Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20793

Shock-induced disturbance of Pb isotopes and preservation of Cl isotopes in apatite within Lunar Granulite Northwest Africa 3163.

KATELYN LEHMAN FRANCO[1], BENNETT WILSON[2], RITA ECONOMOS[1] AND KIMBERLY T. TAIT[3]

[1]Southern Methodist University
[2]York University
[3]Royal Ontario Museum

Presenting Author: kmlehman@smu.edu

Apatite $Ca_5(PO_4)_3(F, Cl, OH)$ is a near-ubiquitous mineral that forms in various deposit types throughout the solar system. The flexible nature of the crystal structure allows for the incorporation of U, Th, Pb, and REEs and is a compelling mineral to decipher volatiles[e.g., 1, 2]. However, despite the prevalence of studies utilizing lunar apatite, understanding how Pb and Cl isotopes and REE are disturbed or preserved during shock in lunar apatites is limited.

To address this disparity, this study analyzed two large apatite grains (>200 µm) in an anorthositic clast of NWA 3163, which experienced S4 or S5 shock state corresponding to shock pressures of >28 GPa [3]. This study performs in situ Secondary Ionization Mass Spectrometry (SIMS) Pb and Cl isotope analyses on different micro-textural domains of these two apatites previously characterized using electron backscatter diffraction (EBSD), atom probe tomography (APT), Raman spectroscopy [3] to evaluate two hypotheses. (1) More deformed regions of the crystals, as indicated by microfractures or nanocrystalline textures, will display the most disturbed Pb-Pb ages. (2) Regions with differing deformation magnitudes will display measurable differences in $\delta^{37}Cl$.

Isotopic analyses of Pb and Cl were conducted in the two main deformation domains (crystal plastic and cataclastic deformation). Each of the regions displayed variations in the $^{207}Pb/^{206}Pb$ ratios and, in turn, the associated Pb-Pb age. Microtextural domains with primarily cataclastic deformation textures typically displayed the lowest $^{207}Pb/^{206}Pb$ ratios and youngest ages. The youngest Pb-Pb, age 3964 ± 36 Ma, is from a region with the lowest crystallinity. The areas with the highest crystal integrity had Pb-Pb ages of 4311 ± 16 Ma and 4319 ± 14 Ma, within the error of the previous Pb-Pb age of the baddeleyite grains 4308 ± 18.6 Ma. $\delta^{37}Cl$ values showed minor variations in the microtextural domains but largely remained consistent. These findings highlight the importance of characterizing shock prior to dating and argue against shock metamorphism as a mechanism for producing large, heavy Cl isotope fractionations in lunar samples.

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