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Influence of pore space anisotropy on the development of compaction bands, their acoustic signature and effect on permeability in Diemelstadt sandstone

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Anisotropy of pore space is a ubiquitous feature of sedimentary rocks which leads to an anisotropy of the physical, transport and mechanical properties of the rock. The material used in this study is an anisotropic sandstone with an initial porosity of 22.8% and a mean grain size of 0.3 mm .

We have quantified the pore-space anisotropy of Diemelstadt sandstone by measuring radial elastic S and P wave velocities as a function of azimuth around cores samples taken in three orthogonal directions. Fluid permeability has also been measured along these three principal directions, and the technique of measuring anisotropy of the magnetic susceptibility of the pore space saturated with magnetic ferrofluid (pAMS; see Benson et al. 2003) has been used to further characterise the anisotropy ellipsoid of the pore space. We find an anisotropy of around 10% for P-wave velocity and 5% for S-wave velocity, lower permeability normal to bedding and a mean pore-space geometry approximating to an oblate spheroid.

With the pore-space anisotropy established, we characterised its influence on mode of failure by performing triaxial deformation experiments on samples cored normal and parallel to bedding. Both orientations demonstrated a transition from brittle faulting at low effective pressure to the growth of discrete compaction bands at higher effective pressure. We found that the compactive yield envelope for the perpendicular-to-bedding samples expanded more towards higher stress values than the envelope for parallel-to-bedding samples.

We find that compaction bands formed both normal and parallel to bedding act as barriers to flow and reduce bulk permeability. This is consistent with previous work (Vajdova et al. 2004). Microstructural comparisons of the discrete compaction bands formed parallel vs normal to bedding show that those formed normal are more tortuous and less extensive than those formed parallel. The acoustic emission signature of bands forming parallel and normal to bedding were also compared and their differences interpreted.