The shocking state of Ca-phosphates in martian meteorites

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Apatite and merrilite provide powerful chemical records of planetary evolution, including the abundance and isotopic composition of volatiles, trace-element records of magmatic processes and absolute (thermo)chronology via U-Th-Pb-(He) isotope analysis. However, little is known about how these minerals respond to the extreme compression and heating associated with shock-metamorphism prior to, or during, earthward launch in meteorite impacts. This is despite recent recognition of shock-related devolatalization in apatite from shergottite NWA 7755 [1,2] and the prospect that preserved (anhydrous) martian merrillite may have originally been hydrous whitlockite prior to shock events [3].

Here we present nanoscale structural and chemical data for chlorapatite and merrilite in five shergottites (Zagami, NWA 6342, NWA 7257, NWA 5298, Tissint), spanning a range of shock-conditions (S4-S6 of [4]; ca. 25 to >60 GPa). We have combined nanostructural analysis by electron backscattered diffraction (EBSD) with chemical analysis by SEM-EDS and EPMA. We have also undertaken TEM and atom-probe tomography (APT) on a highly-shocked apatite to investigate physicochemical effects at the nanoscale.

Our findings reveal a wide-range of micro- to nano-structures in both apatite and merrilite from these highly-shocked samples that are not observable with routine SE/BSE imaging. These include planar features, intense crystal-plastic deformation, nanocrystalline states, granularization and the occurrence of the high-pressure polymorph tuite. These are linked to either enrichment or depletion of volatile element abundances, and/or the occurence of elements that are not major structural constituents (e.g. Fe), evidencing that shock-metamorphism is driving chemical mobility. The results have significant implications for phosphate-based interpretations of volatile and magmatic records of planetary evolution.

[1] Wang S.Z. et al. (2017) *MAPS* **52**, 2437-2457. [2] Howarth G. H. et al. (2015) *GCA* **166**, 234-248. [3] Adcock, C.T. et al. (2017) *Nature Comms.* 14667. [4] Fritz et al., (2017) *MAPS* **52**, 1216-1232.