Applications of electron backscatter diffraction to lunar and other extraterrestrial samples. N. E. Timms[1], S. M. Reddy[1], A. A. Nemchin[1], M. L. Grange[1], R. T. Pidgeon[1], P. A. Bland[1], G. Benedix[1], K. A. Dyl[1], M.-A. Kaczmarek[1] and F. Jourdan[1]. [1]Department of Applied Geology, Curtin University, GPO Box U1987, Perth, 6845, Western Australia. Corresponding author email: n.timms@curtin.edu.au

Introduction: Electron backscatter diffraction (EBSD) is a scanning electron microscope (SEM) based technique whereby kikuchi diffraction patterns are acquired from points on a polished sample surface and indexed for mineral phase and its crystallographic orientation. Automated EBSD mapping produces microstructural maps with typical angular resolution less than 1 degree. The small activation volume for most minerals mean that spatial resolution of ~50 nm can be achieved on most field emission SEMs.

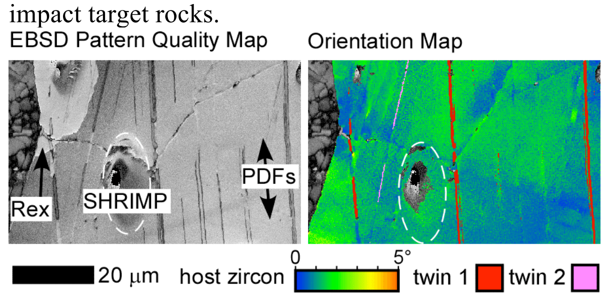
EBSD is ideally suited to resolve many types of microstructure in lunar and meteorite samples, and is an emergent technique in lunar and meteorite science. So far, EBSD has been successfully used to investigate fabrics in the Allende chondrite [1] and to resolve microstructures within lunar zircon grains from the Apollo 17 samples [2], [3], [4], [5]. Many internal features were only recognized in lunar zircon via EBSD. Therefore, EBSD compliments cathodoluminescence and backscatter electron imaging to provide context for ion probe U-Pb age data to facilitate new interpretations of magmatic and impact history of the moon [2], [4], [6]. This presentation summarises the capibalities and limitations of EBSD analysis of lunar and meteorite samples using a range of the latest data.

Petrofabrics and grain boundary microstructures: Full quantification of crystallographic preferred orientation (CPO) for all phases present in the sample is a routine part of EBSD analysis. Definition of grains based on crystallographic orientation provides statistically robust data on 2-D grain size and shape distributions. Grain boundary characteristics can be quantified, including the angle and axis that describes the misorientation between a grain and its neighbour. This kind of analysis can reveal insights into the processes and mechanisms of solid state deformation [1] and/or magmatic flow. CPO data can be used to calculate material properties, such as seismic anisotropy.

Intragrain microstructures:

Dislocation-related microstructures. Analysis of crystallographic orientation variations within individual grains, manifest as lattice curvature, deformation bands and/or subgrains [5], can yield information about the density and type of defects responsible, which can be characteristic of the conditions of deformation and link with intragrain geochemical variations.

Twins and polymorphous lamellae. EBSD has been used to investigate shock twinning [5], and is ideally suited to identify high-pressure polymorphs in impact target rocks.



Lattice damage and annealing microstructures. The quality of EBSD patterns is dependent on the crystallinity in the activation volume. Completely amorphous materials do not yield diffraction patterns. Consequently, EBSD pattern quality maps can be used to identify domains of lattice damage, such as shock-induced planar deformation features (PDFs) and other domains of shock vitrification [5]. EBSD pattern quality is consequently also sensitive to radiation damage. A preliminary attempt to calibrate EBSD as a radiation damage probe for zircon is in progress. EBSD has also been used to delimit recrystallised and annealed domains in lunar zircon [5].

Reaction and recrystallisation textures. EBSD can be used to investigate reaction and replacement textures such as fine-scale mineral intergrowths, symplectites, and coronas [3], yielding insights into alteration / reaction processes and mechanisms in lunar samples.

Limitations: Successful EBSD analysis relies on high quality polished sample surface where the damage from mechanical polishing has been removed. This is usually achieved by chemical-mechanical approach using colloidal silica on a vibrating lap. However, thin sections cut from samples from early Apollo missions are delicate and require alternative polishing approaches. In some cases, automated EBSD may not be able to distinguish between phases with similar diffraction pattern characteristics. However, the latest developments in EBSD acquisition systems largely overcome this issue.

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