Geophysical Research Abstracts
Vol. 15, EGU2013-10973, 2013
EGU General Assembly 2013
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Frictional behavior of simulated anhydrite fault gouge: effects of temperature and implications for Apennines seismicity

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Seismicity in the Apennines (Italy), notably the recent L'Aquila earthquake (M$\sim$6; 2009) and the Umbria-Marche sequence (M$\sim$6; 1997-1998), apparently involves nucleation at the bottom of the sedimentary cover sequence, specifically in the Triassic Burano Formation, which consists of alternated anhydrites and dolomites. To date, little is known about the frictional behaviour of these materials. Therefore we have investigated the rate and state frictional properties of simulated anhydrite fault gouge as a function of temperature (80 - 150˚C) under dry and wet conditions, to gain insight into its seismogenic potential.

Anhydrite core material from the base of the Dutch Zechstein Group was used. This was powdered and sieved to a grain size $<50\mu$m to simulate fault gouge. Experiments were conducted using a direct shear set-up placed in a triaxial testing machine. The gouge layer was 1mm thick. Testing conditions covered a range of temperatures (80 - 150˚C) and sliding velocities (0.2-10μms^{-1}). The effective normal stress was fixed at 25 MPa. Experiments were conducted both dry and pressurized with water at a fluid pressure (P_f) of 15MPa.

The experiments on dry anhydrite gouge showed a friction coefficient (μ) of approximately 0.65, independently of temperature. At 80˚C wet anhydrite fault gouge was slightly weaker than dry gouge, with μ=0.6, with the friction coefficient increasing to 0.65 at 150˚C. Dry experiments showed a transition from velocity strengthening frictional behavior at 80 and 100˚C to velocity weakening behavior, occasionally with stick-slip, at higher temperatures. In contrast, all wet experiments exhibited predominantly velocity neutral to velocity strengthening behavior at all temperatures investigated.

At the depth (5-10 km), temperature (150˚C), and low effective stresses believed to typify seismic foci in the Apennines (e.g. 6 km for the Umbria-Marche sequence, and 10 km for the main shock of the L'Aquila earthquake) our results imply that dry anhydrite fault gouge will exhibit velocity weakening behavior. At such depths fault zones are likely to be wet; however, the regional scale CO_2 degassing in the Northern Apennines may possibly dry out fault zones, offering an alternative explanation for seismogenesis in the region.