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Relation of quartz c-axis pole figures to deformation processes and flow

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Quartz c-axis pole figures are hugely popular for the estimation of various deformation conditions, such as strain state, slip system interpretation or deformation temperature. Most of these relations are purely empirical. Here we present quantitative results of the relation between microstructure and quartz c-axis pole figure data to add to the insights between deformation processes and texture development. We analyze EBSD data of experimentally sheared quartzite (kinematic vorticity number Wk = 0.9, experiments of Heilbronner & Tullis, 2006), a mylonitic quartzite from Eriboll (Wk = 0.5, Lloyd's pers. collection) and a deformed quartz vein from the Tonale line (Wk = 0.4, Stipp & Kunze, 2008). All samples are composed of deformed old grains and recrystallized (by bulging and/or subgrain rotation) and deformed grains in variable proportions.

C-axis pole figures can be decomposed into several components (girdles and point maxima) which occupy distinct positions. These components can be related to two simple microstructural parameters, aspect ratio and long axis direction of grains. While the grain shape evolution in each of the samples differ in detail, they have several features in common:
1) c-axes of equiaxed grains occupy a position close to the inferred instantaneous shortening direction,
2) c-axes of grains with higher aspect ratios contribute to single girdle distributions,
3) the girdle position depends on the grain long axis direction,
4) grains with long axes parallel to the foliation (inferred XY plane of finite strain) provide highest c-axis concentrations in the center of the pole figure,
5) grains contributing to an oblique grain shaped foliation ("freshly" recrystallized, deformed grains) show elongated, peripheral maxima grading into single girdles inclined with the sense of shear and
6) grain shapes which relate to antithetic flow (in the low Wk samples), relations 3-5 hold, with the exception that the resulting peripheral maximum or girdle is also inclined against the sense of shear.

We interpret the individual c-axis pole figure components to reflect contributions from different processes which relate to oriented nucleation or growth (in the case of bulging recrystallization), as well as to a grains' strain history. This strain history depends on the ratio of how fast a grain is straining (by glide) to how fast it is recrystallizing. The final c-axis pole figure of a polycrystalline aggregate simply reflects the weighted mixture of these components based on the synchronous contribution of each process.

The individual contribution of each process depends on several parameters (e.g., stress as a driving force for local grain boundary migration, grain boundary mobility, or rate of deformation among others). Since many of these parameters are also temperature-dependent, we suggest, for instance, that the variability of the c-axis opening angle with temperature is merely the result of the temperature different dependencies of the contributing processes. Hence, it is unsurprising that the so-called c-axis opening angle cannot be universally applied as a thermometer and is a good example of unrelated cause and correlation and may be expected to give arbitrary results.

References:

Heilbronner, R., Tullis J., 2006 https://doi.org/10.1029/2005JB004194, 2006.
Stipp, M. and Kunze, K., 2008 https://doi.org/10.1016/j.tecto.2007.11.041, 2008.