CHEMICAL-CRYSTALLOGRAPHIC INVESTIGATION INTO THE PETROGENESIS AND SHOCK DEFORMATION HISTORY OF AN OLIVINE-RICH CLAST IN LUNAR METEORITE DAYET EL AAM 003: A DUNITE FRAGMENT FROM AN MG-SUITE PLUTON THAT ASSIMILATED LUNAR CRUST

Daniel Sheikh[1], A. M. Ruzicka[1], and T. C. Prissel[2], [1]Cascadia Meteorite Laboratory, Portland State University (dsheikh@pdx.edu), [2]Department of Earth, Atmospheric, and Planetary Sciences, Purdue University.

Introduction: Studies of lunar meteorites containing unique lithic clasts linked to the Lunar Highlands Magnesian Suite (Mg-suite) [e.g., 1-3] have refined models constraining the timing and extent of secondary crust building on the Moon following lunar magma ocean (LMO) crystallization and cumulate mantle overturn [4-6]. Here, we report on a mm-sized olivine-rich clast (herein referred to as clast "D2") identified during the classification procedure (by X-ray mapping) of lunar meteorite Dayet El Aam (DEA) 003. as potentially representing a fragment of a unique type of Mg-suite rock, warranting further study. Following precedent [7], we apply a combination of electron probe microanalysis (EPMA) and electron backscatter diffraction (EBSD) techniques to investigate the petrogenesis of clast D2 from DEA 003, and evaluate any physical/chemical modification that may have occurred in D2 as a result of secondary shock deformation.

Results: Clast D2 appears subrounded and is comprised of a large single crystal of olivine (~1.1 mm in the longest dimension) containing several small (<10 µm) single grain inclusions of Cr-bearing spinel (Fig. 1a-b). Olivine from D2 [Mg# (molar Mg/(Mg+Fe) x 100) = 91.7±0.1, Al_2O_3 (wt. %) = 0.10±0.07, Cr (ppm) = 190±43, Ni (ppm) = 347±65, n=11] is compositionally consistent with olivine from Mg-suite ultramafic rocks, pink spinel troctolites (PST), and pink spinel anorthosite (PSA) clasts [3-5]. The Cr-spinel in D2 [Mg# = 73±0.3, Cr# (molar Cr/(Cr+Al) x 100) = 20.7±1.0, n=3] is intermediate in composition relative to high-Cr (e.g., troctolites and dunites) and low-Cr (e.g., PSA/PST) spinel-bearing Mg-suite lithologies [3-5] (Fig. 1c-d).

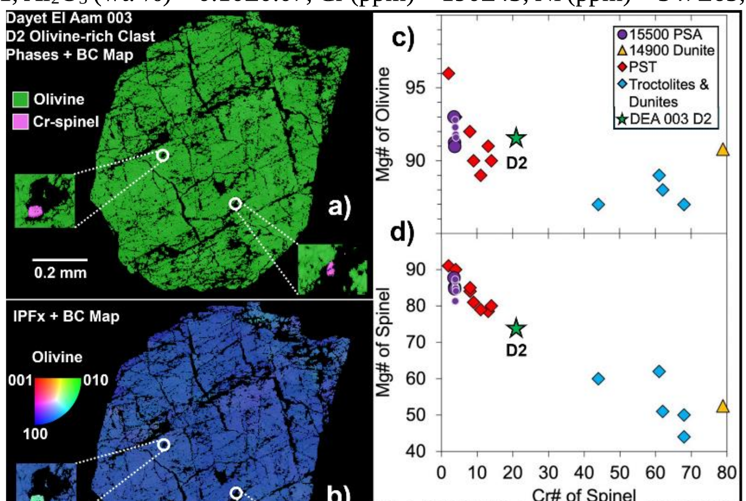

Fig. 1.
(a-b): EBSD maps of D2 olivine-rich clast.
(c-d): Olivine and spinel compositions of D2 clast, alongside Mg-suite lithologies [3-4].

Low-angle (2-10º) subgrain boundaries within D2 are primarily misoriented along the <100> rotation axis, indicating a predominance of **c**-type slip and a calculated deformation temperature (T_{deform}) for D2 of 760±97 ℃ [8], consistent with the olivine-spinel Fe-Mg geothermometer [9] equilibrium temperature for D2 (T_{equil}) of ~779 ℃.

Discussion: Our interpretation of the petrogenesis and shock deformation history of clast D2 is as follows: 1) decompression melting of olivine-rich LMO cumulates [10] to form an initially plagioclase-undersaturated Mg-suite parental melt that subsequently intruded into and assimilated anorthositic crust at the magma-wallrock interfaces within a magma chamber [4], 2) co-crystallization of olivine + a spinel phase from the wallrock-contaminated Mg-suite parental melt (resulting in a relatively intermediate Cr-spinel composition), forming dunites (with olivine grain sizes >1.1 mm) that then fractionally settled to the base of the magma chamber, 3) slow cooling of the dunites at the base of the magma chamber (relative to the PSA/PST rocks at magma-wallrock interfaces) resulting in extensive Fe-Mg diffusion within Cr-spinel down to a sub-solidus re-equilibration temperature of ~779 ℃, and minor Cr diffusion into Cr-spinel from the surrounding olivine (forming thin <1 µm rims), 4) impact-induced brecciation, plastic deformation (e.g., forming planar fractures), and excavation of D2 from depth at an ambient temperature of 760±97 ℃ (supported by overlap between T_{deform} and Fe-Mg T_{equil}), and 5) emplacement of clast D2 either on or near the lunar surface (requiring fast cooling to preserve Fe-Mg T_{equil}) where it would be eventually incorporated into DEA 003 by a subsequent impact event.

References: [1] Takeda H. et al. (2006) *Earth and Planetary Science Letters* 247:171-184. [2] Gross J. et al. (2020) *Journal of Geophysical Research: Planets* 125:1-24. [3] Sheikh D. et al. (2025) *Meteoritics & Planetary Science* 60:206-224. [4] Prissel T. C. et al. (2016) *American Mineralogist* 101:1624-1635. [5] Shearer C. K. et al. (2015) *American Mineralogist* 100:294-325. [6] Elardo S. M. et al. (2011) *Geochimica et Cosmochimica Acta* 75:3024-3045. [7] Sheikh D. et al. (2025) *LPSC LVI*, Abstract #1833. [8] Ruzicka A. M. et al. (2024) *Geochimica et Cosmochimica Acta* 378: 1-35. [9] Jianping L. et al. (1995) *Chinese Journal of Geochemistry* 14:68-77. [10] Prissel T. C. and Gross J. (2020) *Earth and Planetary Science Letters* 551:1-13.