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Hydrocarbon Exploration for Large 'Overpressure-Enhanced' Oil and Gaspools in Large Cenozoic Sand/Shale Depositional Systems

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Abstract

Oil and gas pooled in large sand/shale depo-systems along Cenozoic divergent continental margins, (e.g., the Gulf of Mexico [GoM] depo-system) and Cenozoic convergent margins (e.g., the East Venezuelan depo-system), are often controlled by over-pressure enhanced [OPE] hydrocarbon seals. Syndepositional normal faults in Cenozoic rapidly-deposited shelfal sand/shale depo-systems often juxtapose thick normally-pressured young sand-rich neritic sandstone packages against older over-pressured sand-poor slope shales, thus creating OPE hydrocarbon [HC] traps. Deltaic toe-thrust faults can also create OPE HC traps when normally-pressured deep-water sandstones are ramped upward against over-pressured shales. These 'pressure anomaly faults' may in some cases also provide vertical HC migration pathways into OPE HC pools during periods of fault movement.

Reversed-pressure faults occur where the top of over-pressure has moved stratigraphically upward to a maximum flooding surface shallower than slope sediments deposited on the downside of a down to the basin normal fault, causing basinward-dipping over-pressured sediments in the footwall block to overhang normally-pressured sediments in the contiguous landward upthrown block. Numerous large oil and gas fields in the GoM Tertiary depositional complex exhibit this 'over-pressure wall' entrapment configuration, and most OPE HC traps in sand/shale depo-systems occur in upthrown fault closures. But downthrown OPE faulted nose traps of all sizes have also been found (e.g., the McPac field, offshore Texas, and the North Soldado oilfield, offshore Trinidad & Tobago).

World class giant anticlinal and structural-stratigraphic HC pools with OPE seals also exist (e.g., the Alba field, EUR=2 TCFG + 400 MMBC; and the Zafiro field, EUR=1.2 BBO, offshore Equatorial Guinea). In some Cenozoic deep-water petroleum systems, lateral HC migration appears to have occurred in areas where submarine canyons have incised deeply into over-pressured HC source-bearing sediments deposited outside the canyon (e.g., Zafiro submarine canyon). Consequently, submarine canyon 'over-pressure wall' truncation traps are also OPE exploration targets. Over-pressured shales can also represent reservoir cap rocks (an over-pressured blanket) for HC pooled in subjacent normally-pressured sandstones (e.g., Alba field).

Compared to HC traps encased in normally-pressured seals, oil columns in OPE HC traps are often longer because: 1) OPE trap columns can exceed the impingement point of the top of a major sandstone reservoir unit against the landward fault plane; 2) OPE seals (lateral & vertical) are more effective in trapping oil and gas; and, 3) stacked normally-pressured HC pays can develop in fault blocks bracketed between a large updip normal fault that displaces the top of over-pressured sediments downward and a downdip reverse-pressure fault that displaces the top of over-pressured sediments upward. (the West Chalkley gas field, Cameron Parish, South La., EUR=1 TCFGE.)

Exploration for OPE HC traps can be facilitated by subsurface mapping and reflection seismic methods that include: well log analysis, fault plane reflectivity analyses, velocity analyses, DHI analyses (‘Bright Spot’/AVO/absorption studies/ HC chimney studies). Many geophysical methods are applied during the seismic data processing phase, but some are applied during the seismic interpretation phase when potential HC prospects and leads are singled out for economic analysis and de-risking.