

The Geology of Labuan as A Guide to Hydrocarbon Occurrence in
Offshore West Sabah

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Labuan island forms part of the Labuan Muara ridge, one of a series of roughly North-South trending reverse-faulted anticlinal structures offshore West Sabah. The Sabah Ridges appear to be due to a continuing process of compressional sinistral wrench faulting that was contemporaneous with deposition of a thick Neogene sedimentary prism. The ridges separate broad synclinal basins which have had a continuous history of subsidence and have accumulated more than 12 km of sediment.

Labuan itself is a northward-plunging, asymmetrical, anticlinal nose with a steeper western limb. The core of the anticline exposes the Lower Miocene Temburong (turbidites and olistostromes) and Setap (slope clays) Formations, whereas the fluvial-coastal sandstones of the Middle Miocene Belait Formation outcrop on the flanks.

Numerous oil and gas seeps are known from Labuan but no commercial hydrocarbon accumulations have yet been found. The island is however an interesting place to study the sedimentology and stratigraphic relationships of some of the units which do contain significant hydrocarbons elsewhere offshore West Sabah.

The Kubong Bluff-Bethune Head section through the Belait Formation at the northernmost tip of the island contains potential reservoir sandstones deposited in fluvial channel, crevasse-splay and tidal shoal environments. The section contains thick lacustrine/

lagoonal shales rich in potential source rock material including coals up to 4 m thick, abundant coalified plant matter, and resins. Historically an important oil seep is known from coal mining records. Equivalent basal Middle Miocene sandstones contain oil and gas in a number of small accumulations in the southern Sabah Ridges area. One such accumulation is illustrated on logs and by a seismic line. Oil typing studies demonstrate that the oils in these accumulations were land plant derived and hence were very probably generated from intraformational source rocks.

A second section through the Belait Formation at Layang-Layangan on the northwest coast, exposes different sedimentary facies, interpreted as delta-front deposits. This sequence, which is not exposed and which in fact is probably absent in the north of the island is older than the base of the section at Kubong Bluff. There has been a long controversy over the nature of the contacts between these delta-front transitional deposits and both the "true Belait Formation" fluvial deposits above and the Setap Formation below. Seismic shot in the shallow water jut offshore Labuan shows no clear unconformity between Belait and Setap Formations. However field and age relationships suggest that the Layang-Layangan sequence wedges out towards Kubong Bluff. One possible explanation of this is that the Labuan Ridge is a syn-depositional structure and that during the regional Base Middle Miocene tectonic event it was uplifted. Erosion on the crest gave way gradually down-flank to deposition of an expanded section in somewhat deeper water. In the broad Labuan-Paisley syncline to the west relative sea level rise and deposition were continuous and there is no hint of the important Base Middle Miocene unconformity. The synchronicity or otherwise of local unconformities on growing structures leads to important problems in establishing a regional seismostratigraphic correlation framework. These concepts will be illustrated with panels from seismic sections on the west flank of the Labuan anticline.

The final outcrops from which lessons are drawn regarding offshore Western Sabah lie near the Sabah Shell Petroleum Company crude oil terminal in the southwest of the island. Here an olistostrome and two types of turbidite are exposed in a strongly faulted section. The turbidites are either thin-bedded deposits of low density turbidity currents or thicker-bedded deposits of high density turbidity currents. Both facies contain abundant disseminated organic matter which yields oil on test-tube pyrolysis in the field. The association of relatively coarse turbidites, together with slumped blocks of turbidite sands redeposited in an olistostrome, and abundant detrital organic matter suggests a tectonic shelf edge or delta-slope close to the coast. It is possible that the ancestral Labuan ridge was such a tectonic line and that wholesale slumping of lower coastal plain and coastal deposits initiated the turbidity currents.

Elsewhere in the ridges province of southern Sabah minor quantities of hydrocarbons are known from age equivalents of the Temburong Formation in a turbidite facies and, again, hydrocarbons are thought to have been generated from within this sequence. One of these accumulations will be illustrated by logs. In the Upper Miocene a similar ridge-like structure became the source area for a major turbidite basin, in which Exxon Production Malaysia's Tembungo Field is to be found. The activity of this ridge will be illustrated with seismic sections.

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