Outcrop Observations and Analytical Models of Deformation Styles and Controls at Salt-Sediment Margins

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A key problem in sediment-salt margins is interpreting the updip trap mechanism against the salt diapir. Are faults developed at the margins or is the trap a juxtaposition of the sediment against the diapir? Outcrop studies from three basins with sediments dipping steeply against a residual salt diapir, microstructural analysis and analytical models provide insight into the process. Exposures in the Lusitanian Basin in Portugal of steep Jurassic sandstones and shales against a diapir show distributed grain crushing and few deformation bands. Larger throw faults were not observed.

Siliciclastic beds in the La Popa basin in Mexico have steep dips away from the diapir. The sandstones are cemented with quartz leaving little host porosity. No larger throw faults are exposed, but distributed grain fracturing occurred pre-cementation. Deformation bands occur locally but are not wide spread. The Carboniferous Mabou Group of shale and sandstone along the coast of Cape Breton, Nova Scotia steepen against evaporite diapirs. Small throw faults occur in shale rich sections, but are not observed in thicker sand sections. The sandstones contain deformation bands with cataclasis as damage zones to larger throw faults. Distributed grain fracturing predates quartz cementation. The outcrops show a common deformation response by distributed grain fracturing but few deformation bands and faults. Small throw faults are more common in thinly bedded sandstones and shales. In the context of a simple 2D analytical model, a diapir modeled as a viscous fluid between rigid walls displaced with a constant rate of shortening will continue to narrow without wall rock deformation. At a critical diapir width the wall rock will deform preserving a residual diapir thickness. The critical width of the diapir before wall deformation is a function of the shortening rate, salt viscosity, and height of the diapir. The general absence of macro faulting in the outcrops may be interpreted as shortening absorbed by a thick salt diapir with insufficient differential stress for sediment failure. The observations, however, suggest a mean effective stress in the sediments sufficient for distributed grain fracturing. The observed deformation styles are unlikely to have a significant impact on flow and juxtaposition against the diapir is likely to be a more important seal than local mesoscale faulting for the geohistories and geometries observed.