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MATURATION CHARACTERISTICS OF THE NEW ZEALAND COAL BAND: PART 1 – EVOLUTION OF OIL AND GAS PRODUCTS

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The Cretaceous–Cenozoic coals of the New Zealand Coal Band represent one of the World's best natural rank series for investigating the maturation characteristics of humic (i.e. vitrinite-rich) coals in that they provide essentially continuous coverage of rank from peat to semi-anthracite, while comprising a relatively restricted range of coal type. Thus, natural maturation processes spanning both the conventional oil and gas windows can be investigated with minimal influence from kerogen type effects. Sykes and Snowdon (2002) developed Rock-Eval-based maturation pathways for the New Zealand Coal Band in which rank-related changes in BI (S1/TOC) and QI ([S1+S2]/TOC) were used to infer the rank thresholds for oil and gas generation and expulsion. In addition, a rank-related increase in HI (S2/TOC) of up to 150 mg HC/g TOC prior to oil expulsion indicated significant enrichment of the original hydrocarbon generating potential and means that immature coals can not provide reliable representation of natural oil and gas potentials.

In the present study, we further examine the maturation pathways of Sykes and Snowdon (2002) using quantitative, thermal extraction- and pyrolysis-gas chromatography (TE-Py-GC) to elucidate the progressive evolution of specific oil and gas fractions with respect to Suggate rank [Rank(S_r)], vitrinite reflectance (R_o) and Rock-Eval T_{max}. The origin of the pre-expulsion increase in HI and its implications for kinetics-based modelling of petroleum formation are examined in an accompanying presentation (Sykes et al., this volume).

Sequential TE-Py-GC (with external butane standard) was carried out on 51 well-characterised coals from many New Zealand basins, ranging in rank from lignite B to semi-anthracite [Rank(S_r) 0–19.3, T_{max} 368–565°C, R_o 0.25–2.61%]. The samples were selected from towards the middle of the New Zealand Coal Band to minimise kerogen type variation with respect to both bulk chemical and petrographic compositions; all samples are vitrinite-rich (> c. 80%, mineral matter-free) and liptinite- and inertinite-poor. As a consequence, strong correlations were obtained between Rank(S_r) and R_o (R^2=0.99), and T_{max} (R^2=0.99).

The thermal extract compositions show that the generation of non-volatile paraffinic oil (nC$_{15+}$) commences at Rank(S_r) ~9–10 (R_o ~0.55–0.65%, T_{max} ~425°C), whereas the

generation of volatile paraffinic oil (nC_6–nC_{14}) commences slightly later at Rank(S_r) ~10–11 (R_o ~0.65–0.7%, T_{max} ~430°C; Fig. 1). A sharp decline in total extract yields from Rank(S_r) ~14 (R_o ~1.15%, T_{max} ~455°C) likely signals the onset of primary gas generation and the efficient expulsion of oil out of the coal pore system.

The pyrolysate compositions indicate that paraffinic oil potential (volatile and non-volatile) is largely exhausted by Rank(S_r) ~16 (R_o ~1.6%, T_{max} ~485°C), signifying the base of the effective oil window. The full extent of the oil window, from Rank(S_r) 9–16, coincides with the rank range of elevated vitrinite fluorescence intensity, consistent with the presence of a mobile phase within the pore system. Significant gas (C_1–C_5) potential of c. 35 mg/g TOC still remains at the end of the oil window, but diminishes to c. 5 mg/g TOC by Rank(S_r) ~19 (R_o ~2.6%, T_{max} ~555°C), indicating proximity to the base of the conventional gas window.

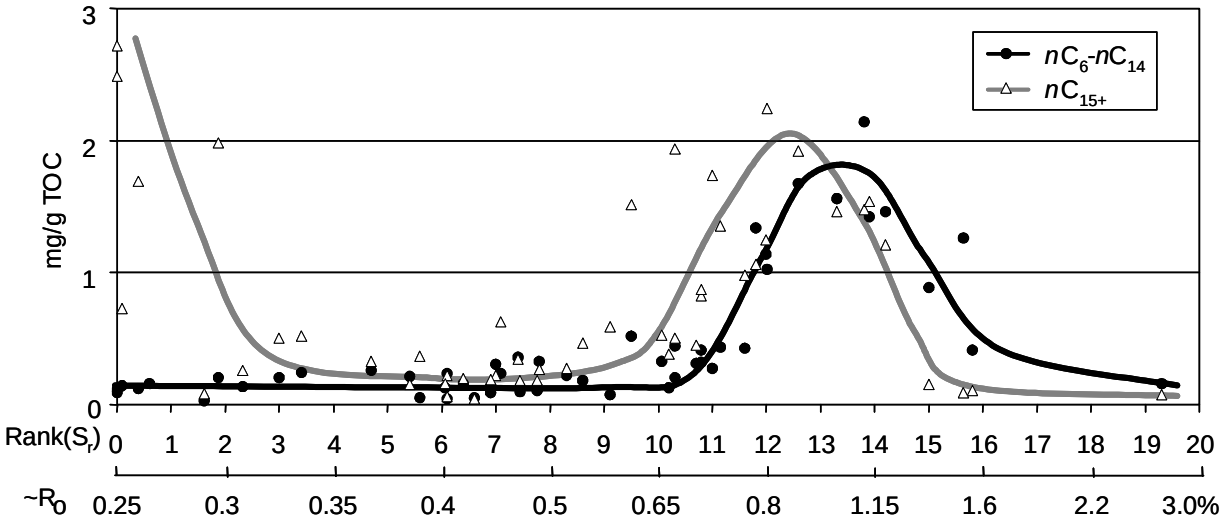

Figure 1. Plot of volatile (nC_6–nC_{14}) and non-volatile (nC_{15+}) paraffinic oil yields in thermal extracts of New Zealand coals in relation to Suggate rank [Rank(S_r)] and equivalent vitrinite reflectance (R_o). High yields of nC_{15+} at low ranks are of biogenic and diagenetic origin.

REFERENCES

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