Frictional properties of simulated fault gouges of natural dolomite and anhydrite

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The integration of seismic reﬂection proﬁles with well-located earthquakes shows that the mainshocks of the 1997-1998 Umbria-Marche seismic sequence (M$_{max}$ = 6.0) nucleated at a depth of ∼6 km on normal faults within the Triassic Evaporites (anhydrites and dolomites). This result appears enigmatic since evaporitic rocks are commonly considered to deform ductily and thus aseismically. In order to investigate the frictional properties of the Triassic Evaporites, we performed frictional sliding experiments on simulated fault gouges of natural dolomites and anhydrites and 50/50 mixtures of the two. Dry and wet experiments were done in a double-direct shear conﬁguration inside a biaxial loading apparatus using granular fault gouges at a range of normal stresses (10 - 150 MPa), sliding velocities (1-300 µm/s) and at room temperature and 75 ºC. Under dry and cool conditions all the lithologies exhibit: i) a brittle behaviour with the coefﬁcient of friction ranging from 0.6 to 0.7; ii) a velocity strengthening (i.e. stable, aseismic) behaviour. For the experiments at 75 ºC, we observe a decrease in the coefﬁcient of friction from 0.65 to 0.44 with increasing normal stress and strain. All the lithologies exhibit a velocity strengthening behaviour except for the mixtures of anhydrites and dolomites that show an evolution from velocity strengthening to velocity weakening with increasing sliding velocity. The microstructures developed during all experiments show a general grain size reduction from 150 µm to 30-40 µm, with localised deformation and strong comminution (grain-size 5-10 µm) along B$_1$ and R$_1$ planes. With increasing shear strain and temperature the R$_1$ planes are more pronounced in particular for the mixtures of anhydrite and dolomite. Thus at a seismogenic depth of ∼6 km, with increasing temperature and the presence of ﬂuid, the localization of deformation along planes composed of anhydrites and dolomites, as observed along exhumed evaporite-bearing faults from the Apennines, may be a mechanical explanation for the occurrence of frictional instabilities (i.e. earthquakes within the Triassic Evaporites).