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Enhanced Exploration and Development Through Kinematic Modeling

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Exploration and development in deformed areas is challenging because of structural complexities, limited well, outcrop, and seismic resolution, and linkages between petroleum migration and evolving reservoir geometries. Kinematic modeling provides critical risk reduction in these endeavors by validating competing interpretations and generating quantitative information on hydrocarbon migration and deformation-induced porosity and permeability variation.

Kinematic analysis depends on lithology and tectonic setting, but is primarily concerned with the history of rock geometries. In both 2D and 3D, the kinematic methods that have proven most useful for multiple-horizons (and intervening regions) are all simple shear based, with some combination of a straight slip vector (i.e., vertical/oblique slip) or curvilinear/curviplanar slip system (i.e., flexural slip and slip line). Readily available computer programs allow application of these techniques, together with decompaction and isostatic adjustment, to quickly limit subsurface interpretations within a narrow range of physically likely solutions. These validated configurations are “balanced”, and include bedlength and/or area preservation, correspondence between hanging wall and footwall ramps and flats, fault displacement consistency, and viable deformation intensities. Once the range of solutions is determined, kinematic results also yield quantitative risk assessment at the prospect and reservoir compartment scales on the structural and depositional history of hydrocarbon traps.

Examples of these concepts – restoration, interpretation testing and validation, incremental evolution, and fracture prediction from strain and curvature – are presented with several examples, including salt basins (La Popa basin and Gulf of Mexico), thrustbelts (southern Alberta and Idaho-Wyoming-Utah), and inversion zones.