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Brittle-viscous transition in granulite-facies perthites: implications for lower crustal strength

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Deformation in granulite facies rocks of the mangerite-charnockites in Lofoten (Norway) is localized in shear zones, which have formed at P=0.65-0.8 GPa, T=710-725° C. In the shear zones, recrystallization of perthites is localized along intracrystalline bands. The bands are parallel to shear microcracks and to trails of amphibole and biotite, interpreted as healed microcracks. Fracturing preferentially occurred (but non necessarily) along the excellent cleavage planes (010) and (001). EBSD analysis of perthite porphyroclasts indicates a very low degree of internal misorientation (within 5°) and the lack of recovery features. Recrystallized grains show coarsening with increasing width of the bands, and chemical changes with respect to the host grains (e.g. An14 in the recrystallized grains vs. An22 in the hosting perthites). Crystallographic orientation of the new grains does not show a host-control relation to the parent perthite grains. In summary, there is no evidence for dominant dislocation creep deformation, and the microstructure and CPO data consistently indicate an intragranular recrystallization of perthite by nucleation and growth processes along microcracks.

Perthite porphyroclasts are surrounded by a matrix of recrystallized plagioclase + K-feldspar (average grain size of 25 μm) $\pm$ amphibole. Amphibole and K-feldspar commonly occur at triple and quadruple junctions between plagioclase grains. There is extensive evidence of phase boundary migration in the matrix, with plagioclase grains forming bulges and protrusions towards K-feldspar. The phase boundaries between K-feldspar and plagioclase are more frequent than grain boundaries, indicating that feldspars are well intermixed in the matrix. Phase boundaries occur with a high density in a C'-type shear band orientation. These observations are consistent with diffusion creep as the dominant deformation mechanism in the matrix, associated with grain boundary sliding and syndeformational nucleation of phases in dilatant sites. Accordingly, recrystallized plagioclase and K-feldspar show a very weak crystallographic preferred orientation, which is not interpretable in terms of intracrystalline slip systems.

Fracturing in feldspars under high P, T conditions is probably indicative of a high stress at the onset of deformation (depending on the absence or presence of a high pore fluid pressure). We suggest that the microstructural evolution of perthites reflects a transition from dry-and-strong conditions in the protolith to wet-and-weak conditions in the mylonites, promoted by extensive fracturing and grain size reduction, resulting in the operation of grain-size sensitive creep and in strain localization.