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# Experimental study of clay-smear and shear band formation in unconsolidated sediments

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Faults that affect fluid flow in hydrocarbon reservoirs are produced by the deformation of a large variety of sediment types under different stress conditions. Deformation processes comprise grain reorientation, clay smear and cataclasis. Before the hydromechanical effect of faults can be implemented into a reservoir model, it is essential to understand the basic mechanisms that control clay smear and fault gouge generation, and measure how these processes affect fluid flow.

A new ring shear apparatus has been designed and constructed to investigate clay-smear processes and shear band formation under large strains and stresses. The new equipment allows for deformation of ca. 90 cm pr round and normal effective stresses up to 20 MPa, as well as fluid flow testing during shearing to quantifying the effect of clay smear and other deformation processes on the hydraulic properties of the seal. This corresponds to a depth of ca. 2600 m under hydrostatic conditions or even higher in over-pressured reservoirs. These depth ranges cover the depth at which deformation (faulting) may have occurred for most North Sea reservoirs.

The paper will present the results from some preliminary testing which illustrates the capabilities of the equipment. The samples consisted of Jurassic sand from Bornholm mixed with variable amount of kaolin clay sheared under 5 and 20 MPa normal stress. After testing, thin sections were analysed in the optical microscope to qualitatively describe the development and micro-structure of the shear zone.

The results of the experiments were compared to 3D numerical simulations of granular shear zones performed with the commercial software PFC. Such experiments allow us to investigate the micromechanics of fault zone development. The simulations are able to reproduce many features of the laboratory experiments (grain rolling, crushing,

stress-strain response) and are consistent with published comminution models of fault gouge development.

Based on the experimental data collected, improvement of fault seal algorithms which are currently used in commercial tools can be achieved.