THERMAL INSIGHTS IN THE MCARTHUR BASIN BASED ON BITUMEN REFLECTANCE AND ILLITE CRYSTALLINITY

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ABSTRACT

The intracratonic McArthur Basin is located in the Northern Territory, extending northwest along the Gulf of Carpentaria, separated from the coeval Mount Isa Basin in the south by the Murphy Inlier. This Precambrian (Palaeoproterozoic and Mesoproterozoic) basin consists of relatively undeformed sedimentary and volcanic rocks (Lindsay, 2001; Plumb et al., 1981) comprising four major stratigraphic groups, the Tawallah Group that unconformably overlies the Early Proterozoic Pine Creek Inlier, followed by the McArthur and Nathan Groups, with the Roper Group at the top. The drill cuttings analysed in this study come from two drill holes from the Glyde Sub-basin (Batten Fault Zone), which is considered as equivalent of the HYC sequence but is not mineralized in the same manner (Davidson and Dashlooty, 1993). The drill cores cut through the Bukalara Sandstone at the top followed by the Umbolooga Subgroup (McArthur Group), consisting from top to bottom of the Barney Creek Formation, Teena Dolomite and Emmerugga Dolomite.

The main objective of the study was to investigate the thermal and fluid flow history of the Batten Fault Zone since this is fundamental to understanding hydrothermal influence on hydrocarbon accumulations in this region. To pursue this objective, organic matter maturation and illite crystallinity were determined. It is considered that organic matter maturation is a reliable thermal indicator since it is sensitive to temperature changes recording the maximum heat peaks. To determine the paleotemperatures, reflectance measurements were performed on the organic fraction – bitumens. These organic components may migrate through fracture system or stay in place (essentially "in-situ" bitumen, parallel to the stratification). In this work the reflectance values (BRr%) obtained from bitumen parallel to the stratification were used to estimate paleotemperatures. These values were converted into vitrinite reflectance using Landis and Castaño (1995) equation and paleotemperatures were estimated by applying Barker and Pawlewicz (1986) formula. Illite crystallinity was evaluated to establish the temperature range for illite formation based on the 001 illite peak at 10Å (Kubler and Jaboyedoff, 2000; Warr and Rice, 1994).

The BRr% results indicated paleotemperatures values of 133-153^{o}C for Well Glyde 1 and 125-167^{o}C for Well Glyde 1 ST1, which placed the organic maturation stage in the oil/wet gas

window. On the other hand, based on the X-ray diffraction analysis of the clay separates, illite was the dominant phyllosilicate, and Warr and Rice values ranged from 0.526 to 0.977 in Well Glyde 1 and from 0.672 to 0.873 in Well Glyde 1 ST1, indicating that both wells are placed in the low diagenetic zone (≈ 150°C to 200°C).

Both organic matter reflectance and illite crystallinity follow a similar trend with depth, that is, both techniques indicated an erratic behaviour and no systematic trend with depth, although inflections in the trends at similar depths (around 400-500m depth in the Barney Creek Formation) were observed. The erratic pattern of the estimated paleotemperatures as well as the downhole illite crystallinity profiles indicate that the thermal history of the Batten Fault Zone was influenced by factors such as fluid-to-rock interactions due to hydrothermal events rather than basin subsidence alone.

The appearance of different bitumen types with varying organic reflectance, such as bitumen surrounding crystals and rounded bitumen, may reflect episodic pulses of hydrocarbon generation and/or migration (Glikson, 2001). Detailed petrographic analysis on core blocks that preserve the relationship between bitumens and rock-matrix may help to determine the migration behaviour of hydrocarbons in the McArthur Basin.

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