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Carbonates in thrust faults: High temperature investigations into deformation processes in calcite-dolomite systems

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The role of dolomite on the strength and evolution of calcite-dolomite fold and thrust belts and nappes (as observed in the Canadian Rockies, the Swiss Alps, the Italian Apennines, and the Naukluft Nappe Complex) is largely unknown. Field investigations indicate that strain in natural systems is localized in calcite, resulting in a ductile response, while dolomite deforms in a dominantly brittle manner. To date, experimental studies on polymineralic carbonate systems are limited to homogeneous, fine-grained, calcite-dolomite composites of relatively low dolomite content. The effect of dolomite on limestone rheology, the onset of crystal-plastic deformation in dolomite in composites, and the potential for strain localization in composites have not yet been fully quantified.

Constant displacement rate ($3x10^{-4}$ $s^{-1}$and 10^{-4} s^{-1}), high confining pressure (300 MPa) and high temperature (750˚C and 800˚C) torsion experiments were conducted to address the role of dolomite on the strength of calcite-dolomite composites. Experiments were performed on samples produced by hot isostatic pressing (HIP) amalgams of a natural, pure dolomite and a reagent, pure calcite. We performed experiments on the following mixtures (given as dolomite%): 25%, 35%, 50%, and 75%. These synthetic HIP products eliminated concerns of mineralogical impurities and textural anomalies due to porosity, structural fabrics (e.g., foliation) and fossil content. The samples were deformed up to a maximum finite shear strain of 5.0 and the experimental set up was unvented to inhibit sample decarbonation.

Mechanical data shows a considerable increase in sample yield strength with increasing dolomite content. Experimental products with low starting dolomite content (dol%: 25% and 35%) display macroscopic strain localization along compositionally defined foliation. Experimental products with high dolomite content (dol%: 50% and 75%) demonstrate no macroscopic foliation. Post-deformation microstructure analysis shows that small dolomite grains ($<\sim50$ μm) are characterized by diffuse and poorly defined grain boundaries; in samples containing 25% and 35% dolomite, high aspect ratio grains are realigned along foliation. Large dolomite grains ($>\sim50$ μm) are characterized by well-defined grain boundaries and cleavage controlled fracture. There is evidence of the interruption of foliation development due to the presence of large-grained dolomite. Calcite grains are characterized by triple junction grain boundaries, providing evidence for recrystallization. Ongoing microstructural analyses (including: thin section analysis, EBSD, SEM, and Microprobe analysis) are being conducted to better constrain the deformation mechanisms and the degree of strain localization in these composites.

Our experiments provide insights into the processes controlling rheology within bimodal calcite-dolomite systems, which can be used to improve models of the evolution of fold and thrust belt systems.