# Predicting Seal Efficiency and Trapped Hydrocarbon Type in Gulf Coast Hydrocarbon Systems: Lessons Learned From West Fulton Beach Field, Mid-Texas Gulf Coast

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Many Gulf Coast fields consist of multiple vertically stacked sandstones in which oil and gas are seemingly randomly distributed stratigraphically. Hydrocarbon entrapment is strongly affected by seal competency and possibly by formation pressure, and these factors are in turn controlled by the characteristics of the interbedded shales. In West Fulton Beach field, Aransas County, Texas, the Oligocene Frio Formation shales were deposited as shelf mudstones and represent flooding events in a barrier bar/strandplain and inner shelf setting. Reservoirs were placed into a high-frequency genetic stratigraphic framework to test the theory that hydrocarbon entrapment is controlled by a hierarchy of maximum flooding surfaces. Cumulative oil and gas production and gas-to-oil ratios were tabulated for individual reservoirs, as well as for all reservoirs in each 5th–, 4th-, and 3rd-order genetic unit, as measures of entrapment.

Total producible hydrocarbons (oil plus gas, in barrels of oil equivalent) increase in volume in successively shallower 3rd-order Frio units (each 800 to 1,000 ft thick), capped by the 600-ft-thick Miocene Anahuac Shale. Likewise, successively shallower 4th-order units (120 to 200 ft thick) within each 3rd-order unit contain greater volumes of total hydrocarbons, as well as greater percentages of gas. This pattern exists independent of shale thickness or reservoir porosity, and it is repeated at the 5th- and 6th-order levels, when viewed on a per-gross-ft-of-sandstone basis. Thus, although appearing random, when evaluated carefully within a stratigraphic framework, total hydrocarbon volumes and oil versus gas distributions follow a systematic pattern tied to their position within a stratigraphic hierarchy.

This finding can be used to more accurately constrain seal risk in exploration or deeper pool drilling and to evaluate hydrocarbon type ahead of the drill bit. Further study is needed to model reservoir filling, incorporating reservoir pressures, to better understand the petrophysical controls on hydrocarbon entrapment. Additionally, observations of lateral changes in the observed cyclic patterns may produce a greater understanding of the effects that facies changes and genetic unit stacking patterns have on seal competency.

# Wet Bacterial Gas in the Northern Gulf of Mexico Basin

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The northern margin of the offshore Gulf of Mexico Basin is a mixed gas-oil province. Natural gas pools are commonly found that consist largely of bacterial methane enriched in isotopically-light carbon ($\delta^{13}$<None>C (-55 per mil). But some bacterial gas accumulations are much wetter than might be expected— they produce commercial amounts of condensate. The wet fraction of these gas accumulations typically consists of crude oil that has dissolved into dry bacterial methane. We illustrate these concepts using field data collected at two wet bacterial gas fields in the northern Gulf of Mexico.

The Popeye Field (EUR = 320 Bcf, plus 3 MMB condensate) is located along the Louisiana continental slope c. 40 km (25 mi) east of the Bullwinkle Field. This field consists of two commercial gas pools in Pleistocene turbidites (G pay sands). The two pools are separated by a structural saddle. A few thin, sub-commercial oil zones (H sand series) also occur at Popeye. Conventional cores from the G sand that were obtained in the southern gas pool generally do not fluoresce. But a thin fluorescent zone immediately above the seat seal of the G sand contains remnant oil. The natural gas at Popeye consists largely (c.90%) of bacterial methane. The geochemistry of Popeye condensate indicates that it represents dissolved sour oil that probably was similar to the crude oil produced at the Bullwinkle Field.

The Peccary Field (EUR = 105 Bcf) is located on the Louisiana Shelf c. 40 km (25 mi) northeast of Popeye. The pay sands at Peccary also contain wet bacterial gas. During re-development of this field, one well unexpectedly produced waxy sweet oil when it was recompleted in an intermediate objective (the $C_6$ sand). Indirect evidence suggests that a wet gas accumulation in the shallower $C_5$ pay sand (which generally yielded colorless condensate) was underlain by a black oil rim — just before a gas well in the $C_5$ pay sand watered out, it produced a waxy, amber-colored liquid that appears to have been a mixture of gas-condensate and waxy crude similar to the oil encountered in the deeper $C_6$ sand.