Transport properties and microstructural evolution in fault gouges - examples from a deltaic collapsed crest structure deformed at shallow depth

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This contribution presents the results of a study of the transport properties and microstructure of samples taken from fault zones in the Airport Road outcrop, Sarawak, Malaysia. This outcrop is an exhumed collapsed crest structure, which formed in a Miocene, deltaic sand-clay sequence. Burial depth was less than 1000 m, as indicated by Vitrite Reflectance measurements. Detailed field study of a large number of faults exposed in this outcrop shows that fault gouge has a wide range of composition and structure, depending on fault throw and lithology. We collected samples covering the full range of different fault gouges, from deformation bands in clean sand to clay gouges. Optical microscopy and Backscattered Electron Microscopy of thin sections shows the almost total absence of cataclasis in sand and silt, in agreement with the effective pressures at this depth of burial. Thin layers of clay-rich material embedded in sand are sites of mixing of sand and clay. Deformation mechanisms in clay-rich lithologies are a combination of granular flow and crystal plasticity of phyllosilicates. XRD of the clay-rich gouge shows no indication of diagenetic changes with increasing degree of deformation.

Changes in porosity and permeability of the sand-rich deformation bands show a clear trend which is sub parallel to the poroperm trend of the host rocks. Within individual samples deformation bands have lower permeability but no significant change in porosity, in agreement with microstructural evidence of the enrichment of fine-grained phases in the pore space.

Directional Mercury injection experiments show that deformation bands often form significant barriers to two-phase flow, with up to an order of magnitude increase in displacement pressure.