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Infrared absorption band in deformed qtz crystals analyzed by combining different microstructural methods

Holger Stunitz (1,2), Anja Thust (3), Harald Behrens (4), Renee Heilbronner (3,1), and Ruediger Kilian (3)

(1) University of Tromsø, Dept. of Geology, Tromsø, Norway (holger.stunitz@uit.no), (2) Institut de Sciences de la Terre, Université d′Orleans, France, (3) Geologial Institute, Basel University, Switzerland, (4) Institute of Mineralogy, Hannover University

Natural single crystals of quartz have been experimentally deformed in two orientations: (1) normal to one prism-plane, (2) In O+ orientation at temperatures of 900 and 1000°C, pressures of 1.0 and 1.5 GPa, and strain rates of ∼1 x 10-6s-1. The starting material is milky quartz, consisting of dry quartz (H_2O contents of <150 H/106Si) with fluid inclusions (FI). During pressurization many FI′s decrepitate. Cracks heal and small neonate FI′s form, increasing the number of FI′s drastically. During subsequent deformation, the size of FI′s is further reduced (down to ∼10 nm). Sample deformation occurs by dominant dislocation glide on selected slip systems, accompanied by some dynamic recovery. Strongly deformed regions show FTIR spectra with a pointed broad absorption band in the ∼3400 cm-1 region as a superposition of molecular H_2O bands and three discrete absorption bands (at 3367, 3400, and 3434 cm-1). In addition, there is a discrete absorption band at 3585 cm-1, which only occurs in deformed regions. The 3585 cm-1 band is reduced or even disappears after annealing. This band is polarized and represents structurally bound H, its H-content is estimated to be 1-3% of the total H_2O-content and appears to be associated with dislocations. The H_2O weakening effect in our FI-bearing natural quartz crystals is assigned to the processes of dislocation generation and multiplication at small FI′s. The deformation processes in these crystals represent a recycling of H_2O between FI′s, dislocation generation at very small fluid inclusions, incorporation of structurally bound H into dislocation cores, and release of H_2O from dislocations back into FI′s during recovery. Cracking and crack healing play an important role in the recycling process and imply a close interrelationship between brittle and crystal plastic deformation. The H_2O weakening by this process is of a disequilibrium nature and thus depends on the amount of H_2O available.