Fault Zone Structural Styles: Examples from Outcrop from Macro to Micro-Scale

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Abstract

Seismic scale faults are most typically interpreted as single surfaces. Outcrop data, however, show that in many cases, faults are complex zones of deformation separated into outer damage zones of discrete deformation features below seismic resolution such as small faults, deformation bands or open fractures, and inner damage zones of strong deformation shearing the protolith by offset across small faults or ductile smear that localizes the deformation into a narrow zone defined by fault rock. In this presentation, we will review deformation styles and mechanisms of fault zones from outcrops across faults with increasing throw from small to large. We examine deformation styles from different stratigraphic settings (siliciclastic and carbonate) and the macro to microscale deformation styles of fault zones. Deformation processes in the fault can be separated on clay content into deformation bands, phyllosilicate bands and clay smears and by degree of fragmentation; into disaggregation and cataclastic bands. Deformation in clean, porous sandstones is characterized by deformation bands that may show no grain fracturing, moderate grain fracturing to a cataclasite. This deformation may occur distributed within the fault zone and is not necessarily restricted to localized bands of deformation. Higher clay content fault rocks in phyllosilicate bands involve similar deformation processes with the addition of clay minerals. Commonly in faults cutting a mechanically layered section of sands and shales, fault rocks in the inner fault zone are separated by domains or lenses of unique deformation styles. Faults cutting layered or thicker platform carbonate sections have unique characteristics. Layered carbonate sections can shear into the fault zone forming discrete fault rock domains in the fault core bounded by more complex damage zones. More massive

carbonates tend to form fault gouge and breccia that can be strongly cemented. These observations suggest that fault zone complexity is related to the mechanical contrast between layers with the sheared and domanial fault rock distributions more characteristic of strong mechanical contrasts between layers in siliciclastics and carbonates. The examples of these faults at the macro and microscale provide insight into the fault processes, which is helpful in modelling cross-fault flow for exploration or development of oil and gas reservoirs.

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