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Determining dislocation density and types from EBSD data: the Weighted Burgers Vector

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Intracrystalline distortion is common in minerals, and not only those in tectonites. Such distortion is manifest at the atomic scale in subgrain walls and distributed "geometrically necessary" dislocations. Dislocations may relate to slip systems in intracrystalline plasticity, in which case it would be useful to deduce Burgers vectors. They may have other origins and whatever their origin, dislocations provide fast diffusion pathways and the chemistry and isotope chemistry of distorted grains can be modified as a result, depending on the dislocation density. Although lattice distortion may be visible optically, EBSD maps provide a more quantitative and complete description. Here I show how EBSD maps can yield information on dislocation density and Burgers vectors. Conventional methods use misorientation axes in distorted crystals to deduce slip systems but these are not robust – they are often based on visual assessment of stereonets so are error prone, and involve assumptions such as a "tilt" rather than "twist" nature for boundaries. Instead I calculate a vector quantity, the "Weighted Burgers Vector" (WBV) which contains information on the Burgers vector and on dislocation density. It relates to part of the Nye dislocation density tensor and is weighted towards dislocation lines at a high angle to the map, hence the name. Despite not yielding all the information we might desire, the WBV still provides insights into the Burgers vectors of dislocations in the microstructure, and can be used to test hypotheses. There are few assumptions behind the calculation and it can be used for rigorous analysis of tilt, twist or mixed distortions. Errors in EBSD measurements do propagate through the calculation of local WBV by a "differential" method. A complementary "integral" method, in which the total dislocation population of a large region on the map is quantified, is less error prone, though cannot provide the spatial distribution of those dislocations. I present applications of the method in relation to various geological problems, to emphasise its usefulness.

Wheeler, J., Mariani, E., Piazolo, S., Prior, D.J., Trimby, P., Drury, M.R., 2009. The Weighted Burgers Vector: a new quantity for constraining dislocation densities and types using Electron Backscatter Diffraction on 2D sections through crystalline materials. Journal of Microscopy 233, 482-494.