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The influence of anisotropy on the transition from dilatant to compactant behaviour in Diemelstadt sandstone

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Diemelstadt sandstone is a visibly anisotropic rock with an initial porosity of 23% and a mean grain diameter of 0.3mm. The pore-space anisotropy of this material has been quantified by measuring radial elastic S and P wave velocity as a function of azimuth around orthogonally cored samples, and has shown anisotropies of 3% and 7% respectively. Measurements of the anisotropy of magnetic susceptibility of ferro-fluid saturated pore-space (pAMS) indicates that the pore space geometry approximates an oblate spheroid, consistent with the wave velocity data.

Having established the pore-space anisotropy of our material, we characterised it's influence on failure mode by performing conventional triaxial deformation tests at a range of effective pressures (from 10 MPa to 250 MPa) on samples cored both normal and parallel to bedding. Our tests cover the brittle-ductile transition and focus on the development of compaction bands. Throughout our tests we monitored the evolution of porosity, permeability and acoustic emissions (AE). The influence of sample size was investigated by repeating tests on samples an order of magnitude less in volume; allowing the direct comparison of yield-caps.

Samples from both orientations and of both sizes demonstrate a transition from brittle faulting at low confining pressure to the growth of discrete compaction bands at higher confining pressure. We found that samples deformed parallel to bedding were stronger throughout the brittle-ductile transition, with the difference becoming more apparent in the ductile regime. We observe that the smaller samples tested are consistently stronger than the larger samples.

Consistent with previous work (Vajdova et al. 2004), we find that permeability is reduced by compaction bands. Microstructural comparisons of compaction bands show greater tortuosity when formed normal to bedding, and are less extensive when formed parallel to bedding.

AE event locations indicate that compaction bands initially develop in the middle of a sample, before sequentially forming towards the sample ends. AE hit rate and energy data indicates that during compactive yield the scale of cracking is constant, in contrast to the change of scale observed during the dilatant deformation that leads to localised faulting.