Geophysical Research Abstracts,
Vol. 10, EGU2008-A-10479, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-10479
EGU General Assembly 2008

Extreme Grain Size Reduction in Dolomite: Microstructures and Mechanisms

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Pure dolomite sample were deformed at room temperature and under a variety of confining pressures (0 - 100MPa) to examine the processes of grain size reduction. The dolomite is composed of $>$ 97 vol. dolomite with accessory quartz, calcite, tremolite, and muscovite and has been metamorphosed to amphibolite facies and subsequently annealed. At the hand sample scale, the rock is isotropic, except for minor, randomly oriented tremolite porphyroblasts, and weakly aligned muscovite. At the thin section scale, coarser grains have lobate grain boundaries, exhibit minor to no undulose extinction and few deformation twins, although well-developed subgrains are present. Growth twins are common, as is the presence of well developed $\{10\underline{1}1\backslash\}$ cleavage. Mean grain size 476 microns, and porosity is essentially zero (Austin and Kennedy, 2006). Samples contain diagonal to subvertical faults. Fractures are lined with an exceptionally fine-grained, powdered dolomite. Even experiments done at no confining pressure and stopped before sliding on the fracture surfaces occurred had significant powdered gouge developed along the surfaces. In this regard, fracturing of low porosity, pure dolomite, with metamorphic textures (e.g. lobate, interlocking grain boundaries) results in the development of fine-grained gouge.

Experiments were performed at room temperature and under a variety of confining pressures. For each confining pressure, two experiments were run: 1) experiments stopped at peak strength, 2) frictional sliding along just-formed shear fracture for a predetermined amount of displacement. Microstructures at each stage were observed in order to determine the possible mechanisms for extreme grain size reduction and to evaluate the role of increasing shear strain on grain size distribution. SEM work shows that in samples with little to no apparent displacement along microfractures, extreme grain size reduction still exists, suggesting that frictional sliding and subsequent cataclasis may not be the mechanism responsible for grain size reduction. Within individual dolomite clasts, apparent Mode I cracks are also lined with powdered gouge. TEM analyses demonstrate that grains are reduced in size to nanometer scale. Grain size distribution analyses are measured for experiments stopped at peak strength and for frictional sliding experiments to evaluate the role of shear strain in modifying post-shear fracture grain size. Austin et al. 2005, Geological Society, London, Special Publications, 243, 51-66.3.