# Image Based Characterization of Micro-faulted Sandstones: Implications for Clastic Reservoir Plays of the Middle East

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## ABSTRACT

Applied stresses within high porosity granular rocks (> 15% void fraction) result in characteristic deformation responses; namely granular flow (rigid grain reorganization) leading to compaction, dilation or isovolumetric strain, and cataclasis (grain fracturing and/or crushing) emanating from elevated stress concentrations at grain contacts. The strain localization features produced by these processes are generically termed deformation bands (shear bands / microfaults if produced with a shear component), which occur as narrow tabular (~1mm thick) regions of disaggregated, rotated and/or crushed grains, and consequently, locally reduced porosity / permeability and enhanced capillary entry pressure. These features are ubiquitous in high porosity sandstone reservoirs, and have been described from outcropping and subsurface clastic formations of the Middle East (e.g. the Nubian Sandstone of the Western Sinai desert and the Ras Budran reservoir of the Gulf of Suez, Egypt: Fossen et al. 2007; Harper and Moftah, 1985). The presence of these subseismic scale faults represents a significant source of uncertainty for activities such as hydrocarbon production and the geologic sequestration of $CO_2$. The inability to resolve geometrical properties of these smaller scale faults, such as size, connectivity and intensity, using conventional subsurface datasets (i.e. seismic, log and core), leads to ambiguous representation in reservoir models. Moreover, fundamental questions remain over the role of shear bands in the trapping and transfer of mobile fluids at the pore-scale, particularly if two or more immiscible fluid phases are present. Utilizing structural analogues from the Permo-Triassic and Cretaceous of NW Europe, this presentation will demonstrate advances in the geometric and petrophysical characterization of deformation bands in sandstone using state-of-art 3D imaging techniques. Specifically, the application of close range photogrammetric imaging to microfault characterization and modelling will be presented, which enables reservoir equivalent volumetric fault properties (fault volume and intensity) to be estimated from outcrop. Focusing upon the pore-scale, investigations into petrophysical structure of deformation bands utilizing dynamic synchrotron x-ray micro tomographic imaging of core flood experiments (scC02-brine) conducted using shear band hosted sandstones will also be presented, which reveal microstructural controls upon the trapping and transfer of immiscible fluids at the pore scale within cataclized sandstones. It is hoped that this presentation will serve to promote discussion over the occurrence and potential impact of small scale cataclastic faults within siliciclastic reservoirs of the Middle East. Whilst described extensively in other clastic dominated hydrocarbon provinces (esp. the Southern North Sea and the Gulf of Mexico: Knipe and Fisher, 2001; Losh, 1998), descriptions of Middle Eastern deformation bands are comparatively rare, potentially attributable to misidentification as ‘quartz filled fractures’ in the older literature (e.g. Harper and Moftah, 1985). Through the identification of regionally significant clastic reservoir targets with the textural priors that favor deformation band formation (e.g. high porosity aeolian facies of the Permian Unayzah A reservoir of Saudi Arabia), this work will seek to create a forum through which the occurrence of cataclastic faults within siliciclastic reservoirs of the Middle East can be re-evaluated.