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The relationship between fluid infiltration, metamorphism and deformation: an example from the Bergen Arcs, Norway

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The Bergen Arcs are a classic field area for the study of fluid infiltration into dry, low permeability granulites, resulting in amphibolite and eclogite facies parageneses typically developed along fluid fronts and shear zones. The relationship between fluid infiltration and mineral reactions can be mapped at outcrop as well as micro-scale, and it is now a widely accepted generalization that the metamorphism requires fluids for reactions to proceed.
Given that the metamorphic reactions and deformation in the shear zones are clearly related, raises the question of how appropriate are our "solid state" notions of deformation mechanisms under these conditions. Although deformation mechanisms in minerals have been studied for many decades, experiments have largely been on monomineralic non-reacting samples and mechanisms related to the theories first derived in metals and ceramics. Thus high temperature dislocation glide, diffusion creep both by grain boundary diffusion (Coble creep) and volume diffusion (Nabarro-Herring creep) have been recognised in quartz and feldspar.
In a similar way, the strength of rocks has been equated with the dry strength of component minerals, and rock weakening due to fluids attributed to the formation of 'softer' minerals such as micas. When fluid-induced weakening of individual minerals such as quartz and feldspar was recognized, there was still the tendency to explain this in solid state terms e.g. "fluid enhanced dislocation glide".
An EBSD study of feldspars taken from a sequence of rocks in the Bergen Arcs, across a section from relatively undeformed and unreacted granulites into a highly deformed shear zone shows that crystallographic orientations from groups of feldspar grains within the shear zone can be related to individual parent feldspar grains within the granulite, that is, the crystallographic preferred orientation (CPO) is inherited. The feldspar textures and analysis of the misorientation angle distributions for neighbouring and random pairs of feldspar grains suggest that the deformation mechanism is by dissolution-precipitation creep rather than dislocation creep. The loss of strength of the rock is dependent on the reactivity of the minerals in the specific fluid and not simply on inherent physical properties of the minerals themselves.
A future challenge will be to determine the conditions under which dissolution-precipitation creep is dominant over dislocation creep as the principal deformation mechanism.