Geophysical Research Abstracts
Vol. 13, EGU2011-1518-2, 2011
EGU General Assembly 2011

Mechanical behaviour and microstructure of talc sheared at high strain rates (10^{-4} and 10^{-3} s^{-1}) in torsion

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We have investigated the mechanical behaviour of talc during non-coaxial deformation to large strains at high strain rates. Cylinders of pure synthetic talc samples were deformed in a Paterson gas-medium torsion apparatus under non-drained conditions. Experiments were performed at a constant strain rate of 3 x 10^{-4} and 2.45 x 10^{-3} s^{-1} for a temperature of 600 °C, under 300 MPa confining pressure and for bulk shear strains of up to 7.

Low shear strain (0.5 to 2) experiments display similar microfabrics for the two applied strain rates. They developed P microfractures along inter- and intra-granular (001) planes. In addition, they show the development of R_1 and R_2shear bands linked to Y-shear bands. These Y-shear bands are sub-parallel to the initial schistosity. They consist of a complex array of anastomosing shear planes with C-S or C-S-C' type structural relationship for a thickness ranging from 0.06 up to 0.6 mm They are composed of angular grains, large and small rotated fragments of matrix with prominant kinks and pervasive microcrack along (001) planes. High shear strains of 5 and 7 were reached only by the 2.45 x 10^{-3} s^{-1} experiments, which show a very dense array of Y-shear bands throughout the sample. Microstructural observations thus indicate a combination of crystal plasticity, frictional sliding and cataclasis to accommodate the deformation at high strain rates. This suggests that the deformation mechanim reached the semi-brittle field for the applied strain rates at imposed experimental pressure/temperature conditions. The microfabric development supports correlating with the mechanical behaviour for the two applied strain rates. Shear stress curves exhibit an elastic response up to a yield stress of 65 MPa for 3 x 10^{-4} s^{-1} experiments and 85 MPa for 2.45 x 10^{-3} s^{-1} experiments. This yield stress is followed by a significant strain hardening: 0.0016 MPa s^{-1} for the 3 x 10^{-4} s^{-1} experiments, and 0.0053 MPa s^{-1} for the 2.45 x 10^{-3} s^{-1} experiments.

Several episodes of abrupt drop of internal force concomitant with an increase of sample compaction are correlated with a sudden increase in shear stress. In addition, a modest weakening event precedes each strengthening episode. We speculate that the strengthening episodes are associated with deformation localization along a single Y-shear band.

Under constant stiffness conditions, velocity stepping experiments done for the two strain rates show a progressive change of talc behaviour from positive rate-dependence of shear stress to stable sliding with increasing shear strain. This change in mechanical behaviour is concomitant with an increase of the apparent viscosity of talc.

Slide-hold-slide experiments have also been conducted for the two strain rates. Normal stress was maintained on the sample during the hold time. A rapid strength recovery is observed after a hold time of 1, 10, 100, 1000 and 10000 s for the two applied strain rates. Post-hold yield stress decreases with increasing hold time, suggesting the absence of healing mechanism. However, after a hold time of 10000 s, a strong strength recovery of 0.0034 MPa s^{-1} is observed for the 3 x 10^{-4} s^{-1} experiments and 0.013 MPa s^{-1} for the 2.45 x 10^{-3} s^{-1} experiments, that is two times the strain hardening rate values measured for the constant strain rate experiments.