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Exploring diamond inclusions via combined microtomography and single-crystal X-ray diffraction at GSECARS

DR. STELLA CHARITON, PHD, VITALI PRAKAPENKA, MARK RIVERS, DONGZHOU ZHANG AND CHRISTOFANIS SKORDAS

The University of Chicago

Presenting Author: stellachariton@uchicago.edu

Most of our knowledge on the Earth's deep interior is obtained through surface observations and geophysical surveys in combination with experiments and computational models. Diamond inclusions represent a direct window into the deepest layers of our planet and although rare specimens, the information they carry is invaluable in determining the mantle chemistry and understanding processes such as mantle convection and volatile cycling. A suite of techniques may be used to study diamond inclusions and to identify the phases entrapped. However, many are considered destructive, often requiring exposure of the inclusion to the surface by diamond polishing. Such approaches pose a significant risk to the analysis and results interpretation due to possible alteration of the inclusions by exposure to the atmospheric air and pressure as well as loss of fluid phases. Synchrotron single-crystal X-ray diffraction (SCXRD) is a powerful and unique tool in unravelling complex mineral assemblages by allowing accurate structure determination and phase identification. However, studying sub-surface inclusions (i.e. not exposed to the diamond surface) presents a challenge during alignment procedures, especially in the cases where the entrapped phases are weak absorbers. At the 13BM-D beamline at GSECARS we combined computed microtomography (CMT) and SCXRD to approach this problem (Fig. 1). Diamonds are first scanned with pink or monochromatic beam producing a series of high contrast absorption images, followed by a filtered back-projection analysis that produces their 3D reconstructions revealing sample features such as density contrast, cracks, zoning, fluid rims etc. This allows the precise visualization, location and placement of selected inclusions on the rotational axis aligned with the X-ray beam to collect high resolution SCXRD patterns. This well optimized user-friendly procedure (Fig. 2) is ideal for pilot and advanced measurements on rough unpolished diamonds or other samples without invading the microenvironment of the inclusion, thus providing critical information essential for understanding the structure of the deep Erath's interior. We will present the detailed methodology, discuss the merits and limitations as well as the developments that the APS-U synchrotron upgrade will offer on this dynamic duo of techniques.