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Orientation Tracking - a quantitative description of pole figure development in experimentally deformed and dynamically recrystallizing quartzite

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In texture goniometry, EBSD-, CIP- and U-stage analysis, the maximum density and/or the texture index are often used to assess and compare the strength of c-axis pole figures of naturally and experimentally deformed and annealed rocks. The implicit assumption being that the higher the maximum (or index) the stronger the crystallographic preferred orientation. For single maximum orientations this is probably a safe assumption, however, in the case of other types of c-axis pattern (such as single girdles, crossed girdles, etc.) the formation of an individual high maximum may be fortuitous and thus cannot represent a robust measure for the "tightness" of a given crystallographic orientation. The ranking of single girdle pole figures (from weak to strong preferred orientation) based on a ranking of texture maxima, may be misleading (see also Heilbronner et al., 2002). Finally, the problem is even more aggravated if different types of pole figures are compared to each other.

For a suite of Black Hills Quartzite samples deformed in dislocation creep regime with grain boundary recrystallization (Griggs apparatus, confining pressure: 1.5 GPa, temperature: 900˚C, shear strain rate: 10-6 s-1, 0.17 wt% H2O added), the c-axis pole figures were calculated using the CIP method (Heilbronner, 2000). In a range of shear strains from 1.5 to 8, and with increasing recrystallization from 0 to 100%, the pole figures evolve from random to small girdles about the applied sigma 1 to a single maximum (for basal <a> glide) to an inclined girdle distribution to a girdle with distributed maxima in positions for rhomb <a> and prism <a> glide to a girdle with a single Y maximum (prism <a> glide) (Heilbronner & Tullis, 2002, Heilbronner & Tullis, in prep). The corresponding maxima range between 3.5 and 4.7 at low gamma and increase to 16 once the Y maximum is formed. However the increase is not steady.

Thresholded misorientation images were used to calculate the volume density (= area fraction) in given texture domains which were defined on the pole figures: three 45 degree cones about the applied sigma 1 direction, basal and Y positions were selected, plus two cones in the rhomb positions and a 30 degree single girdle inclined with the sense of shear. The densities are expressed as multiples of the uniform density, i.e, the density of the respective domains in the undeformed case.

Up to a gamma of 5-6, a number of transient pole figure patterns appear reflecting the transition from patterns that are dominated by intracrystalline deformation of old porphyroclasts (100μm) to patterns which are dominated by the dynamic recrystallization of new grains (20μm). If there is a final ('steady state') pattern and if it is an inclined girdle with a strong Y maximum is not clear from our experiments. However, there is a clear and steady increase of rotation and strengthening of the c-axis density in the inclined girdle with increasing recrystallization, i.e., strain.

Detailed results and details of the orientation tracking technique are shown on the presentation. The technique will be made available from the web site (http://www.unibas.ch/earth/micro/)

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