Day: Friday 28 April **Session: 8**
Time: 9:10am

Observations of Hydrocarbon Migration within the Jasmine Field and the Impact on Risk Assignment for Exploration Prospectivity in Eastern Block B5/27, Gulf of Thailand

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The Jasmine and Ban Yen fields, hereafter referred to as the Jasmine Field, are located on the northwestern flank of the Tertiary Pattani Basin within Block B5/27 in the Gulf of Thailand. The Jasmine field was discovered in 1974 by Amoco and Idemitsu, and is currently 100% owned and operated by Mubadala Petroleum (Thailand) Ltd. The five production platforms of the Jasmine field have produced a cumulative 65 MMSTB oil from over 160 pools across 30 fault blocks and 27 separate reservoirs.

The Jasmine Field comprises stacked sandstone reservoirs of Middle to Late Miocene age that are grouped into lower and upper packages, separated by a field-wide shale termed the Hot Shale. This is a major regional seal which enables long distance (>20 km) migration from a distal source kitchen in the Pattani Trough.

Oils of the Jasmine Field are commonly 20-35°API though 15°API oils occur in the north of the field and 40-50°API fluids are present to the south in Ban Yen. Oils below 27°API are typically biodegraded. Biodegradation increases to the north west, though alteration is irregularly distributed. Oils have medium to high saturate contents, highly variable wax content and low sulphur. GC-MS and biomarker data reveal that the oils derive primarily from a non-marine algal (Type C) source rock (low Pr/Ph and C19/C23 tricyclic ratios, moderate gammacerane, presence of C30 4-methylsteranes, high Ts/Tm ratio). There may also be a minor contribution from a terrestrial (Type D/E) source (presence of oleanane and bicadinanes).

It has hitherto proven difficult to understand charge entry points into the field, which makes charge (migration) risk assignment to near-field exploration prospects challenging. The location of the source kitchen(s) and whether there is a single charge entry point below the Hot Shale seal, or multiple entry points above and below the Hot Shale, are key uncertainties. Multivariate statistical analysis of oil biomarkers furthered our understanding of the fill/spill history of the field and offered insights into connectivity and compartmentalisation

Data for the study comprised 59 oils from a 2010 Petroleum Geochemical study undertaken by Core Laboratories. Bulk properties were excluded from this study in order to minimise the influence of the secondary processes of biodegradation or evaporative fractionation on fluid family definition. 29 biomarkers that are resistant to these processes were selected for analysis; therefore families identified by the cluster analysis should largely reflect organofacies and maturity, with fluids that share a fill/spill history clustering together.

Preliminary screening of the biomarker parameter ranges revealed no obvious differences between Jasmine and Ban Yen oils. Furthermore, whole oil δ13C isotope values fall within a narrow range of -23‰ to -24‰, suggesting that hydrocarbons were expelled from similar organofacies at similar maturities. It is considered unlikely, therefore, that charge derives from two separate kitchens, e.g., located both to the south and to the east of the Jasmine Field.

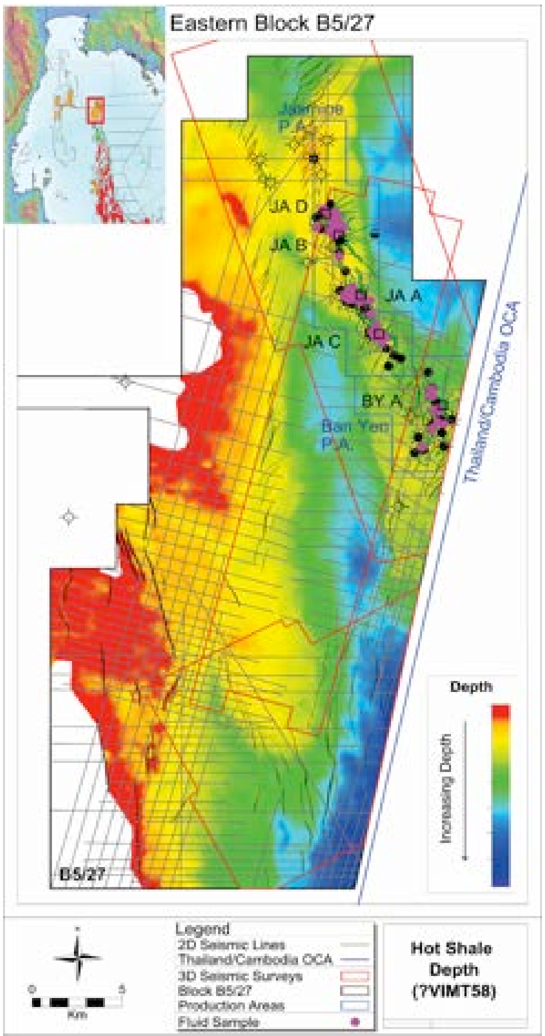

Figure 1: Eastern B5/27 Seismic & Fluid Sample Database

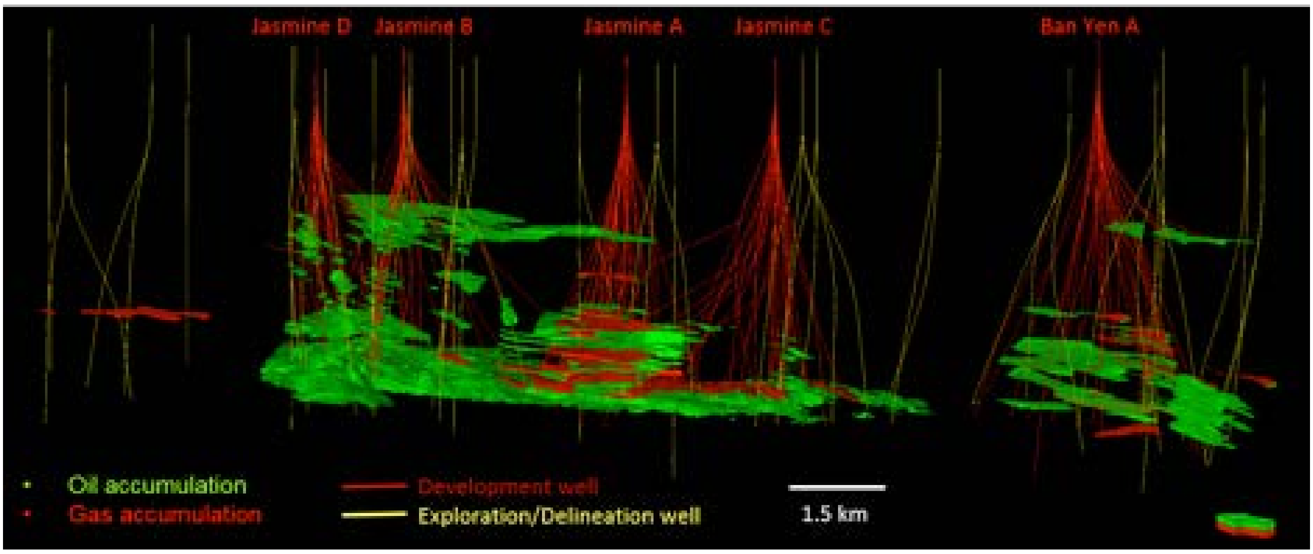

Figure 2: Hydrocarbon Pools of the Jasmine Field

Aromatic maturity parameters yielded slightly higher equivalent vitrinite reflectance in Ban Yen oils compared to Jasmine oils. This supports a migration model whereby the Ban Yen area receives later fluids generated at a higher maturity than the early charge, which spills to Jasmine. This model indicates that hydrocarbons are likely to have been generated in a kitchen located to the south of the Ban Yen area.

Hierarchical cluster analysis identified 16 families, which could be further grouped into six superfamilies. When the fluids are plotted in stratigraphic order it is clear that fluids in upper and lower reservoirs are from consistently different families. Subtle differences in the distribution of Pr/Ph, percent resins (bicadinane) and oleanane, and tricyclic content between oils of the upper and lower reservoirs are consistent with minor organofacies variation.

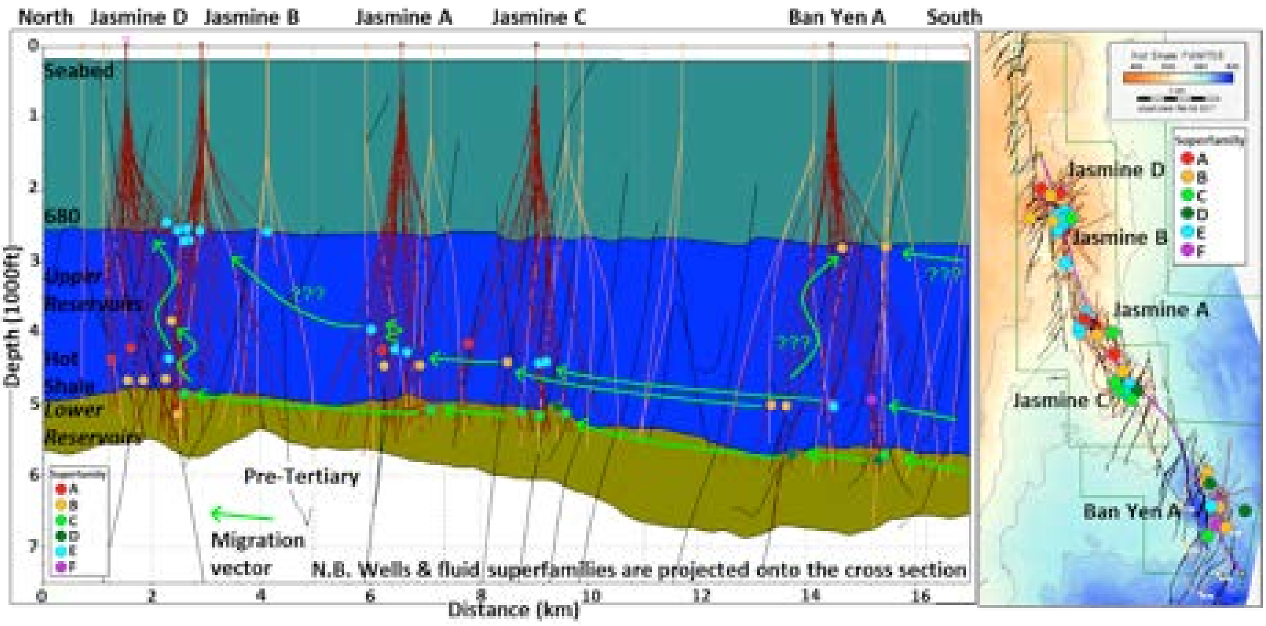

Figure 3: Fluid Superfamilies & Annotated Migration Vectors (Jasmine & Ban Yen

Fluid families of the upper reservoirs can be correlated on a vertical scale of thousands of feet. Fluids of the lower reservoirs demonstrate lateral migration on a scale of 10-12km without significant change to the fluids. That the discrete fluid families retain their fingerprint between pools supports the use of hierarchical cluster analysis as a method of unravelling fill spill pathways within the field.

The occurrence of different fluid families in upper and lower reservoirs at Ban Yen, which is the most southerly and structurally down dip entry point to the field, suggests that there are multiple charge entry points. This conclusion reduces the charge (migration) risk for prospects with upper reservoir targets located to the south of the Ban Yen field, which due to limited vertical relief of structural closures would otherwise rely on breach of the Hot Shale.

The statistical analysis was integrated with seismic interpretation, pressure data and observations drawn from the production history of the field. This integrated approach provided insights into connectivity and compartmentalisation within the field. For example, the occurrence of fluid superfamilies B and E in a single mapped pool within a single fault segment led to the suggestion that a fault should be extended to bisect the pool and place fluid superfamilies B and E either side of the fault, which acts as a baffle. The extension of this fault also resulted in a better history match during simulation modelling.

A 3D migration fill spill scenario is presented based on the integrated study, whereby vertical migration is modelled to occur following top seal breach and lateral migration occurs as fluids spill around fault tips where the closures are full to spill

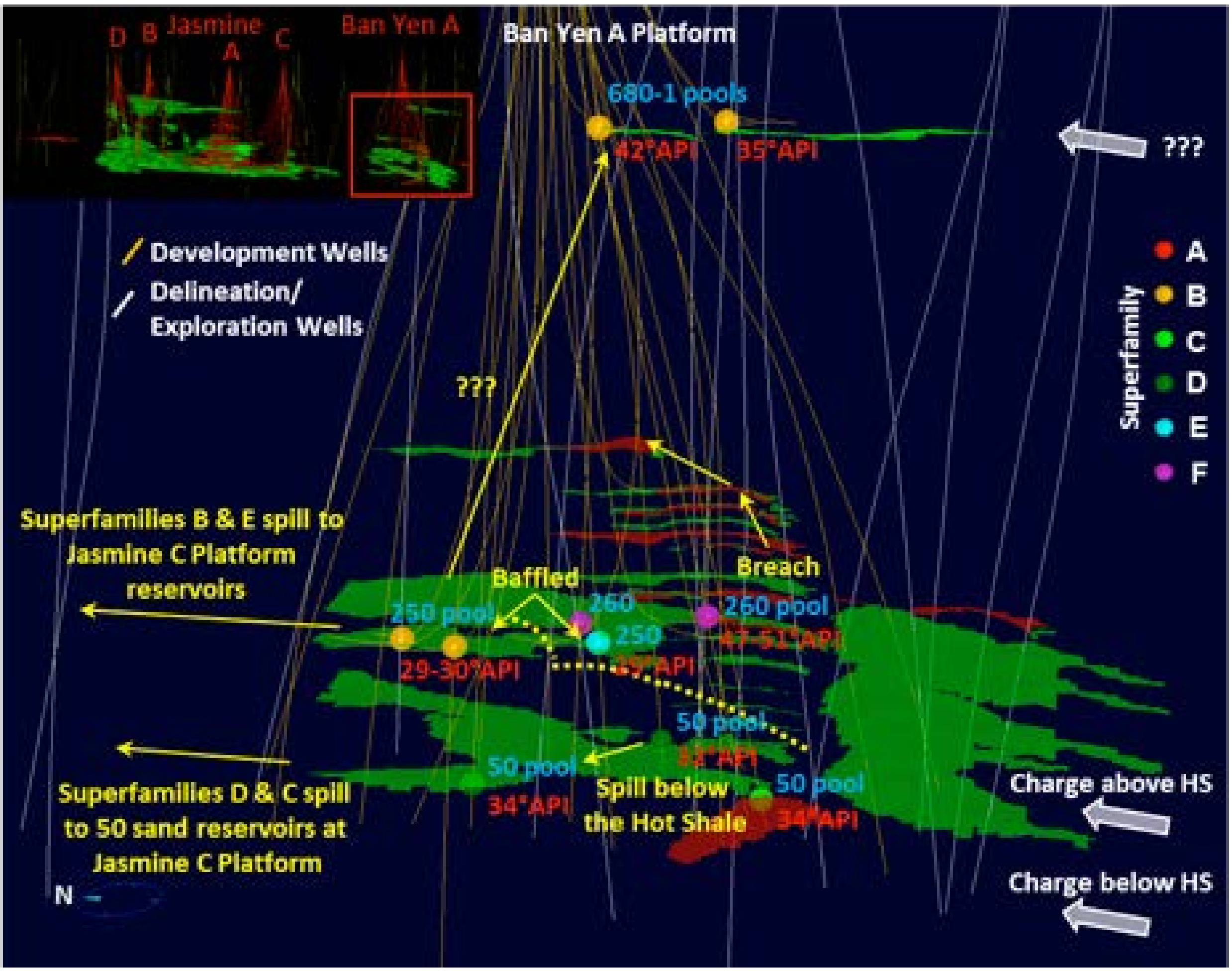

Figure 4: 3D Migration Fill Spill Scenario – Ban Yen Example

The following conclusions have been drawn from this study:

1. Jasmine Field oils have been expelled from similar organofacies at similar maturites. It is unlikely therefore, that they have received charge from multiple source kitchens.
2. Ban Yen has received later fluids, displacing the early charge to Jasmine. This model of migration suggests that fluids derive from a kitchen located to the south of Ban Yen.
3. Correlation of fluids is observed on a lateral scale of 10-12kms in lower reservoirs and on a vertical scale of several thousands of feet in upper reservoirs.
4. The occurrence of distinct fluid families in upper and lower reservoirs at Ban Yen suggests multiple charge access points to the field, both above and below the Hot Shale. This reduces charge risk for upper reservoir targets south of the Ban Yen field.

Integration of the results with seismic interpretation, pressure data and observations drawn from the field's production history provides opportunities to further our understanding of connectivity and compartmentalisation within the Jasmine field.