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Witness to strain: Subdomain boundary length and the apparent subdomain boundary density in large strained olivine grains

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Abstract

Electron backscatter diffraction (EBSD) investigation of strain mainly uses polycrystalline samples to study fabric development. We extend the use of EBSD for the analysis of large single mineral grains by measuring the apparent surficial subdomain boundary density per unit area, reported here as unit segment length (USL). We apply this USL technique to examine and quantify the plastic deformation recorded by naturally shocked olivine in the low to moderately shocked ureilite meteorite Northwest Africa 2221 and the highly shocked martian dunitic cumulate meteorite Northwest Africa 2737, by assessing the types of subdomain boundaries and the increase of subdomain misorientation with increasing shock metamorphism. We further compare USL results for the shocked olivine in the meteorites with those for the terrestrial deformation of Hawaiian olivine. USL of olivine increases with shock level, and USL from shocked olivine is significantly greater than that of terrestrially deformed olivine. USL is a promising tool for the quantification of plastic deformation in large single crystals from shock as well as terrestrial deformation. The results derived from USL measurements along with local EBSD maps are complementary with quantitative 2D X-ray diffraction analysis of crystal deformation and disruption, leading to a more comprehensive understanding of characteristic shock deformation recorded by large single crystals.

Keywords: EBSD, crystal deformation, subdomain walls, shock metamorphism