from the Moon.

What's so special about Dho 733 and Dho 1766? Dho 733 is a magnesian granulite with relatively low incompatible element concentrations except the plagiophile Na_2O, Eu, and LREE. This compositional paradox also characterizes Dho 1766, with its Na_2O-enriched feldspar clasts. However, the bulk rock composition of Dho 733/1766 can not be constituted by isochemical mixing of known pristine lunar rock compositions [3]. This leaves the possibilities that unknown magnesian highlands lithologies were precursor components [3], or that fractional crystallization caused the removal of incompatible elements from the impact melt of which Dho 733 crystallized.

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