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Analysing crystal distortions to deduce dislocation slip systems

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In many parts of the Earth rocks deform by dislocation creep. There is therefore a need to understand which slip systems operated in nature and in experimental products. Knowing the conditions of experiments may then allow natural conditions and strain rates to be characterised. Dislocation creep typically gives lattice preferred orientations (LPOs), since activity on particular slip systems leads to lattice rotations and alignment. For decades LPOs, measured first optically and since the 1990s by EBSD, have been used to infer slip systems. This is a valuable technique but the link between slip sytem activity and LPO is complicated, especially if recrystallisation and/or grain boundary sliding have been involved.

Here we present a more direct method to deduce "geometrically necessary" dislocations (GNDs) from the distortions within crystals. Distortions may be optically visible (e.g. undulose extinction in quartz) but EBSD has revealed how common distortions are, and allowed them to be quantified. The method does not give the complete picture of GNDs but allows hypotheses to be tested about possible slip systems. We illustrate this "Weighted Burgers Vector" method with a number of examples. In olivine the method distinguishes slip parallel to a and c, and in plastically deformed plagioclase it reveals a variety of slip systems which would be difficuilt to deduce from LPOs alone. GNDs may not necessarily reflect the full slip system activity, since many dislocations will have passed through crystals and merged with grain boundaries leaving no signature. Neverthless the method highlights what dislocations are present "stranded" in the microstructure. In many case these will have been produced by deformation although the method can also characterise growth defects.

Wheeler et al. 2009. The weighted Burgers vector: a new quantity for constraining dislocation densities and types using electron backscatter diffraction on 2D sections through crystalline materials. DOI: 10.1111/j.1365-2818.2009.03136.x