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Can epitaxial replacement induce low temperature recovery and recrystallization?

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Microstructural analysis of deformed rocks can help identify which deformation mechanism was dominant during viscous deformation of the mid-to-lower crust. Crystal plastic deformation can result in the development of subgrains and a strong crystallographic preferred orientation (CPO); the presence of such microstructures are traditionally taken as evidence for dominance of dislocation creep. These microstructures are observed in plagioclase (pure albite end member) grains deformed at mid-crustal conditions (greenschist facies) in a km-wide Alpine extensional shear zone. However, crystal plastic behaviour is temperature dependent, and our current understanding of the behaviour of plagioclase suggests dislocation creep should not dominate deformation at these conditions (300-450°C, <9 kbar).
We present the results of an electron backscatter diffraction (EBSD) study that suggests epitaxial replacement was responsible for the development of the observed microstructures. The presence of inclusion trails that record fluid infiltration pathways, chessboard twinning, and high dislocation densities in product porphyroclasts are taken as indicators that fluid-mediated epitaxial replacement of Ca-bearing plagioclase to pure albite occurred to produce mm-scale product grains with an inherited CPO and a high dislocation density (, due to lattice mismatch between parent and daughter grains). We speculate that subsequent deformation has driven recovery of dislocations into subgrain walls at relatively low T (0.3-0.4 Tm); high and associated stored plastic strain energy providing the driving force for recovery. The observation that subgrains with a relatively low dislocation density mantle porphyroclasts with a relatively high dislocation density may indicate that higher local stresses at grain boundaries (with respect to the grain interior) during continued deformation have influenced recovery and the generation of subgrain walls. Subsequent subgrain rotation recrystallization leads to the development of high-angle boundaries, reducing matrix grain size by two orders of magnitude with respect to the porphyroclasts, thus promoting the dominance of grain size sensitive creep during further strain accommodation. CPO domains have undergone adjustment during grain size sensitive creep but a strong preferred orientation has been retained. We show that EBSD can be used to characterise the textures that develop during epitaxial replacement in fine detail. We suggest that epitaxial phase transitions involving a lattice mismatch resulting in product grains with a high can lead to the development of microstructures reminiscent of dislocation creep. Care must therefore be taken when using the presence of features such as subgrains and CPO domains to infer a dominant deformation mechanism.