Integrated petroleum systems analysis and the source of fluids in the Browse Basin

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Browse Basin petroleum systems analysis

The Browse Basin is a proven hydrocarbon province (Fig. 1a) hosting gas with associated condensate and where oil reserves are typically small. This study combines a pseudo-3D petroleum systems model with a review of source rock characteristics to gain an understanding of source rock distribution, quality, maturity and generation potential. Integration of this assessment with fluid characteristics provides insight into the oil and gas prospectivity of the basin.

A regional 3D geological model of the Browse Basin was developed from new seismic interpretation (Rollet et al., 2016; Fig. 1b and c) and forms the basis of a pseudo-3D petroleum systems model. A total of 34 wells were modelled to calibrate (Fig. 2) the 3D model to produce results displayed in Fig. 3.

Figure 3 Browse Basin petroleum systems analysis results showing source rock maturity, quality, typical kerogen and timing of initial expulsion. TOC and HI are quoted in 10, 50 and 90 percentiles. TOC less than 1% are not considered a source rock and have been excluded from these analyses.

Fluid and phase behaviour

Pressure-volume-temperature (PVT) data and fluid analyses in the Browse Basin indicate that most fluids belong to dew-point petroleum systems (Fig. 4a), where gas-liquid-ratios (GLR) are high (>10,000 scf/bbl), consistent with sourcing from gas-prone source rocks. This substantiates the lack of significant oil-prone facies in the penetrated Jurassic and Cretaceous sections, as shown by the geochemistry of source rocks and petroleum systems model. While the search for oil traditionally relies on the presence of oil-prone source rocks, light oil can also be found in basins where the primary hydrocarbon type is a gas-condensate migrating into reservoirs at pressures below their dew point pressure. Most reservoired fluids in the Browse Basin are liquid-undersaturated gas-condensates (Fig. 4b). However, some accumulations are close to their saturation pressure in the reservoir and slightly lower pressure would result in oil-in-formation.

Table 1. Browse Basin petroleum systems analysis results showing source rock maturity, quality, typical kerogen and timing of initial expulsion.

<table>
<thead>
<tr>
<th>Source Rock</th>
<th>TOC (%)</th>
<th>HI (mg HC/g TOC)</th>
<th>D/E</th>
<th>Pressure (psi)</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K2–K3 Vulcan Fm</td>
<td>1.1</td>
<td>1.6</td>
<td>2.4</td>
<td>63</td>
<td>159</td>
</tr>
<tr>
<td>K2–K3 Edhua Fm</td>
<td>1.1</td>
<td>1.4</td>
<td>2.2</td>
<td>58</td>
<td>168</td>
</tr>
<tr>
<td>J3–J2 Plover Fm</td>
<td>1.1</td>
<td>1.8</td>
<td>15.1</td>
<td>31</td>
<td>167</td>
</tr>
</tbody>
</table>

Appendix 1. Source Rock Geochemical Characteristics (Hydrogen Index - HI vs Tmax). Source rocks within the Barcoo Subbasin have transformed most of the kerogen into hydrocarbons, with the majority of organic richness and quality to expel significant amounts of oil. Within the Barcoo Sub-basin, only the source rocks within the J10–J20 supersequences have reached sufficient maturity for significant generation.

Conclusions

Petroleum systems analysis indicates that most hydrocarbon fluids found in the Browse Basin are single-phase dew point fluids (gas-condensate). However, these fluids are expected to drop out oil rims if they migrate into lower pressure (shallower) traps and this may result in light oil spilling up-dip or being present as a residual column after gas loss through leaking seals.

Key references


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Figure 1 a) Regional setting, b) supersequences and petroleum systems elements, and c) 3D perspective of the basin model showing the top-J20 horizon, 2 cross sections and location of the modelled wells. Information on the regional petroleum systems elements of the basin is banded below the Middle Triassic, hence source rocks are only modelled down to the top Triassic (TR30). Top Permian (PSD) is used as the lower thermal boundary for the model.

Figure 2 Initial burial history of the Caswell 2 STS with associated calibration data (pelasic temperature and bottom hole temperature).