Geophysical Research Abstracts, Vol. 9, 07140, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-07140

Influence of loading rate on initiation and propagation of compaction bands in Bentheim sandstone

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Compaction bands are narrow zones with significantly reduced local porosity that may form in high porosity rocks at elevated pressures. Some field observations suggest development of compaction bands induced by local stress concentrations, and recent laboratory investigations of samples with a circumferential notch show the influence of stress concentration on initiation of compaction bands (Vajdova et al., 2003, Tembe et al., 2006). We investigated initiation and propagation of compaction bands in three Bentheim sandstone samples deformed in axial compression tests with strain rates from 3.2 x 10^{-8} s^{-1} up to 3.2 x 10^{-4} s^{-1}. Cylindrical samples were 50 mm in diameter and 105 mm in length, with grain size and porosity of $\approx$ 0.2 mm and 23%, respectively. Circumferential notches of 0.8 mm width and 5 mm depth served to initiate compaction bands at half the sample length. Experiments were performed at 195 MPa confining and 10 MPa distilled water pore pressure. Twelve P-wave sensors, eight S-wave sensors and two pairs of orthogonally oriented strain-gages were glued to the surface of the rock samples to monitor Acoustic Emission (AE), velocities and local strain during the loading process. Fully digitized AE waveforms were recorded by 10 MHz/16bit Data Acquisition System, hypocenters location error was about 2.5 mm.

AE activity started at about 0.8-1% of axial shortening, while the nucleation of compaction bands at the notch tip occurred only after axial strains of 1-1.2% accrued. Nucleation patches are visible from clustering of AE hypocenters. With progressive loading AE activity increased and AE hypocenters indicate propagation of a single compaction band normal to the vertical sample axis. Branching of the compaction band occurred with increasing length at about 10 mm and was indicated by coalescence of separate AE clusters. Lateral propagation of compaction bands in our ex-

periments was about 100 times faster than axial shortening rates, in agreement with Vajdova et al., 2003. Within the range of applied loading rates, only at the slowest displacement rate we found a 20% lower stress level at nucleation of the bands and reduced AE activity during band propagation. This may indicate an increasing contribution of stress corrosion processes in the formation of the compaction bands.