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The role of dynamic recrystallization in the evolution of crystallographic preferred orientations of experimentally deformed calcite

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The evolution of crystallographic preferred orientations (CPO) during dislocation mediated creep impacts many petrophysical properties and their anisotropy. Simulations and observations of CPO development in several minerals indicate that dynamic recrystallization can exert a control on the types and strengths of CPO produced during deformation. However, experimental data constraining the impacts of each recrystallization mechanism on calcite CPO are limited. For this reason, here we present electron backscattered diffraction (EBSD) measurements of CPO and other microstructures developed in experimentally deformed Carrara marble. The experiments were carried out at strain rates of 3×10-6 s-1 to 4.9×10-4 s-1, temperatures of 700−990°C, confining pressures of 150 and 300 MPa, and to strains of 0.15−0.90 under uniaxial compression, triggering dynamic recrystallization of the samples. Resultant flow stresses were in the range 15−85 MPa. The experiments resulted in different CPOs and microstructures, indicating variations in the deformation processes. At low temperature and high stress, grains are diamond shaped with mantles of subgrains indicating operation of grain boundary sliding accompanied by subgrain rotation recrystallization and minor grain boundary migration. With increasing temperature and decreasing stress, grain boundaries become highly lobate, indicating a transition to recrystallization dominated by grain boundary migration (GBM). This transition in grain morphology is accompanied by a transition in CPO, from a point maximum parallel to the compression axis to small circles or scattered point maxima. Misorientation axes of subgrain boundaries are parallel to {f}, {m}, (c) and/or <a>, all of which are consistent with tilt or twist boundaries comprised of dislocations on the {f}<0-111> and/or (c)<a> slip systems, indicating that one or both of these slip systems operated in all samples. These observations are broadly consistent with a model recently proposed based on observations of ice, in which (c)<a>, the weaker of the two slip systems above, is also the weakest slip system. At lower temperatures and/or higher stresses, subgrain rotation contributes to a [c]-axis maximum parallel to the compression axis. In contrast, at higher temperatures and/or lower stresses, GBM consumes grains that are poorly oriented for (c)<a> slip and therefore support higher stresses and dislocation densities than their neighbours. These results elucidate the control exerted by recrystallization mechanisms on CPO type, which in turn impacts anisotropy in viscosity and seismic wave velocity.