APPLICATION OF ELECTRON BACKSCATTER DIFFRACTION (EBSD) TO INVESTIGATE THE PETROGENESIS AND SHOCK DEFORMATION HISTORY OF A PINK SPINEL ANORTHOSITE (PSA) CLAST IN LUNAR METEORITE NORTHWEST AFRICA (NWA) 15500

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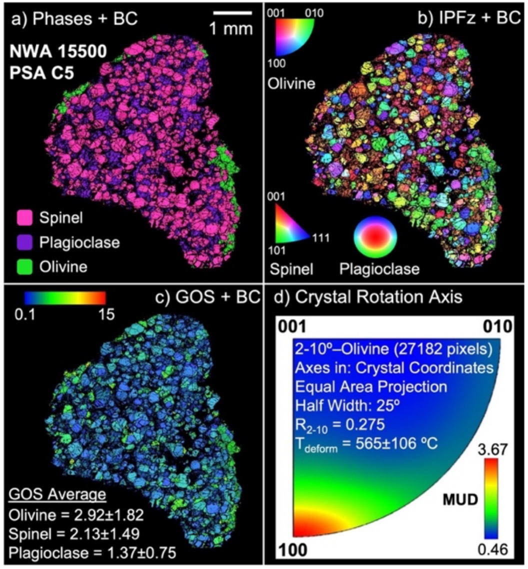
Introduction: Geochemical investigation of pink spinel anorthosite (PSA) clasts from lunar meteorites Northwest Africa (NWA) 15500 and 16400 [1-2] have yielded important findings supporting the petrogenesis of PSA, and pink spinel troctolites (PST), by magma-wallrock interactions between plagioclase-undersaturated Mg-suite parental melts and anorthositic crust [3-4]. However, evaluating the exact temporal/spatial relationship between PSA and PST is challenging given the complexities associated with geochemical modeling of assimilation in a magma chamber [5], and the limited sample pool of PSA/PST material available for study. In addition, the physical/chemical modification of lunar materials by impact(s) needs to be considered, as the excavation of PSA/PST material onto the lunar surface from depth would induce secondary shock deformation effects that may complicate interpretation. Electron backscatter diffraction (EBSD) serves as a useful technique that can provide non-destructive crystallographic analysis of lithic clasts in lunar samples and disentangle primary characteristics inherited during igneous crystallization versus those formed by later shock deformation; previous application of EBSD to ordinary chondrites (OCs) [6-7] using inverse pole figure (IPF, assessing mineral crystallographic orientations) maps and intragrain deformation metrics such as grain orientation spread (GOS, the average misorientation within a grain) and crystal rotation axis (CRA, displays the rotation axis direction for boundaries with 2-10° misorientations) have provided insight into the syn-deformational P-T conditions and extent of shock deformation occurring on OC parent bodies. Here, we apply this technique to a PSA clast (C5) from NWA 15500 in order to elucidate the crystallization and shock deformation history of PSA.



Results: Indexing of spinel, plagioclase, and olivine grains from PSA C5 resulted in a high-quality phases + band contrast (BC) image (Fig. 1a), where non-indexing areas indicate the presence of maskelynite; mineral phase fractions are: spinel (51 %), plagioclase + maskelynite (45 %), olivine (4 %). Spinel grains on the IPFz chart (Fig. 1b) are randomly oriented, whereas plagioclase and olivine grains display noticeable lattice-preferred orientations (LPO). There is a variation in GOS within and between mineral phases (Fig. 1c); the highest GOS values are observed in olivine (relative to spinel and plagioclase) concentrated at the rim of PSA C5. The CRA plot for olivine (Fig. 1d) yields a concentration of points at <100> indicating a predominance of C-type slip [6-8]; calculation of $R_{2\text{-}10}$ and model deformation temperature (T_{deform}) using the approach of [6-7] yields a syn-deformation temperature of 565±106 °C.

Discussion: The IPF, texture, and phase abundances from PSA C5 provide additional evidence favoring a genetic relationship between PSA and PST. For PSA C5, only spinel is randomly oriented, indicating a crystallization sequence that began spinel-saturated (Sp→Sp+Pl→Sp+Pl+Ol). In contrast, in a PST clast from 73002, only plagioclase (neither olivine nor spinel) had an LPO [9], which indicates a crystallization sequence that began with olivine and spinel prior to plagioclase. This would be consistent with an increasing degree of crustal assimilation for PSA relative to PST [3-4]. The lower temperature of T_{deform} (565±106 °C) compared with the Sp-Ol Fe-Mg geothermometer [10] equilibration temperature (T_{eq}) for PSA C5 (~1136 °C) indicates that olivine records a later, strong shock event from low ambient temperature following the crystallization of PSA at depth. Thus, there were two distinct shock events: 1) a basin-forming impact excavated PSA material at T_{eq} ~1136 °C to a cool near-surface setting, 2) a later, strong shock deformed all phases and incorporated the PSA clast into NWA 15500 after brief reheating to T_{deform} ~565 °C.

References: [1] Sheikh D. et al. (2023) *LPSC LIV*, Abstract #2066. 9:941-958. [2] Sheikh D. et al. (2024) *LPSC LV*, Abstract #2023. [3] Prissel T. C. et al. (2014) *Earth and Planetary Science Letters* 403:144-156. [4] Prissel T. C. et al. (2016) *American Mineralogist* 101:1624-1635. [5] Heinonen J. S. et al. (2021) *Crustal Magmatic System Evolution*, Chapter# 7. [6] Ruzicka A. M. and Hugo R. C. (2018) *Geochimica et Cosmochimica Acta* 234:115-147. [7] Ruzicka A. M. and Hugo R. C. (2022) *LPSC LIII*, Abstract #1757. [8] Karato S. et al. (2008) *Annual Reviews of Earth and Planetary Sciences* 36:59-95. [9] Stadermann A. C. et al. (2024) *LPSC LV*, Abstract #1498. [10] Jianping L. et al. (1995) *Chinese Journal of Geochemistry* 14:68-77.