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Coupled Dynamic Evolution of Stress, Fracture, Porosity, Permeability and Fluid Flow: Basin.RTM Simulation Results from U.S. Basins

Stress is a constantly evolving property of sediments that is produced due to loading and tectonic forces. It is also a tensorial property that reflects the conditions of sediment composition and texture, pore fluid pressure, and presence or absence of oil or gas. An important role of stress on fluid migration is by controlling the occurrence and characteristics of fractures and permeability pathways. Fractures occur when fluid pressure exceeds the confining stress, and their rates of growth and collapse depend on stress, overpressure, sediment and fluid properties.

A number of basins in US have been simulated using Basin.RTM to capture the interdependence of these processes. Basin.RTM is a process-oriented 3-dimensional simulator that accounts for plasto-elasto-viscous rheology, 3-dimensional multi-class dynamic fracturing mechanics, multiphase fluid flow, and organic maturation. By using a composite media approach to sediment description, Basin.RTM computes viscosities and permeabilities as sediment properties change.

Results of simulations show that stress is strongly dependent on evolving sediment and fluid properties and stratigraphy. Nonlinear feedbacks among the RTM (reaction-transport-mechanical) processes result in heterogeneous distribution and orientation of fractures, and varying periodicity in fracturing-healing cycles. A strong correlation of fracturing with basin deformation is observed, and it demonstrates why flexure alone is not a good indicator of fracture distribution.

Overall, overpressured and fractured compartments occurring in basins migrate from deeper to shallower sections in geologic time. Fluid migration paths are intrinsically affected by their occurrence and movement, and change constantly throughout a basin’s evolution.