RECOGNISING TERRESTRIAL INPUTS IN MARINE ENVIRONMENTS FOR AUSTRALIAN PETROLEUM SYSTEMS THROUGHOUT THE PHANEROZOIC

G. Spaak[1], D. S. Edwards[2], E. Grosjean[2], C. B. Foster[3], R. E. Summons[4], A. P. Murray[5], N. Sherwood[6], A. G. Scarlett[1], K. Grice[1]

[1]Curtin University, Perth, Australia; [2]Geoscience Australia, Canberra, Australia; [3]UWA, Perth, Australia; [4]MIT, Cambridge, USA; [5]Murray Partners PPSA Pty. Ltd., Perth, Australia; [6]CSIRO Energy, Sydney, Australia

Understanding, quantifying and predicting inputs of terrestrial organic matter delivered from the continents to the oceans is a classic but still topical problem in marine biogeochemistry [1] which has direct implications for petroleum systems analysis. The fate of terrestrial organic carbon within the earth system governs our understanding of the global carbon cycle and is critical for constraining biogeochemical models and predicting past and future atmospheric CO_2 levels. From a petroleum systems perspective, the composition of source rocks, including the contribution of terrestrial versus marine organic matter, is one of the main factors controlling whether gas and/or oil can be generated [2]. Classical biomarker analysis of crude oils (e.g. hopane and sterane distributions) often fails to adequately identify terrestrial inputs and other compounds need to be considered (e.g. semi-volatile aromatics (SVA)), especially in accumulations where there is a mixture of low and high maturity fluids. Here we compare geochemical characteristics of four Australian petroleum systems ranging from the Ordovician to Early Cretaceous that are typified by source rocks deposited in marine environments with varying contributions of terrestrial organic matter.
In the Canning Basin, Western Australia, the Middle Ordovician, Upper Devonian and Lower Carboniferous formations containing source rock potential were deposited under marine conditions but contain evidence of terrestrial inputs (Fig 1A).
The Middle Ordovician upper Goldwyer Formation records the earliest occurrence of land-plant microfossils (cryptospores and trilete spores) in Australia. The higher-molecular-weight *n*-alkane distributions and isotopic compositions recorded in the upper Goldwyer Formation show resemblances to those derived from modern day bryophytes. The Upper Devonian sediments were deposited under stratified, photic zone euxinic (PZE) environments [3]; however, a terrestrial input is indicated by high abundances of perylene and methyltrimethyltridecylchromans, which potentially played a key role in the development of PZE [3]. The carbonates and shales of the Lower Carboniferous Laurel Formation were deposited in a transgressive shallow marine to open shelf environment. Petrological analyses show a pre-dominant contribution of land-plant remains in these rocks and terrestrial biomarkers including methylated dibenzofurans and tetrahydroretene [4] were present.
The Ordovician and Devonian terrestrial signatures were identified in organic lean, carbonate-rich sections of the source rocks, and these signatures are not obvious in the generated hydrocarbon accumulations. This signifies the local origin and/or relatively small contribution of the lipid-poor terrestrial organic matter within the source rock formations, and the presence of localised source rock pods in the more marine-influenced parts of the basin. Furthermore, the lack of hydrogen-rich, terrestrially derived liptinites in the Lower Carboniferous source rocks could account for the absence of terrestrial biomarkers in the related oils.

The Early Cretaceous Echuca Shoals Formation shales from the Australian North West Shelf are typical passive margin sedimentary rocks, ranging from shallow marine siliclastics to open marine claystones. The organic matter is mainly inertinite, consistent with a dominant terrestrial input. Oils in the Browse (Caswell 1 and 2) and Bonaparte Basin (Elang West 1) both correlate to the Echuca Shoals Formation. SVA ratios and $\delta^{13}C$ of *n*-alkanes indicate that the Caswell accumulation exhibits a greater terrestrial contribution than that at Elang West (Fig 1B). This terrestrial contribution could be a result of mixtures from more than one source rock or the same source at differing maturity.

This work highlights that terrestrial inputs are historically under recognised in Australian marine Paleozoic basins and can have significant impacts for source rock development and govern the variations between source rocks and their generated hydrocarbons.

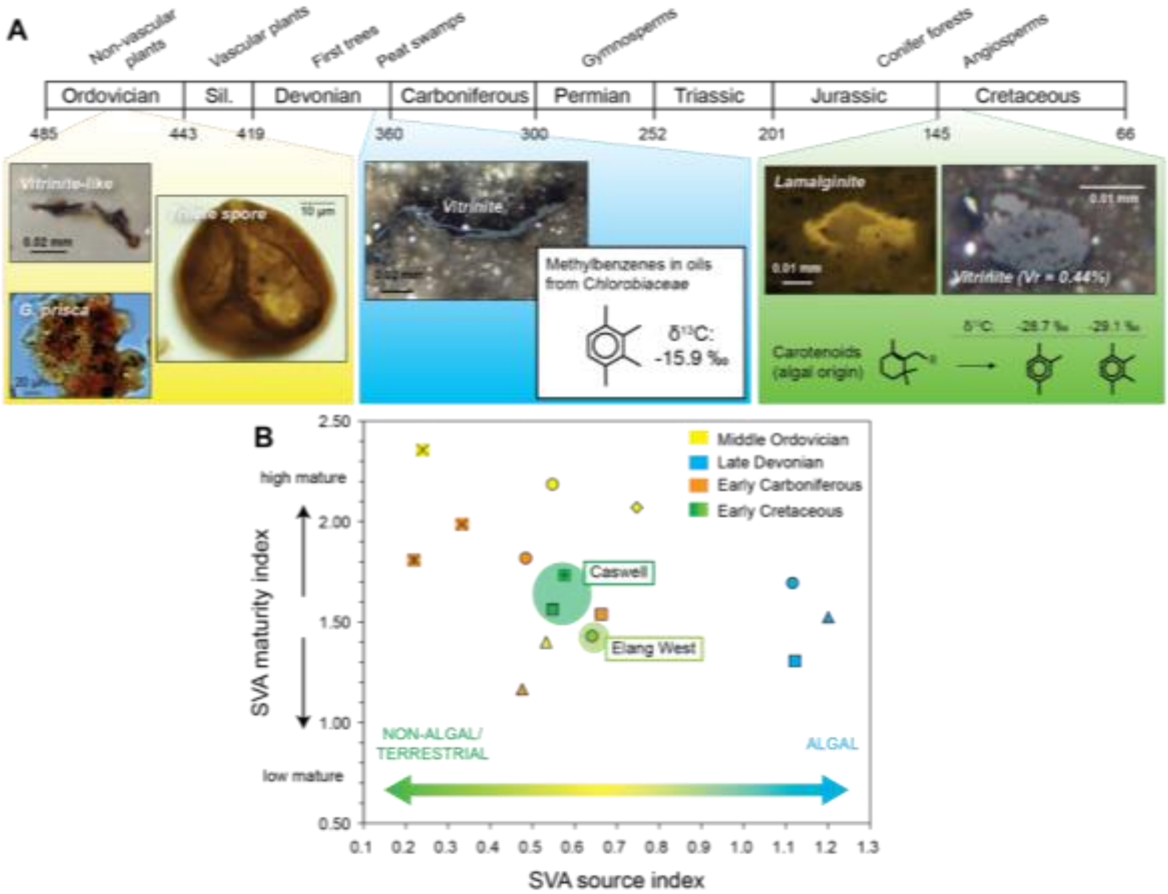

Fig 1. (A) Palynology, organic petrology and stable carbon isotopes reflecting different organic matter sources within the discussed petroleum systems. (B) Source discrimination using ratios between selected tetramethylbenzenes and tetramethylnaphthalenes.

References

[1] Blair, N. E., and Aller, R. C., 2012. The Fate of Terrestrial Organic Carbon in the Marine Environment. Annual Review of Marine Science 4:401-23.

[2] Pepper, A. S., and Corvi, P. J., 1995. Simple kinetic models of petroleum formation. Part I: oil and gas generation from kerogen. Marine and Petroleum Geology 12 (3), 291-319.

[3] Tulipani, S., Grice, K., Greenwood, P. F., Schwark, L., Bottcher, M. E., Summons, R. E., Foster, C. B., 2015. Molecular proxies as indicators of freshwater incursion-driven salinity stratification. Chemical Geology 409 61-68.

[4] Romero-Sarmiento, M. F., Riboulleau, A., Vecoli, M., Laggoun-Défarge, F., Versteegh, G.J.M. 2011. Aliphatic and aromatic biomarkers from Carboniferous coal deposits at Dunbar (East Lothian, Scotland): Palaeobotanical and palaeoenvironmental significance. Palaeogeography, Palaeoclimatology, Palaeoecology 309, 309-326.