Grain boundary structure: misorientation dependence

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The low-angle misorientation between two grains is often accommodated by the elastic displacement fields associated with a periodic array of dislocations (Burgers, 1940). Such a dislocation model would lose its physical meaning for high-angle grain boundaries, because then the dislocation would become so closely spaced as to lose their characteristic elastic displacement field. It has, therefore, been common to assume the border between low and high angle boundaries to be in the region around a misorientation of 15 degree (Brandon, 1966). A recent detail analysis of grain boundary mobility of Al also suggests the transition occur at a misorientation of approximately 13.6 degree in case of strain driven grain boundary migration (Gottstein et al., 2001). On the other hand, the transition of boundary structure from low-angle to high-angle boundaries of minerals is still poorly understood. In this study, we analyzed the grain boundary structure in a deformed planar quartz vein within the Lewisian basement gneiss in Torridon, NW Scotland.

The microstructure was firstly characterized using a mapping of crystallographic orientation determined by electron backscattered diffraction (EBSD) in the scanning electron microscope (SEM). The same area was then imaged using double two-beam bright field images in the transmission electron microscope (TEM).

The preliminarily analyzed area was from the low strain area of the quartz vein. Large relict grains are clearly visible and separated by narrow bands of fine-grained matrix quartz. Optical images indicate that the large relict grains show undulate extinction. The mapping of crystallographic orientation revealed that the analyzed area consists of grains misorientated by 1 and 104 degrees.

For a low-angle boundaries with a misorientation less than 8 degree, double two-beam images revealed that these boundaries consist of arrays of dislocations. Along low angle boundaries, fluid inclusions often exist. On the other hand, no periodic fringe systems can be seen in the images of a boundary with a misorientation of approximately 23 degree, except for the pendellösung fringe. Our preliminary results, therefore, suggest that a transition of boundary structure from low to high angle boundaries takes place in the region between 8 and 23 degrees.