Deformation Mechanisms
Rheology
Microstructures

Neustadt an der Weinstraße
22.-26. March 1999
Microstructure Development in Naturally Deformed Carrara marble (Alpi Apuane, Italy)

Molli G.1, Conti P.2, Giorgetti G.2 and Meccheri M.2

1 Dipartimento Scienze della Terra, Università di Pisa, Via S. Maria 53, I-56126 Pisa. e-mail: gmolli@dst.unipi.it
2 Dipartimento Scienze della Terra, Università di Siena, Via Laterina 8, I-53100 Siena. e-mail: conti@unisi.it

The Alpi Apuane region represents a former crustal-scale shear zone developed at mid-crustal levels (greenschist facies) during the Tertiary evolution of the northern Apennine thrust system (D1), later involved in exhumation and extensional collapse (D2).

The presence of marble in different geometrical positions, the partitioning of strain, the development of different generations of structures formed during thermal perturbation provided the preservation of various calcite microstructures that allowed to unravel the thermomechanical evolution of this portion of the northern Apennine during continental collision and exhumation.

The microstructural features and calcite/dolomite thermometry of two main groups of microstructures will be discussed:

a) the static microstructures, characterized by the typical granoblastic polygonal "foam" grain shape and by an increase in grain size from approximately 0.08-0.1 mm to 0.15-0.3 mm from the eastern to the western part of the Alpi Apuane metamorphic complex. Calcite/dolomite investigations yield increasing temperatures from 360-390°C in the east to 430-440°C in the west suggesting a direct control of the temperature on the grain size;

b) the dynamic microstructures, characterized by shape and crystallographic preferred orientations, mechanical twinning and dynamic recrystallization features. These microstructures can be found in different tectonic settings: i) associated with decametre-thick late-D1 shear zones in the eastern part of the Alpi Apuane; ii) within millimetre- to decimetre-thick D2 shear zones in the western part.

Microstructures associated with the decametre-thick shear zones show a coarse grain size (0.1-0.2 mm) and calcite/dolomite temperature of 380-390°C, while the microstructures in the millimetre- to decametre-thick D2 shear zones show grain size reduction (0.02-0.05 mm) associated with lower temperatures (about 350°C).

Though commonly considered homogeneous and statically recrystallized, the Alpi Apuane marbles reveal complex relationships between fabric development, deformation mechanisms and thermal evolution.

Effect of Stress on Dissolution Rate and on Optical Dissolution Microstructure of Free Faces of Single Crystals of Very Soluble Elastic-Brittle Salts.

Jacques Morel1 and Bas den Brok2

1 Institut für Geowissenschaften, Johannes Gutenberg-Universität, Becherweg 21, D-55099 Mainz, Germany.
2 Geologisches Institut ETH, Sonneggstr 5, CH-8092 Zürich, Switzerland.

Elastic strains are commonly regarded to have a negligible effect on growth and dissolution rate, especially compared to crystal-plastic strain (crystal defects). Recent experimental work by Ristic et al. (1997) on K-alum and sodium chlorate has shown, however, that (tensile) elastic strain may have a very strong effect on growth and dissolution rate. For example, an increase in the tensile stress by a factor ~2 caused a decrease in the growth rate by a factor ~2. We studied the effect of compressive elastic strain on the dissolution rate and on the (optical) dissolution microstructure of free-faces of single crystals of different elastic-brittle salts. To this end, solution-grown single crystals of three different elastic-brittle salts (K-alum, sodium chlorate and potassium dihydrogen phosphate) were elastically strained in their solution undersaturated to 0.1-1.5 degrees and held under stress for 1 to 5 days. The solution was continuously stirred and the temperature controlled to 0.1°C in the range 18-30°C. Samples were right-angled with sides of 10, 6, and 4 mm long. Stress was applied parallel to the long side and fell in the range 5-20 MPa.

In all experiments, one stressed and one stress-free sample were put next to each other ~5 cm apart, so that the dissolution features in the stressed and stress-free material could be directly compared. A 2 mm diameter hole was drilled in the middle of all samples, perpendicular to the applied stress. Hole diameter was measured before and after each experiment. After experiments, hole diameter was larger in the stressed than in the stress-free samples and elliptical, with long axis perpendicular to stress. Dissolution rate was roughly three times larger in the stressed than in stress-free material. For example, for K-alum at 28°C and an undersaturation of 0.25%, the stress free hole grew at 1.5 mm/hr whereas the stressed hole grew at 5 mm/hr (9 MPa applied stress). Note, that this increase dissolution rate is much too large to be explained by the theoretic increase in driving force by elastically stored energy. Optical microscopy of the dissolved surface of the stress-free sample show fine dissolution grooves parallel to <100> directions, ~5 mm apart and several mm deep. In the stressed samples, dissolution grooves are much larger in size, typically 20-30 mm wide, 10-20 mm deep and oriented sub-parallel to <100> directions and always perpendicular to the stress.