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Formation of Faults in Diorite and Quartzite Samples Extracted From a Deep Gold Mine (South Africa)

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We performed triaxial compression tests on two quartzite and two diorite specimens at an effective confining pressure of 75 MPa. Samples were retrieved from deep gold mine Mponeng, South Africa at 3543 m depth. At 30 m distance to the sampling location an earthquake of MW 1.9 magnitude occurred on December 27, 2007 (Plenkers et al., 2009; Kwiatek et al., 2009; Yabe et al, 2009). Two cylindrical diorite (dyke rock) and two quartzite (host rock) samples of 40 mm diameter and 100 mm length were prepared from cores of a borehole of about 50 m length crossing both host rock and dyke. To monitor acoustic emission (AE) and ultrasonic velocities, sixteen P-wave and four polarized S-wave sensors were glued to the surface of the rock. Full waveforms were stored in a 16 channel transient recording system (PRÖKEL, Germany). Polarity of AE first motion was used to discriminate tensile, shear and pore-collapse type of cracking. To monitor strain in the rock, two pairs of orthogonally oriented strain-gages were glued onto cylindrical surface of the rock. Experiments were performed in a servo-hydraulic loading frame from Material Testing Systems (MTS) with a load capacity of 4600 KN in three consecutive steps: 1) To investigate elastic wave velocities, estimate dynamic moduli and crack density of the rock, samples were first loaded hydrostatically at the rate of 0.5 MPa/min up to 195 MPa. The P-wave velocities measured at 75 MPa confining pressure (about the in situ mean stress) are 6.34 km/s (quartzite) and 6.78 km/s (diorite) and very similar to Vp measured in the field by ultrasonic transmission tests (Naoi et al., 2008). 2) Triaxial loading was performed at 75 MPa confining pressure using load control by acoustic emission rate until the samples failed. 3) Subsequently, confining pressure was increased to 160 MPa and triaxial loading was continued at a constant displacement rate of 20 μm/min to induce frictional sliding along the fault surface. In one of the samples, we observed stick-slip behavior of the sliding fault (8 distinct events) with stress drops of about 10-15 MPa and slip displacements of about 0.3 mm. Detailed acoustic emission analysis revealed a series of spatial acoustic emission clusters that likely represent asperities on the fault surface. The AE activity in these clusters varies between stick slip events. Analysis of AE source types reveals episodic increase of double couple mechanisms during the slip events in close correspondence with activity bursts. Detailed analysis of AE parameters shows a decrease of b-values during the slips and Omori-type decay of AE activity after each stick-slip event.