Oil Below Water: Perched Water and High Order Sealing Elements, Implications for Exploration in Stratigraphic Traps*

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Abstract

Stratigraphic traps represent a major target for exploration, with the trap/seal often being the critical risk in evaluating prospects. Operators are especially interested in seismic evidence of the elusive “updip pinchout” of slope channel complex or slope fan reservoirs to de-risk the stratigraphic trap. Recently there has been mixed success in the exploration for these “classic” stratigraphic traps. We will present two concepts for stratigraphic traps that differ from this classical model, which have implications for both the identification and risking of prospects and the interpretation of well results.

The first of these concepts is recognition that higher order sealing components can combine to create the updip seal of an accumulation. These trap styles can be likened to a “frayed rope” where higher order depositional elements are represented by individual strands of the rope, terminating in different locations. The effect is that within a stratigraphic trap, the updip seal can be a zone with multiple sealing elements instead of a single, solid updip pinchout of the whole reservoir. We envision these higher order elements to be combinations of updip facies changes, updip/lateral pinchouts and lateral sealing elements in higher order channels.

The second concept is one that we call “translated stratigraphic traps”, where the updip extent of an oil accumulation occurs in a place other than an identifiable stratigraphic pinchout. In this scenario, hydrocarbons migrate laterally up a depositional system, with water being displaced downdip. In certain geometrical configurations, water cannot move further downdip, and becomes perched. Continued charge will build a hydrocarbon column downdip from the locked perched water contact. The ultimate result is an overpressured wet stratigraphic pinchout, and a downdip hydrocarbon accumulation. A well drilled to test the stratigraphic pinchout could therefore miss this potential accumulation.

The concepts presented here are not mutually exclusive, and are envisioned to occur at a variety of scales and in different combinations. Using well log, fluid pressure, geochemical and high quality 3D seismic data, we demonstrate the existence of a complex yet subtle stratigraphic trap in a turbidite reservoir that exhibits evidence of both of these phenomena. These stratigraphic trapping styles should be considered when assessing (or reassessing) stratigraphic traps within submarine slope channel complex reservoirs around the world.
Deepwater Slope Channel Reservoir

- High porosity, high permeability, suitable sandstone reservoir
- Seismic amplitudes define troughs-porosity, no fluid effect
- Oil accumulation commonly across wells (A,C,D), and 15 psi offset in Well B. Oil biomarkers and isotopes indicate a common origin and stored charge history
- Pinchout on the SW lateral edge, no updip pinchout observed, channel system continues for 128 km up-dip

Evolving trap concept as prospect was drilled and appraised.

- Amplitude anomaly with thickening reservoir observed below a low-stand at a pure steep trap – no updip pinchout identified. However, 3-way closure against lateral seal made possible risk acceptable to drill.
- Well D found a single pressured oil column, with updip below spill point to the 3-way. Oilm stands defined by ultra high pressure and intersected in Well W and D.
- Well B drilled and found a separate oil column – 105 psi overpressured from Well W, with overpressured water below it (948 psi).
- Preliminary stratigraphic breakpostaled to explain major elevation change of OWC and pressure effect in oil columns.
- Well found oil below overpressured OWC. Well D found water above the OWC and the "true top" - all oilcommon pressured with Well B.
- Pressure, geochemistry and detailed seismic interpretation integrated to reassess the trap and fit history of the reservoir.
- Similar data points to a subtle stratigraphic trap where the concepts of higher order sealing elements and perched water are both present.

Classical concepts aren’t discarded/invalidated, but they are inadequate to fully explain our observations and our understanding of the trap.

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