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Temporal Evolution of Fault Architecture and Diagenesis : Coupling Between Fault Development and Fluid Flow

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Constraining the dynamic feedback between deforming porous media and fluid is crucial for understanding hydrocarbon reservoirs, CO_2 storage sites and other evolving porous media. In particular, predicting complex fault architecture at depth, currently relies on deterministic algorithms, that do not take account of these dynamic coupling. For instance creation of permeability due to fracturing may permit fluid flow to enter a fault zone, resulting in mineralisation (strengthening) or alteration (weakening) of the fault and host rocks. The resulting changes in rock strength may enhance or retard further fracturing and may even result in a switch of deformation mechanism

Temporal evolution of fluid flow through faulted porous rocks has been studied in a field site in SE USA. The field area presents a well-exposed fault system that contains evidence for flow of multiple phases of groundwater with varying chemistries and flow of hydrocarbons. By detailed field mapping and microstructural observations of the fault rocks and of the evidence for fluid flow (e.g. bleaching and hydrocarbon staining) we unravel the fluid flow history and evolving flow properties of the rocks.

The 16km long fault presents an erosional scarp of up to 20m high at its centre. This scarp is dissected with canyons that permit cross-sectional views of the fault and associated alteration to be mapped. The field area contains two general classes of lithology. In porous sandstones, deformation is accommodated by deformation bands and fractures. In tight limestones and siltstones deformation is accommodated by fracturing and the formation of clay-rich fault rocks. Evidence for multiple fluid flow events can be observed. Hydrocarbon staining is confined to the coarsest grained layers in the sandstones, and to fractures in all lithologies. Bleaching occurs around small fractures in the fault damage zone and within structural terraces in the fault zone.

We present evidence of the evolving structural and geochemical history of the fault zone and discuss how such data can be used to improve predictive capability of fault zone properties at depth where the faults have accommodated syn-faulting fluid flow.