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Towards a stress and strain-related interpretation of quartz crystallographic preferred orientations

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Deformation by dislocation creep in quartzites is usually accompanied by the development of a crystallographic preferred orientation (CPO). Quartz CPOs have been suggested to reflect conditions of deformation through, e.g., a temperature dependent selection of slip systems. Contrary to this current interpretation, we suggest that the finite CPO is rather the result of the total accommodated strain by dislocation creep and an additional, stress-dependent, CPO forming mechanism (Kilian & Heilbronner, 2017).

Quartz CPO of experimentally sheared Black Hills Quartzite (dislocation creep regimes 1 to 3 experiments of Heilbronner & Tullis, 2002/2006) have been re-evaluated by means of EBSD. It can be shown that the CPO has two end-members: (i) a dislocation glide induced component where c-axes migrate along a kinked girdle towards the center of the pole figure, dominant in regime 3 and (ii) a stress induced component with new grains forming with their c-axes at periphery of the pole figure, dominant in regime 1. The strength of the CPO increases with strain in the low stress regime while it weakens in the high stress regime. Weakening typically results from a higher contribution of grain boundary sliding and associated rigid grain rotation of newly formed grains. The finite CPO is the result of the competing contributions of both texture forming processes. We therefore conclude that any relation of CPO and temperature is only of an indirect nature, and furthermore, that peripheral quartz c-axes do not relate to basal-a glide.

We propose that quartz CPOs can be used as tracers of strain localization, and by discriminating between typical high stress and low stress CPO types, it is possible to distinguish between stress driven localization in contrast to weakening by crystal plastic processes.

References:

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