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3D CRYSTALLOGRAPHIC ORIENTATION OF OLIVINE IN BJURBÖLE CHONDRULES.

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Introduction: The crystallographic orientations of chondrule minerals can provide important insights into their formation and deformational history. For example, the orientations of the olivine bars and surrounding rim in barred olivine chondrules provide information and on the conditions of crystallization [e.g., 1-2] and the orientations and shapes of olivines within porphritic chondrules can record the reactions with the surrounding nebular gas during chondrule formation [3]. Later deformation on the parent body can cause crystal-plastic deformation of chondrule minerals that is evident through their intracrystalline lattice misorientations [4]. Typically these crystal orientations and lattice misorientations are determined using electron backscatter diffraction (EBSD) on thin sections but this gives only a 2D picture for what is actually a 3D texture. While it is possible to combine EBSD with serial sectioning to build a 3D dataset of texture, this is a destructive, time-intensive process.

A recent technological development that enables non-destructive, 3D crystallographic orientation measurement is X-ray diffraction contrast tomography (DCT), which uses the X-ray diffraction of the crystal lattice to determine orientation. Originally only possible using monochromatic X-ray beams at 3rd generation synchrotron light sources [5], DCT has been recently adapted to polychromatic sources of laboratory X-ray microscopes (referred to as Lab-DCT) [6]. Up to this point LabDCT has only been applied to large, well-formed crystals of high symmetry (i.e., metals) [6], but we recently acquired DCT datasets for a pair Bjurböle chondrules to determine the applicability of the technique to natural, mutlimineralic samples composed predominately of olivine (i.e., chondrules).

Methods: We first extracted a set (~10) of chondrules from the Bjurböle chondrite by manually segregating them from the highly friable matrix using hand crushing, tweezers, and a binocular microscope. Adhering matrix was removed as much as possible by rolling the chondrules between fingers, scraping with tweezers, and/or dusting with a brush. The cleaned chondrules were imaged with X-ray computed tomography (XCT) using an Xradia MicroXCT scanner (80 kV, 10W, ~5 µm voxels) at the University of Texas High Resolution XCT Facility in order to select two candidates for DCT - a porphyritic olivine chondrule and a barred olivine chondrule. The chondrules were then sent to Zeiss X-ray Microscopy, Inc. for collection of LabDCT data on a Versa 520 system.

Results: LabDCT was successful in mapping the 3D orientation of olivine within the interior of both chondrules. Due to the large size of the barred olivine chondrule (~1.85 mm) relative to the field of view of the DCT system (~ 750 µm), only the interior portion of the chondrule was mapped (Fig. 1A). However, two sets of bars with distinct crystallographic orientations are clearly visible. The porphyritic chondrule shows a variety of olivine orientations as well as a radial distribution in crystal quality (Fig. 1B). Olivine grains in the center are relatively large and well-defined while the those on the periphery are smaller with highly irregular boundaries, suggesting that they may be deformed. Possible explanations for deformed or irregular peripheral grains include impact deformation on the asteroid parent body [4] or reactions with the surrounding nebular gas during chondrule formation [3,6]. We are continuing to analyze both datasets to extract additional information on the relative orientation of the bars and the 3D spatial distribution of the porphyritic olivine orientations.

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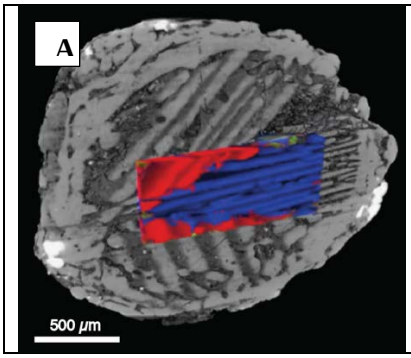


Figure 1. A) DCT data (color) showing two different crystallographic orientations overlain on absorption tomography data (grayscale) of the Bjurböle barred olivine chondrule. B) [