THE OCEANOGRAPHIC AND CLIMATIC CONDITIONS IN THE PALEOCENE THAT LED TO FORMATION OF UNIQUE WAIPAWA SOURCE ROCKS IN THE SW PACIFIC

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The Waipawa Formation is a dark brown-black, poorly bedded, organic-rich, marine mudstone ranging from 2 to ca. 70 m in thickness (e.g., Schiøler et al., 2010; Hollis et al., 2014). The unit has a high organic carbon content (1–12 wt% TOC) typically dominated by terrestrial organic matter, particularly woody phytoclasts, and with unusually enriched bulk $\delta^{13}C$ values (up to -16‰) and high concentrations of 24-*n*-propylcholestanes (up to 55% of regular C_{27}–C_{30} steranes) (Killops et al., 2000; Schiøler et al., 2010). Coeval rock units that share these features but vary in lithology, including well-bedded siliceous mudstone and glauconitic sandstone, are grouped into "Waipawa organofacies", which appears to have been deposited over ca. 700,000 years in the early late Paleocene (59.4–58.7 Ma) (Hollis et al., 2014). Waipawa organofacies is widespread in the eastern basins of the North and South Islands of New Zealand and has also been found in the offshore Taranaki Basin, west of New Zealand and in sediment cores from the western Tasman Sea (Killops et al., 2000; Hollis et al., 2014).

The purpose of our study is to determine the oceanographic and climatic factors that led to the deposition and preservation of this apparently unique organofacies. Improved understanding of these depositional conditions will aid in assessing the petroleum potential of the organofacies within the wider New Zealand region.

Our approach involved integration of bulk, molecular, and isotope geochemistry (SRA bulk pyrolysis, lipid biomarkers, bulk and compound-specific C and S isotopes) with palynofacies and nannofossil biostratigraphic results, combining new data with existing data from over 30 years of research. In addition to a general assessment of spatial and temporal variations of the Waipawa organofacies throughout New Zealand, we also investigated one near-continuous record (Taylor White section, Hawke's Bay, eastern North Island) in great detail, delineating a succession of short-term variations in organic matter properties within the Waipawa Formation and suggesting that sulfur enhanced the preservation of organic matter within the unit (Fig. 1).

To understand the unusually high bulk $\delta^{13}C$ values, palynofacies assemblages were sieved and separated into six density fractions and their $\delta^{13}C$ values were measured. We were able to quantify the relative contributions of marine and terrestrial organic matter within the fractions. Our results suggest that the higher (i.e., more enriched) $\delta^{13}C$ values are associated with greater contributions of terrestrial organic matter relative to marine organic matter.

Our data indicate that the Waipawa organofacies was deposited in shallow to deep marine, continental margin settings under cool, hypoxic conditions associated with high marine productivity, a large influx of terrestrial organic matter, and a global fall in sea level. We infer that Waipawa organofacies deposition is associated with a short-term cooling event in the late Paleocene. A lower base level increased erosion of vegetated coastal areas whereas cooler ocean conditions promoted upwelling via intensification of southern-sourced currents.

The thermally immature outcrop samples of the Waipawa organofacies typically have good to excellent petroleum generative potential with S2 values of up to ca. 40 mg HC/g rock. However, with HI values mostly below 300 but up to ca. 400 mg HC/g TOC, the generative potential is primarily for gas with subordinate oil. This organofacies has, however, sourced the subcommercial Kora oil accumulation in the offshore northern Taranaki Basin and a number of oil seeps and stains in the onshore central East Coast Basin (e.g., Killops et al., 2000) and is a promising source rock target for petroleum exploration in other New Zealand onshore and offshore basins, and perhaps further afield.

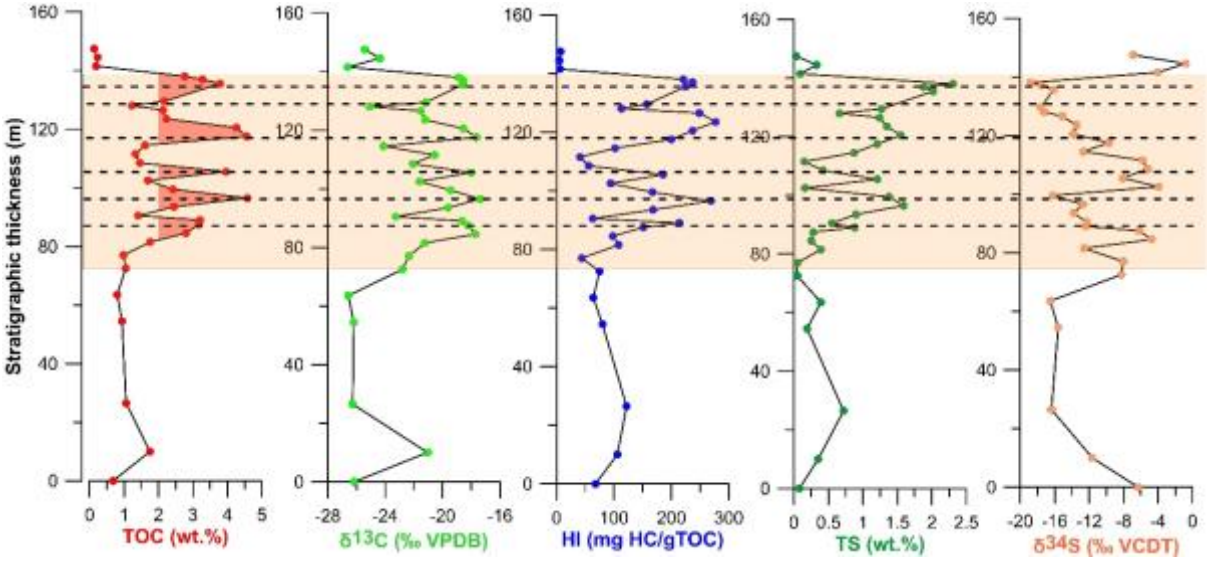

Figure 1 *Stratigraphic variations in total organic carbon (TOC), bulk $\delta^{13}C$ (‰ vs Vienna PeeDee Belemnite), hydrogen index (HI), total sulfur (TS), and $\delta^{34}S$ (‰ vs Vienna Canyon Diablo Troilite) within the Taylor White section, Hawke's Bay, New Zealand. The orange background indicates Waipawa Formation. Shaded area in TOC profile indicates TOC values ≥2.*

References

Hollis, C.J., Tayler, M.J.S., Andrew, B., Taylor, K.W., Lurcock, P., Bijl, P.K., Kulhanek, D.K., Crouch, E.M., Nelson, C.S., Pancost, R.D., Huber, M., Wilson, G.S., Ventura, G.T., Crampton, J.S., Schiøler, P., Phillips, A., 2014. Organic-rich sedimentation in the South Pacific Ocean associated with Late Paleocene climatic cooling. Earth-Science Reviews 134, 81–97.

Killops, S.D., Hollis, C.J., Morgans, H.E.G., Sutherland, R., Field, B.D., Leckie, D.A., 2000. Paleoceanographic significance of Late Paleocene dysaerobia at the shelf/slope break around New Zealand. Palaeogeography, Palaeoclimatology, Palaeoecology 156, 51–70.

Schiøler, P., Rogers, K., Sykes, R., Hollis, C.J., Ilg, B., Meadows, D., Roncaglia, L., Uruski, C., 2010. Palynofacies, organic geochemistry and depositional environment of the Tartan Formation (Late Paleocene), a potential source rock in the Great South Basin, New Zealand. Marine and Petroleum Geology 27, 351–369.