Maturation profile at the Glyde Gas Discovery in the Southern McArthur Basin, Australia*

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Search and Discovery Article #10799 (2015)**
Posted November 30, 2015

*Adapted from poster presentation given at AAPG/SEG International Conference & Exhibition, Melbourne, Australia, September 13-16, 2015
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Abstract

The Glyde gas discovery is situated within the Glyde Sub-basin of the Southern McArthur Basin in the Northern Territory. The McArthur Basin is an extensive Paleo- to Mesoproterozoic intracratonic basin of carbonate to siliciclastic sediments and lesser volcanic rocks. This basin has seen renewed oil and gas exploration activity in recent years, with operators targeting numerous prospective source rock formations. Within the middle McArthur Group, the Barney Creek Formation has been recognised for its hydrocarbon source and unconventional reservoir potential. To investigate the thermal and fluid flow history of the Glyde Sub-basin, organic matter maturation (“in situ” solid bitumen reflectance – organic petrography) and illite crystallinity (001 illite peak at 10Å – X-ray diffraction) were determined in 26 drill cutting samples from two wells, Glyde-1 (vertical well) and Glyde-1 ST1 (lateral well). These samples are representative of the Barney Creek Formation. Reflectance values of the solid bitumens were then used to estimate paleotemperatures. Observations from organic petrography revealed the presence of lamalginite kerogen (hydrocarbon precursor), and solid bitumens, which indicate the production of oil. The solid bitumen reflectance values and paleotemperatures placed the maturity of the samples in the oil window passing to gas window in both wells. Very weak correlation between illite crystallinity and the organic reflectance data was found, which is possibly representative of hydrothermal fluid-to-rock interaction, due to the organic particles being affected faster than the growth of illite can occur. Nevertheless, reflectance values and illite crystallinity profiles of Glyde-1 showed an erratic behaviour with depth suggesting that thermal history was influence by factors other than regional basin subsidence. The same observations were found for the lateral well Glyde-1 ST1, implying lateral variations in the maturation of the organic matter. These results suggest hydrothermal fluid interaction has influenced thermal maturation of the organic matter as expressed by the erratic character of the profiles. This type of study is fundamental to understanding hydrothermal influence on hydrocarbon accumulations in this region.
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McArthur Basin – Batten Fault Zone

The Batten Fault Zone is a complex fault system that provided conduits for hot fluid circulation (mineralized and non-mineralized).

Stratigraphy

The southern McArthur Basin has been targeted for conventional and unconventional reservoirs (oil and gas).

Glyde Wells

Glyde-1 (vertical well) and Glyde-1 ST1 (lateral well) conventional gas discovery wells drilled through the Bukalara Sandstone (Ediacaran age) that lies unconformably on the sediments of the Barney Creek Formation (Paleoproterozoic). The gas reservoir is in the underlying Cosco Dolomite Member of the Tessa Dolomite.

Organic Matter Characterisation

Sample Depth

<table>
<thead>
<tr>
<th>Sample Depth</th>
<th>Total Organic Carbon (TOC) (mg/g)</th>
<th>PI (mg/g)</th>
<th>Rr%</th>
<th>Lamalginite</th>
<th>Illite</th>
<th>Solid Bitumen</th>
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<tbody>
<tr>
<td>00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>Lamalginite</td>
<td>Illite</td>
<td>Solid Bitumen</td>
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<td>100</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>Lamalginite</td>
<td>Illite</td>
<td>Solid Bitumen</td>
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<tr>
<td>200</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>Lamalginite</td>
<td>Illite</td>
<td>Solid Bitumen</td>
</tr>
<tr>
<td>300</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>Lamalginite</td>
<td>Illite</td>
<td>Solid Bitumen</td>
</tr>
</tbody>
</table>

Lamalginite:
1) Lamellae oriented perpendicular to the bedding.  
2) Strong fluorescence in the first 200m, decreasing in intensity down hole.  
3) Main component in the samples at 200m, decreasing in its occurrence down hole. Below 500m is no longer recognised.

Illite:
1) Strongly affected by hydrothermal fluids circulating through the fracture system. These fluids may also have interacted with or even migrated hydrocarbons. PI is strongly affected by illite crystallinity (IC) shows a similar profile to PI.

Solid Bitumen:
1) Lamalginite reflectance values (Glikson et al., 1992) indicate vitrinite (VR%) values between 0.0 to 0.8 VR%
2) The conversion of the solid bitumen reflectance to vitrinite reflectance (VR%) by the Landis and Catuneanu (1983) formula gives: Solid bitumen with low reflectance - 0.76 to 0.36 VR%; Solid bitumen with high reflectance - 0.76 to 1.5 VR%.  
3) T_max values, where these are less affected by the presence of solid bitumen, indicate that the samples are immature to marginally mature for hydrocarbon generation (Crick et al., 1986).

The relationship between petrography and organic geochemical parameters gives a good approach to understand the thermal maturity achieved by the organic matter in relation to hydrocarbon generation. It also shows that vertical and lateral variations of the profiles are frequent within a stratigraphic level.

Thermal Maturation

Thermal maturation index profiles:
1) Reflectance values of lamalginite tend to increase relatively smoothly with increasing depth.
2) Solid bitumen shows two reflectance trends. The lower reflectance solid bitumen shows an increase with depth and may have a direct relationship with the lamalginite in the samples, while the higher reflectance solid bitumen may have migrated from somewhere else and show an erratic profile with depth.
3) T_max and PI show erratic profiles with depth. T_max is strongly affected by the type of kerogen. In the first 200 meters, T_max is high due to the presence of Type I kerogen, which has a relatively high decomposition temperature during pyrolysis. Below 200m, the presence of solid bitumen (especially higher reflectance solid bitumen) suppresses T_max values. PI is strongly affected by migrated hydrocarbons especially between 200 and 350m.
4) Illite crystallinity (IC) profile shows an influence of hydrothermal fluids circulating through the fracture system. These fluids may also have interacted with or even generated hydrocarbons since IC shows a similar profile to PI.
5) In Glyde ST1 lateral well, erratic profiles for reflectance values and illite crystallinity can be seen, indicating that lateral variation also occurs.

References: