The Smackover-Norphlet Petroleum System, Deepwater Gulf of Mexico: Oil Fields, Oil Shows, and Dry Holes

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ABSTRACT

Exploration for oil in the Norphlet Formation of the deepwater Gulf of Mexico, has resulted in wells with major discoveries, economic tie-back discoveries, sub-commercial discoveries and dry holes. The Norphlet petroleum system is defined by the adjacent stratigraphic formations of the Norphlet reservoir with the overlying source rock and seal of the Smackover formation. The two formations lie directly on top of the Louann Salt, also an underlying seal. Examples of the Norphlet field sizes range between the giant Appomattox Oil Field (Mississippi Canyon [MC] block 392) and much smaller and economically challenged oil fields such as Gettysburg (De Soto Canyon [DC] block 398) and Shiloh (DC 269). Appomattox is the first Norphlet field to be producing oil with its first production having started in May 2019. The petroleum system has also yielded smaller volumes of only residual oil (Leesburg–MC 475), and residual oil columns below a thinner, live oil column (Titan–DC 178) and Antietam (DC 269). In other wells, the Norphlet is devoid of oil shows even when the overlying Smackover source rock is present and sufficiently rich and thermally mature.

Analyses of these wells indicate that three essential play components are required for discovering large oil fields and what limits field size. The aeolian dune facies of the Norphlet, is the only facies that has the required preserved permeability to create a pressure “sink” for oil to accumulate in today’s subsurface. A “sink” is defined here as permeable sandstone with significant lateral continuity that is "under-pressured" relative to bounding stratigraphy. The Norphlet sandstone pressure sink provides the outlet for oil to enter from the overlying and higher pressured maturing Smackover source rocks. The Smackover source rocks must have a high enough threshold level of thermal maturity, measured by the vitrinite reflectance equivalent (VRE) level. A VRE level of 0.9 is the minimal level of maturity needed for oil migration to effectively fill a trap to an economic amount.

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Smaller “fetch areas” can also limit accumulations to smaller volumes especially at lower maturity levels. Higher maturity levels more effectively “squeeze out” Smackover oil creating more robust oil volumes charged downward into the permeable Norphlet reservoir. The timing of expulsion and migration from the source rock must occur from the recent to no older than 15 to 20 million yr ago. Otherwise, older formed traps will leak, leaving only residual oil. Only in older formed traps with a simple four-way basal Smackover closure component, will retain oil under this top-seal (e.g., Titan–DC 178 and Antietam–DC 269). All other trap components having any fault juxtapositions of other formations, will allow a slow leakage from the trap.

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