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Passive Margin Deltas and Petroleum Systems

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Passive margin deltas differ from typical petroleum systems in that the key elements of reservoir and seal deposition, trap formation, and maturation/migration occur nearly simultaneously. Furthermore, as deltas prograde through time, the position and type of structural deformation, direction of hydrocarbon migration, and source rock maturity levels change. All these factors make them difficult to model quantitatively.

Most petroliferous passive margin deltas exhibit compressional deformation along the lower slope. These deepwater fold belts are linked to extensional faulting at the shelf edge via a regional decollement surface. Such linked systems are formed by the large scale gravitational collapse of sediments at the shelf edge into the basin. In basins lacking a salt substrate, we believe that formation of linked systems may be directly related to the presence and maturation of source rock.This hypothesis has predictive value: the presence of such a system in a frontier basin may be taken as an indirect indicator of a working petroleum system.

Activation of the decollement surface may be caused by overpressure enhanced by source rock maturation. Source rocks at or near the decollement surface enter the oil window at the leading edge of compressional structural deformation. Early oil migration occurs vertically though dilational gaps in tear faults between thrust sheets into deepwater reservoir facies in overlying compressional structural traps.

As the delta progrades, sediment loading pushes the source rock though the oil window and into the gas window. Sand-prone toe-of-slope deposits are overlain by more shaly, upper slope strata, and the stress regime changes from compressional to extensional. Gas migration occurs vertically though dilational gaps in extensional faults at the shelf edge, then into upper slope/shelf reservoir facies in overlying growth fault traps.Continued gravity collapse produces counter-regional faults between the shelf edge and deltaic platform, tilting the aggrading shelf pile seaward, rupturing footwall traps, and initiating tertiary migration of hydrocarbons along bedding planes.

When the source rock is eventually depleted, overpressure generation ceases, the decollement surface locks, and the outer shelf extension zone migrates seaward, establishing a new shelf edge.

Source rock quality/quantity, continuity of deposition, thermal history and regional dip at the decollement surface impact the geometry of the passive margin delta and the effectiveness of the petroleum system. Regional seismic transects from the Niger and Nouakchott Deltas of West Africa and the Lamu and Rovuma Deltas of East Africa are presented.

Linked extensional-compressional systems are the key to understanding petroleum occurrence in non-salt floored, passive margin deltaic basins.