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Microstructural evolution of fine grained calcite aggregates deformed in direct shear: constraints from Electron Backscatter Diffraction analysis

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The evolution of microstructure and crystallographic preferred orientation (CPO) of fine grained calcite aggregates (Solnhofen limestone) deformed in direct shear has been investigated. Aim of this ongoing study is to test and develop quantitative microstructural criteria to distinguish grain size sensitive (GSS) “superplastic” deformation mechanisms from grain size insensitive (GSI) dislocation creep. Square samples of 8x8x0.5 mm have been deformed in a direct shear piston configuration mounted in an axial loading set-up in a constant volume, internally heated argon gas medium deformation apparatus. Samples have been deformed to a shear strain of γ = 6, at temperatures of 900, 1000, 1100 and 1200 K, 300 MPa confining pressure and a shear strain rate of 1.7x10^{-4} s^{-1}. Conditions have been chosen such (after Schmid et al., 1977, Tectonophysics, 43, 257-291), that the experiments represent deformation in the GSI (lower temperature) and GSS (higher temperature) creep fields. In addition to the direct shear experiments, axi-symmetric compression tests in strain rate stepping mode have been performed on cylindrical samples of Solnhofen limestone in order to constrain its rheology. We used Electron Backscatter Diffraction (EBSD) to determine the texture strength of the samples, the distribution of misorientation axes and the grain size distributions. The results show an oblique shape preferred orientation at 35° to 40° to the shear plane and a moderate LPO in all samples. The c-axis preferred orientation

shows a girdle with one main maximum at a variable angle to the shear plane. The c-axis maxima girdle becomes slightly stronger, more steeply oriented and oblique to the shear plane with increasing temperature. All samples show a similar misorientation distribution with a main peak at low angle. Subgrain formation and rotation with misorientations up to 10˚ occurred in the coarser grains even in the experiments at high temperatures. This shows the formation of new high angle boundaries. The mean grain size of the material increases with temperature. The formation of subgrains and subgrain rotation, along with the fact that the misorientation rotation axes plot preferentially in the center of the figures for the low angle boundaries (5-15˚), subparallel to the rotation axes of the imposed simple shear, suggest a component of dislocation creep to the overall deformation in all the samples. We suggest therefore that the GSS regime inferred for fine grained calcite aggregates (at relatively low strain) may be a transient stage evolving into hybrid deformation (GSI and GSS mechanisms) at high strain, mainly due to grain growth during the deformation.