Shock deformation of major and accessory minerals in an unbrecciated lunar basalt

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Unlike most basalts sampled during the Apollo and Luna missions, lunar meteorite NWA 479/032 is fresh and unbrecciated. With a crystallization age of 2.8 Ga, it is the youngest ever-dated lunar basalt, clearly post-dating the Late Heavy Bombardment period (4.0 - 3.6 Ga) and the last twitches of lunar tectonism (~4 Ga). The pristine preservation state of NWA 479/032 makes it a sample of choice for anyone willing to investigate lunar shock metamorphism.

Deformation of minerals in extraterrestrial rocks have been the subject of numerous TEM studies over the last 40 years. Most of the attention has been given to the deformation of major minerals, whereas accessory phases have received little interest. In addition, in spite of being an extremely valuable tool to image and characterize deformation features, TEM is limited to the very local scale, which prevents the broad picture of deformation from being investigated. We present here preliminary results on shock deformation of major (olivine and pyroxene) and accessory (ilmenite, chromite, FeNi metal, pentlandite, troilite) minerals in lunar basalt NWA 479 taking advantage of the flexibility of electron backscatter diffraction (EBSD).

Olivine and pyroxene phenocrysts display gradual crystal-plastic deformation features characterized by lattice distortion of up to 40° resulting from the combined activation of several slip systems. Olivine also shows typical planar deformation features (PDF) parallel to (001) and brittle fractures parallel to (100). Pyroxene phenocrysts are overgrown by radiating pyroxene grains with crystallographic orientation mimicking that of the underlying crystal lattice, a feature interpreted as magmatic epitaxial growth followed by concomitant shock-induced lattice distortion. Ilmenite shows misorientation of up to 22° along the main elongation axis, whereas that of chromite generally remains below 20°. FeNi metal particles consist of a core of tiny deformed bcc crystals (probably martensite) surrounded by a heavily distorted fcc single-crystal rim (probably taenite). Pentlandite and troilite form aggregates of undeformed randomly-oriented polygonal crystals with triple-junction grain boundaries.