Geophysical Research Abstracts,
Vol. 11, EGU2009-6761-1, 2009
EGU General Assembly 2009

Why calcite can be stronger than quartz

N. S. Mancktelow (1) and G. Pennacchioni (2)

(1) Department of Earth Sciences, ETH Zurich, CH-8092 Zurich, Switzerland (mancktelow@erdw.ethz.ch, +41 44 6321030),
(2) Department of Geosciences, University of Padova, I-35137 Padova, Italy (giorgio.pennacchioni@unipd.it)

Calcite and quartz are two of the most common minerals in the continental crust and it is therefore not surprising that these minerals have been extensively studied since the very beginning of laboratory rock mechanics experiments. Extending such laboratory data to geological deformation rates around 10^{-14} s^{-1} requires an extrapolation of more than 7 orders of magnitude, with correspondingly large uncertainties. Extrapolation is based on the assumption that flow parameters are constant with changing conditions and that parameters not included in the flow law have a negligible influence on the creep properties. The validity of this extrapolation can only be tested, at least semi-quantitatively, by comparison with naturally deformed rocks. Observations generally indicate that quartz is significantly stronger than calcite in natural rocks, with quartz forming porphyroclasts in calcite marble mylonites, or with quartzite layers being folded or boudinaged within a weaker calcite marble matrix. However, in the Neves area (Tauern Window, Eastern Alps), shearing of Alpine coarse grained quartz-calcite veins under hydrous amphibolite facies conditions (ca. 550˚C) produced quartz mylonites containing asymmetric cm-scale single crystal calcite porphyroclasts. Under these conditions, coarse calcite is clearly stronger than the surrounding polycrystalline, dynamically recrystallized, quartz matrix. The important parameter controlling this difference in observed natural behaviour is the grain size of the calcite. Although there is considerable variation, uncertainty and even contradiction in the published experimental results, we show that extrapolation of laboratory creep data on calcite single crystals and coarse marbles, together with the corresponding data for wet quartzites, is indeed consistent with these natural observations. Extrapolation indicates an inversion in the relative strength of coarse calcite and quartz at a strain rate around 10^{-11} s^{-1}, corresponding to a differential flow stress of ca. 50 MPa. At lower strain rates and stresses, wet quartz should be weaker than coarse calcite crystals. Field evidence (flow of quartz-rich layers even for orientations with very low resolved shear stress) and the preserved microstructure (lack of recrystallized or bulged twins in the calcite porphyroclasts) in the Neves area are also consistent with flow stresses of less than ca. 50 MPa. These low values during deformation under water-rich amphibolite facies conditions are in marked contrast to the much higher differential stresses reported for the flow (and fracture) of quartz-rich rocks under dry conditions in the middle to lower crust.