

### 3D shapes of olivine negative crystals in equilibrated ordinary chondrites: Estimation of equilibrium form

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It is important to understand the crystal shapes of olivine, which is one of the most common minerals both in the earth and cosmic environments. There are two kinds of crystal forms; growth and equilibrium form. The equilibrium form was obtained by *ab initio* calculation [1] but it has not been confirmed by natural crystals. In this study, the equilibrium form was estimated from the 3D shapes of negative crystals along healed cracks in olivine grains in equilibrated ordinary chondrites. Relative ages of the healed cracks were also discussed based on the negative crystal shapes.

We used the Tuxtuac (LL5), Kilabo (LL6) and Y793214 (LL5) meteorites. Seven cube-shaped samples 20-30  $\mu\text{m}$  in size were extracted from olivine crystals in thin sections by using FIB. Then, their 3D structure were imaged by microtomography at BL47XU, SPring-8 with the effective spatial resolution of  $\sim 150$  nm. The crystallographic orientations of the host olivine crystals were determined by EBSD. The lengths along the crystal axes and the crystal planes of negative crystals were determined from the CT images together with the EBSD information.

Void inclusions with facets, or negative crystals, 0.5–8.0  $\mu\text{m}$  in size were clearly recognized along a plane, which corresponds to a healed crack. The axial length ratios of negative crystals along one healed crack in the Tuxtuac meteorite are almost similar irrespective of their size. This indicates the negative crystals in this healed crack were annealed and the shape, which has (100), (010) and (021) planes with rounded edges, comes close to the equilibrium form. The development of (100) is different from the equilibrium form obtained by *ab initio* calculation [1], where (100) has a high surface free energy. Possible causes for this discrepancy are Fe-rich surface composition or adsorption of molecules onto the surface of the negative crystals.

Degrees of annealing of healed cracks were also evaluated from the degrees of scatter of the axial length ratios. More than one healed cracks with different degrees of annealing is present in a single rock fragments, indicating different relative ages of these cracks.

[1] Bruno et al. (2014) JCP, 118: 2498.