Geological Configuration of the Betty Field, Baram Delta Province, Offshore Sarawak

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The geological configuration of the Betty Field is typical of oil fields in the Baram Delta Province of offshore Sarawak: (1) structures result from the interaction of delta-related growth faulting and later Pliocene compressional folding, (2) reservoirs comprise Miocene shallow water sandstones and shales which accumulated during repeated phases of progradation and transgression of the wave-dominated Palaeo-Baram Delta, and (3) hydrocarbons occur in numerous vertically-stacked sands separated by sealing shales and trapped by a combination of fault seal and dip closure.

This paper discusses in more detail these aspects in relation to the Betty Field and relates them to the field's development strategy.

Structurally, the field is relatively simple, consisting of a NE-SW trending anticline which is bounded to the south by a major E-W trending growth fault (Betty growth fault). The anticline is a result of rollover associated with this growth faulting combined with Pliocene compressional folding along the NE-SW trending Bokor-Betty-Baronia anticlinal trend.

The Betty reservoirs occur within a ca. 2450 ft thick sequence

(between 7200-9650 ft ss) of Late Miocene, Upper Cycle V clastic deposits, which accumulated in a wave-/storm-dominated, inner neritic to nearshore/ coastal environment within the Palaeo-Baram delta complex.

The sand bodies are characterized by composite (or amplified) coarsening upward/progradational sequences (ca. 160 ft) overlain by generally thinner, fining upward/retrogradational sequences (ca. 20-50 ft thick). The sand bodies are vertically heterogeneous but display high lateral continuity with excellent field-wide well log correlation, which is consistent with the inferred high wave-energy depositional setting.

Vertical heterogeneity is reflected in variations in the thickness and frequency of shale layers, and in the distribution of four distinctive reservoir facies of varying rock quality:

1) *poorly stratified sandstone (porosity ca. 23%, permeability ca. 1200 md).*
2) *bioturbated sandstone (porosity ca. 22%, permeability ca. 500 md).*
3) *laminated sandstone (porosity 19%, permeability ca. 90 md).*
   and
4) *bioturbated heterolithic sandstone (porosity 17%, permeability ca. 50 md).*

The Betty reservoirs are interpreted as representing the repeated build-out and gradual retreat of wave-/storm-dominated sand bodies (shoreface and/or shoreface-connected bars). They probably accumulated in a coastal to inner-shelf environment, which was marginal to the axial part of the Palaeo-Baram delta. Complete coastal progradation never occurred in this area in Upper Cycle V times with the environment remaining sub-littoral. The variations in sequence types reflect fluctuations in sediment supply and repeated base level changes, in which the latter was probably influenced by movements along the nearby Betty growth fault. The preservation of both progradation and retrogradational deposits, and the development of thick amplified sequences are both indicative of the high subsidence rates within the Baram Delta Province.

Hydrocarbons are trapped within at least twenty-one stacked sand bodies separated by sealing shales. The bulk of the hydrocarbons are encountered in a single structural block where trapping is a result of anticlinal dip closure and updip seal against the Betty growth fault. Only minor hydrocarbons are present in subsidiary fault blocks behind the Betty growth fault. Within the Betty structure oil-bearing reservoirs decrease in thickness and frequency with depth, while both associated primary gas caps and unassociated gas reservoirs increase in depth (down to 9500 ft ss). This reflects the thermal maturity profile of oil and gas migration in this area. Late expulsion and migration of gas has led to the preferential displacement of oil by gas in the structurally deep reservoirs.

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