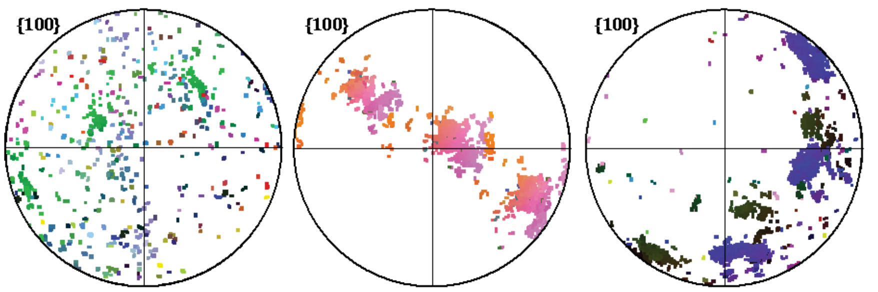
Microstructural shock features in Lunar Mg-suite accessory phases

Ana Černok[1]*, Lee Francis White[2], James Darling[2], Joseph Dunlop[2], Diane Johnson[1], and Mahesh Anand[1]

[1]Open University, School of Planetary Sciences, Walton Hall, Milton Keynes, MK7 6AA, United Kingdom
*Corresponding author: ana.cernok@open.ac.uk

[2]University of Portsmouth, School of Earth & Environmental Sciences, Burnaby Road, Portsmouth, PO1 3QL, United Kingdom

The lunar Mg-suite comprise plutonic highland rocks that represent an episode of crustal evolution following the primordial differentiation of the Moon [e.g. 1] and cover crystallization ages from 4.43 - 4.1 Ga [2]. We have examined thin sections of a shocked norite sampled by Apollo 17 mission and targeted apatite, merrillilite, and baddeleyite in an effort to constrain microstructural variation induced by shock metamorphism. Studied samples were assigned a high index of petrological pristinity but have experienced different levels of shock metamorphism [3]. Therefore, these materials present a unique oppurtunity to critically understand how impact processes have effected the microstructural evolution of these key accessory phases, constraining their effect on distribution of volatiles (Cl, F, OH) and radiogenic ages (U-Th-Pb) [e.g. 4-6]. Applied techniques include scanning electron microscopy (SEM), cathodoluminescence (CL), electron backscatter diffraction (EBSD), and Raman Spectroscopy. The preliminary dataset includes high-resolution (< 300 nm step size) EBSD maps of nine spatially associated apatite, five merrillite, and four baddeleyite grains, surrounded by different minerals. Apatite is found to form planar and non-planar fractures, with domains of sub-micrometer granular features that appear amorphous at the length scales of EBSD (~80 x 40nm). Texture component maps show up 25^{o} of misorientation within a single grain, evidence of severe crystal-plastic deformation. While these grains are heavily deformed, we conclude that no recrystallization of apatite has taken place. Merrillite is predominately granular, yielding randomly orientated subgrains indicitive of solid-state or melt-recrystallization, with coarser granular textures clearly being evidence of a relatively late stage formation. A small number of merrillite grains contain extensive (< 30 ^{o}) crystal lattice deformation. Baddeleyite has degraded crystallinity and is often found to be amorphous at EBSD scale. Based on EBSD and CL analysis, its microtexture can be related to that of group 2 to 3 reported for Martian baddeleyites [6], which are believed to have experienced substantial loss of radiogenic Pb.. CL features show lighter cloudy regions in the areas of lower crystallinity as indexed by EBSD, indicating a high density of defects [e.g. 7]. No high pressure polymorph of any phase was detected by Raman spectroscopy. Raman spectra of all samples complement the EBSD pattern by indicating that well-crystallized sub-micrometer sized crystallites are surrounded by amorphous material. Merrillite shows lower shock impedance than apatite, but both higher than that of baddeleyite. These structural complexities cannot be visualised using backscatter electron (BSE) imaging alone. The evidence of microstructural changes in response to shock metamorphism of widely used accessory minerals should be taken into account when interpreting the volatile content and crystallization ages of lunar highland samples.



Recrystallised, granular merrillite **Crystal plastically deformed apatite** **Crystal plastically deformed merrillite**

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