Petroleum Systems of the North Malay Basin

MAZLAN MADON¹, PETER ABOLINS¹, REDZUAN ABU HASSAN¹, AZMI M YAKZAN¹,
JIU-SHAN YANG² & SAIFUL BAHARI ZAINAL²
¹PETRONAS Research & Scientific Services Sdn Bhd
²CS Mutiar Petroleum Sdn Bhd

The North Malay Basin comprises a 100 km-wide central/basinal gas-prone area, flanked on both sides and to the south by mixed oil/gas zones. Non-associated gas fields in the central zone (Cakerawala to Bujang Trend) are reservoired mainly in groups D and E, in anticlinal traps formed by basin inversion during late Miocene times. This distribution may be biased by the depth of well penetrations in the basin centre due to the onset of overpressure. Oil occurs in faulted traps along the Western Hinge Fault Zone (Kapal to Beranang Trend), and is especially abundant on the NE ramp margin (Bunga Pakma-Raya Trend) where a separate kitchen may be present.

Oil geochemistry reveals three main sources for the oils: lower coastal plain, fluvial marine and lacustrine source rocks. Most of the oils and condensates in the basin centre and on the Western Hinge Fault Zone are lower coastal plain oils, indicating charge from the basin centre. Lacustrine oils are restricted to the Bunga Pakma-Raya Trend on the NE flank, indicating charge from the basin centre as well as input from a small sub-basin to the northeast. Marine influence was found in oils from the most central position in the basin (Cakerawala-Bumi area). Vitrinite reflectance and basin modelling indicate that hydrocarbons were generated from source rocks within two main stratigraphic intervals: Group H and Group I, which are presently in the peak oil generation and gas generation stages, respectively. Figure 1 shows the distribution of oil and gas fields in relation to present-day groups H and I maturity.

The basin-centre gas fields are charged from directly underneath, i.e. from the Group I kitchen, and from the post-mature shales in the older units (e.g. groups J and K). Vertical migration, assisted by deep-seated faults, is the dominant process in the basin centre. The enormous volume of thermogenic gas generated at the basin centre appears to have largely flushed out much of Group H oil that might have filled the D and E reservoirs initially. As a result, oil is more likely to have re-migrated and be trapped along the faulted basin margins, such as in the Western Hinge Fault Zone, away from the basin-centre gas kitchen. Limited oil accumulations may still exist in the basin centre where gas flushing is less effective. Oil could also be present below the regional overpressure seal (Group F) in the basin centre.

The gases in the North Malay Basin contain varying amounts of CO₂. High CO₂ concentrations (>50 mol%) are typical of reservoirs in groups I and older and are mainly derived from inorganic sources. Low CO₂ concentrations (<6 mol%) are more typical of the reservoirs in groups D and E and are derived from organic sources (thermal degradation of kerogen). The inorganic CO₂ distribution appears to be governed by proximity to deep-seated faults that act as conduits for fluid migration.
Map of oil and gas fields with overlay of Group I maturity.

Map of oil and gas fields with overlay of Group H maturity.