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Dynamically- and chemically-induced grain boundary migration in quartz: microstructures, crystallographic fabrics, and trace element contents

Will Nachlas and Jay Thomas

Department of Earth Sciences, Syracuse University, Syracuse, New York, United States (wnachlas@syr.edu)

Grain boundary migration (GBM) is a common mechanism by which quartz recrystallizes in the Earth. In the most basic sense, GBM occurs as atoms exchange structural positions across a planar defect. Reconstitution of grains via GBM imparts a new crystallographic orientation, but its effect on the geochemistry of recrystallized grains remains uncertain and depends on the kinetic and thermodynamic properties of the moving grain boundary. Two of the dominant driving forces for GBM are lattice strain energy, controlled by the applied stress field, and chemical potential energy, controlled by differences in mineral stability. We present observations from static and dynamic recrystallization experiments showing evidence for GBM in response to both of these driving forces. In static recrystallization experiments, quartz recrystallized in response to local variations in trace-level Ti concentrations, whereas in dynamic recrystallization experiments, quartz recrystallized during dislocation creep in response to the imposed differential stress. Each case produced recrystallized quartz exhibiting diagnostic microstructures, crystallographic fabrics, and trace element contents that can be used to infer the mechanisms of quartz recrystallization and the pressure-temperature conditions at which recrystallization occurred.