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Thermal effect on the relative strength of calcite-dolomite: torsion experiments and natural examples

C. Delle Piane, L. Burlini, K. Kunze, J.-P. Burg

Geological Institute ETH Leonhardstrasse, 19 /LEB CH-8092 Zürich Switzerland

dellepiane@erdw.ethz.ch

Calcite and dolomite are among the most common mineral in sedimentary rocks and therefore play an important role in crustal geodynamic processes. Field observations indicate that calcite and dolomite shows interesting deformation behaviour: while dolomite is stronger than calcite at low temperature, it appears to become weaker at elevated temperatures and a relative rheological switch may occur.

We produced and deformed up to large strains (γ up to 10) synthetic aggregate of dolomite using a Paterson apparatus equipped with torsion facilities. Flow strength was systematically measured as a function of strain-rate and temperature.

The resulting material is a homogeneous fine-grained aggregate with an interconnected porosity of 0.9% and density of 2779.7 Kg/m^3. Cylindrical samples were then deformed in torsion at confining pressure of 300MPa, temperature ranging between 600 and 800˚C and strain rate between 1×10^{-6} s^{-1} and $6\times^{-4}$s^{-1}.

The experimental data were fitted to a flow law of the form:

$\gamma = \mathrm{A}\,\tau^{n}\,\mathrm{d}^{-m}\exp(-\mathrm{Q/RT})$

Where γ is shear strain rate, τ is the shear stress, Q is the activation energy, T is the absolute temperature, R is the gas constant, A is a material parameter and n and m are stress and grain size exponents respectively. The n (= 1.3) and Q (368 KJ/mol) values were experimentally determined while the pre-exponential term A (= 10^{15}) and the grain size exponent m (= -2.6) were estimated by fitting the experimental data to the flow law using a non-linear least squares regression.

The extrapolation of these laboratory measurements and those relative to calcite rocks to natural conditions (i.e. strain rate of $1 \times 10^{-12} \mathrm{s}^{-1}$) suggests that a switch in relative strengths occurs between the two carbonates at a temperature of $\sim$ 600º C.

Such a behavior is observed for example around the thermal aureola of the Adamello pluton (North Italy), where estimated peak contact metamorphism yields temperatures ranging between 600-800˚C and where boudins and ptygmatic folds geometry imply that dolomite was weaker than calcite at the time of deformation.