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Dislocation creep accommodated Grain Boundary Sliding: A high strain rate/low temperature deformation mechanism in calcite ultramylonites

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Grain boundary sliding (GBS) is an important grain size sensitive deformation mechanism that is often associated with extreme strain localization and superplasticity. Another mechanism has to operate simultaneously to GBS in order to prevent overlaps and voids between sliding grains. One of the most common accommodating mechanisms is diffusional creep but, recently, dislocation creep has been reported to operate simultaneous to GBS.

Due to the formation of a flanking structure in nearly pure calcite marble on Syros (Cyclades, Greece) at lower greenschist facies conditions, an extremely fine grained ultramylonite developed. The microstructure of the layer is characterized by (1) calcite grains with an average grain size of 3.6 μm (developed by low temperature/high strain rate grain boundary migration recrystallization, BLG), (2) grain boundary triple junctions with nearly 120° angles and (3) small cavities preferentially located at triple junctions and at grain boundaries in extension. These features suggest that the dominant deformation mechanism was GBS.

In order to get more information on the accommodation mechanism detailed microstructural and textural analyses have been performed on a FEI Quanta 3D FEG instrument equipped with an EDAX Digiview IV EBSD camera. The misorientation distribution curves for correlated and uncorrelated grains follow almost perfect the calculated theoretical curve for a random distribution, which is typical for polycrystalline material deformed by GBS. However, the crystallographic preferred orientation indicates that dislocation creep might have operated simultaneously. We also report Zener-Stroh cracks resulting from dislocation pile up, indicating that dislocation movement was active.

We, therefore, conclude that the dominant deformation mechanism was dislocation creep accommodated grain boundary sliding. This is consistent with the observed grain size range that plots at the field boundary between grain size insensitive and grain size sensitive creep, in a deformation mechanism map for calcite.