Geochemical Insights into the Depositional Conditions of Prospective Late Cretaceous – Paleogene Marine Source Rocks of the East Coast Basin, New Zealand

B.R. Hines[1,2], M.F. Gazley[1,3], K. Bland[2], G.T. Ventura[2], J.S. Crampton[1,2], and K.S. Collins[1]

[1]Victoria University of Wellington, PO Box 600, Wellington, New Zealand
[2]GNS Science, PO Box 30-368, Lower Hutt, New Zealand
[3]CSIRO Mineral Resources Flagship, ARRC, PO Box 1130, Bentley 6102, Western Australia, Australia

Abstract

Large proportions of the Late Cretaceous to Paleogene successions of the Southwest Pacific are dominated by thick, lithologically homogenous siliceous to moderately calcareous mudstones. In many localities, this sequence is interrupted by the Late Paleocene, highly prospective organic-rich source rocks of the Waipawa organofacies, identified in the East Coast, Northland, Taranaki, Canterbury and Great South Basins. The importance of these source rocks to the understanding of New Zealand's petroleum systems is well recognized; however, the depositional controls on their formation are not yet well constrained.

We have studied the geochemistry of several key outcrop sections in the East Coast Basin in moderate to high resolution using portable X-ray fluorescence. Elemental concentrations were validated using conventional, laboratory-based analytical procedures (e.g. inductively coupled plasma mass spectrometry, wavelength dispersive X-ray fluorescence and Leco). Samples were further analysed by X-ray diffraction (XRD) to determine modal mineralogy and bulk pyrolysis was used to determine the organic component of samples. Data analysis using principal components analysis combined with model-based cluster recognition has identified systematic vertical and lateral geochemical compositional variation, enabling chemostratigraphic correlation between sections.

These high-spatial resolution datasets provide robust chemostratigraphic divisions, both between and within units. Within this framework, XRD analyses indicate no significant change in detrital source occurred across the transition between the Whangai, Waipawa and Wanstead formations in the East Coast Basin. This confirms that a change in the paleoceanographic setting, rather than a change in provenance, was responsible for the widespread deposition of the lithologically and geochemically distinct Waipawa organofacies. Trace metal indices, enrichment factors (relative to average shale values) and total organic carbon (TOC) – sulphur (S) – iron (Fe) relationships reveal evidence of shifting paleo-redox conditions, from oxic to dysoxic conditions during the Late Paleocene, associated with enhanced preservation of organic matter. TOC – S relationships indicate a considerable proportion of the original organic carbon was reduced by microbial action. Microbial reduction preferentially removes the simpler organic complexes of marine organic matter, potentially explaining the enhanced terrestrial signature often associated with the Waipawa Formation.

In modern sedimentary environments, organic-rich sediments are typically deposited beneath coastal upwelling areas (e.g. Gulf of California, Peruvian and Namibian coasts) or in euxinic basins (e.g. the Black Sea). Comparison of trace element enrichment factors from these regions with values determined for the Waipawa Formation generally fit the coastal upwelling model. This is in line with paleogeographic

reconstructions for the Southwest Pacific, which indicate no oceanographic restriction, as typically required to develop euxinia in the water column.

Integrating these chemostratigraphic approaches into the existing stratigraphic framework provides new constraints on Late Cretaceous – Eocene paleoenvironmental conditions and provides a new tool for correlating lithologically monotonous, prospective mudstone formations in the eastern sedimentary basins of New Zealand.