PHOSPHATE TEXTURAL DIVERSITY IN CI CHONDRITES AND C-TYPE ASTEROIDS.

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Introduction: Apatite, $Ca_5(PO_4)_3$(CL/F/OH-), is a ubiquitous phosphate found throughout the solar system, including the most primitive solids, CI-chondrites [1,2] and related samples of carbonaceous asteroids Ryugu [3] and Bennu [4], returned by JAXA's Hayabusa2 and NASA's OSIRIS-REx missions, respectively. Apatite in these primitive solids is found as individual grains or mineral clusters and has been inferred to form from the hydrothermal sequence during cooling of their respective parent body or bodies. To better understand the formation history and reworking of these early phosphates we have undertaken a highly coordinated study of phosphate microstructures, geochemistry and U/Pb geochronology from a suite of CI meteorites and carbonaceous asteroid samples. These data have identified novel phosphate microstructures and complex relationships across a suite of apatite grains from the early solar system, indicating multiple episodes of growth and modification on the CI parent body(ies).

Methods: Samples of CI chondrites, Alais, Ivuna, Orgueil, Oued Chebeika 002, Yamato (Y) 82162, Y980115, Y980134, and two chips of Hayabusa2 Ryugu particles (A0262 and C0263) have been acquired for analysis. The bulk texture of the samples were first scanned by X-ray Computed Tomography (XCT) using the Nikon XT H 320 within the XFACT facility at NASA JSC or the Xradia 620 Versa at the UTCT facility. Based on the identification of petrofabrics or features of interest from the XCT data, samples were chipped, oriented, potted in epoxy and thick sections were prepared. After anhydrously polishing the samples with silicon carbide and dry diamond powder down to 1 µm, the samples were ion polished using a Hitachi ArBlade. Energy dispersive Xray spectrometry (EDS) maps were collected to ID phosphates of interest using a JEOL 7900F SEM. The internal microstructures of identified phosphates were then mapped by electron backscatter diffraction (EBSD) using the JEOL 7900F. Based on the EDS and EBSD data, domains of interest were targeted for quantitative chemical analyses using a JEOL 8530 EPMA. Subsequently, in situ U-Pb and $^{207}Pb/^{206}Pb$ ages will be collected using a Cameca ims1290 secondary ion mass spectrometer at UCLA across a range of microstructures.

Results: Apatite grains are ubiquitous throughout the CI chondrites and carbonaceous asteroid materials, found as individual grains, disseminated clusters or grain aggregates. Apatite grains are associated with serpentine, magnetite, and/or carbonate. Of particular interest, we have identified individual and aggregate polycrystalline grains exhibiting an internal 'honeycomb' texture (Fig. 1). Some of these grains appear overprinted by subsequent alteration while others remain unaltered. Apatite halogen sites are dominated by the missing component, assumed to be OH, and F, comparable to published values from Bennu, Ryugu and CM-chondrites [3-5]. However, the Yamato CI-like meteorites show a broader range of Cl values, and one grain from Alais is dominated by CL.

Summary: Apatite growth features indicate a protracted and complex growth history, consistent with precipitation from an evolving fluid system. The 'honeycomb' texture identified in some CI meteorites is, to the best of our knowledge, the first report of such a microstructure in meteoritic phosphate. The microtextures and zoning will guide subsequent age analyses, to better constrain the formation and reworking of phosphate in CI(-like) materials.

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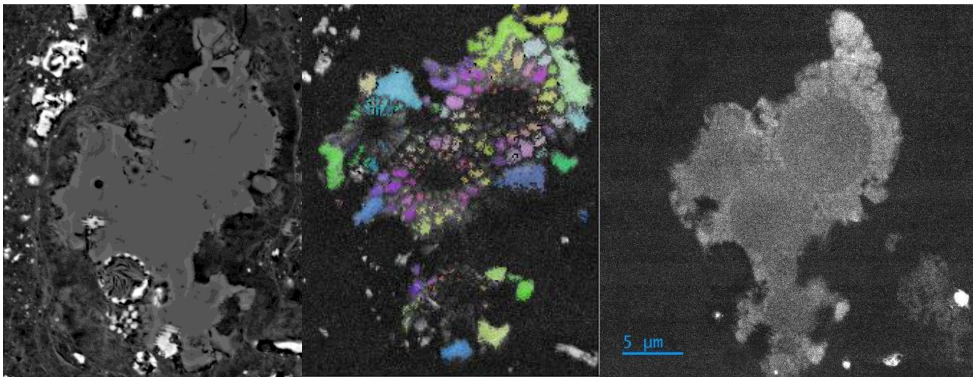

Figure 1. *BSE, EBSD and CL maps of an 'honeycomb'-textured aggregate from Y82162. The aggregate is composed of an aggregate of polycrystalline cores with a overprinted and embayed rim that is brighter in CL.*