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Organic geochemistry of non-marine Permian-Triassic mass extinction (PTME) sections in the Sydney Basin, Australia

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Abstract

Most organic geochemical studies of the Permian-Triassic mass extinction (PTME) have utilised marine sections, and the boundary is readily identified by a negative carbon isotope excursion. It is now well understood from various locations around the world that the marine ecosystem collapse is accompanied by biomarker evidence for photic zone euxinia, including isorenieratane, crocetane and 2,3,6-aryl isoprenoids (e.g. Grice et al., 2005). Far fewer studies have been carried out on non-marine PTME sections, and in particular no biomarker studies have been carried out on Australian sections, despite there being extensive Permian and Triassic sequences in eastern Australia, notably in the Bowen and Sydney basins.

Keywords

basin, (ptme), sections, organic, geochemistry, australia, non-marine, sydney, permian-triassic, mass, extinction

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§ The organic geochemistry in this poster was carried out by 8 masters students and 1 undergraduate student under the supervision of Simon George

Introduction

Most organic geochemical studies of the Permian–Triassic mass extinction (PTME) have utilised marine sections, and the boundary is readily identified by a negative carbon isotope excursion. It is now well understood from various locations around the world that the marine ecosystem collapse is accompanied by biomarker evidence for photic zone euxinia, including isorenieratane, crocetane and 2,3,6-aryl isoprenoids (e.g. Grice *et al.*, 2005). Far fewer studies have been carried out on non-marine PTME sections, and in particular no biomarker studies have been carried out on Australian sections, despite there being extensive Permian and Triassic sequences in eastern Australia, notably in the Bowen and Sydney basins.

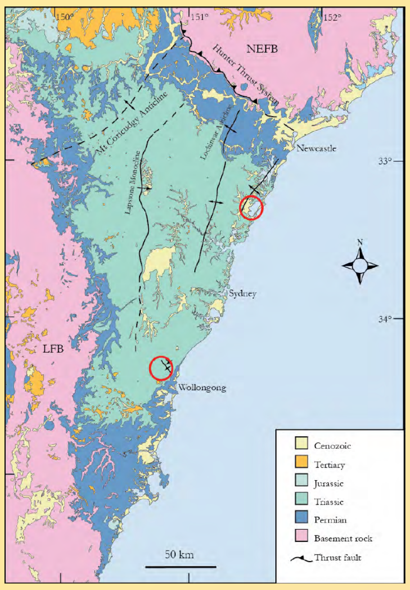

Fig. 1. Geological map of the Sydney Basin, showing the samples location of core DDH15 from Douglas Park near Wollongong, and core WL2 from near Wyong on the Central Coast of NSW (from Williams, 2012).

Study of the non-marine sections will help better assess causal mechanisms, which remain controversial. In the Sydney Basin the PTME occurs after the stratigraphically highest Permian coal, although sometimes the boundary is placed directly on top of this coal (Retallack, 1995), and sometimes shortly after (Morante, 1996). Recently, a study of a continuous non-marine PTME section from the southern Sydney Basin (core DDH15 from near Douglas Park: Figs 1, 2) showed that the boundary is identified by a negative carbon isotope of ~3.8‰ approximately 1 m above the end Permian Bulli Coal (Williams *et al.*, 2012a). In this study samples from that core and a second location from the northern Sydney Basin (core WL2 from near Wyong; Figs 1,3) have been analysed organic geochemically in order to determine variation in source input and depositional environment that might be related to the PTME.

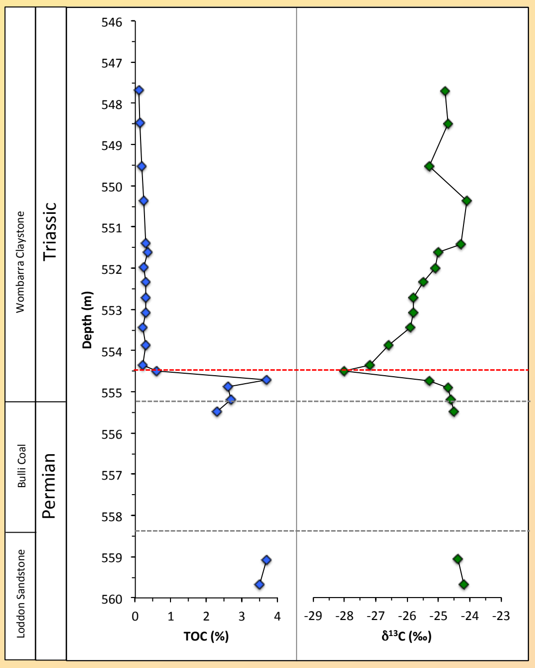

Fig. 2. Stratigraphy of the DDH15 core, with measured total organic carbon and carbon isotopes of organic matter (Williams *et al.*, 2012a).

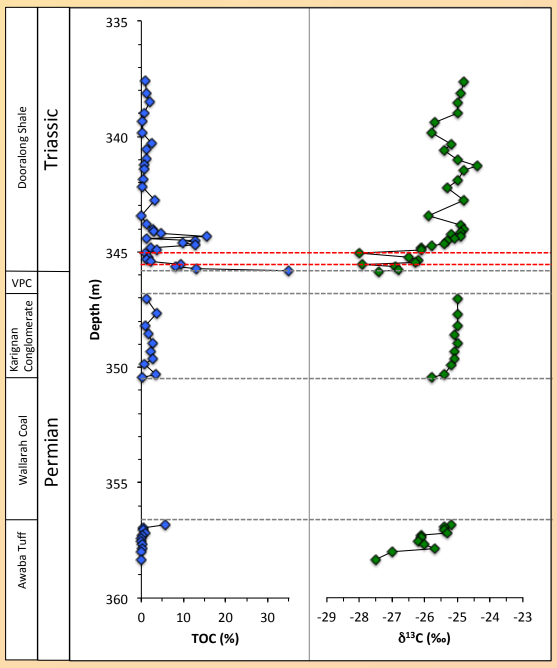

Fig. 3. Stratigraphy of the WL2 core, with measured total organic carbon and carbon isotopes of organic matter (Williams *et al.*, 2012b). VPC = Vales Point Coal.

Variation of TOC and $\delta^{13}C$

The DDH15 core is more thermally mature (vitrinite reflectance equivalent [VRE] from methylphenanthrene index = ~1.0%) than the WL2 core (VRE = ~0.75%), and thus biomarkers are less well preserved although still present in the southern Sydney Basin. The northern Sydney Basin PTME section has a more complex double negative carbon isotope spike at the boundary than in core DDH15 (Williams *et al.*, 2012b), and this occurs in the Triassic Dooralong Shale between 0.3 and 0.8m above the top of the Permian Vales Point Coal (VPC; Fig. 3). The lowest section of the Dooralong Shale contain re-worked coaly material and hence high amounts of total organic carbon (TOC), but at the boundary as defined by the isotope excursion the TOC drops to <2% (Fig. 2).

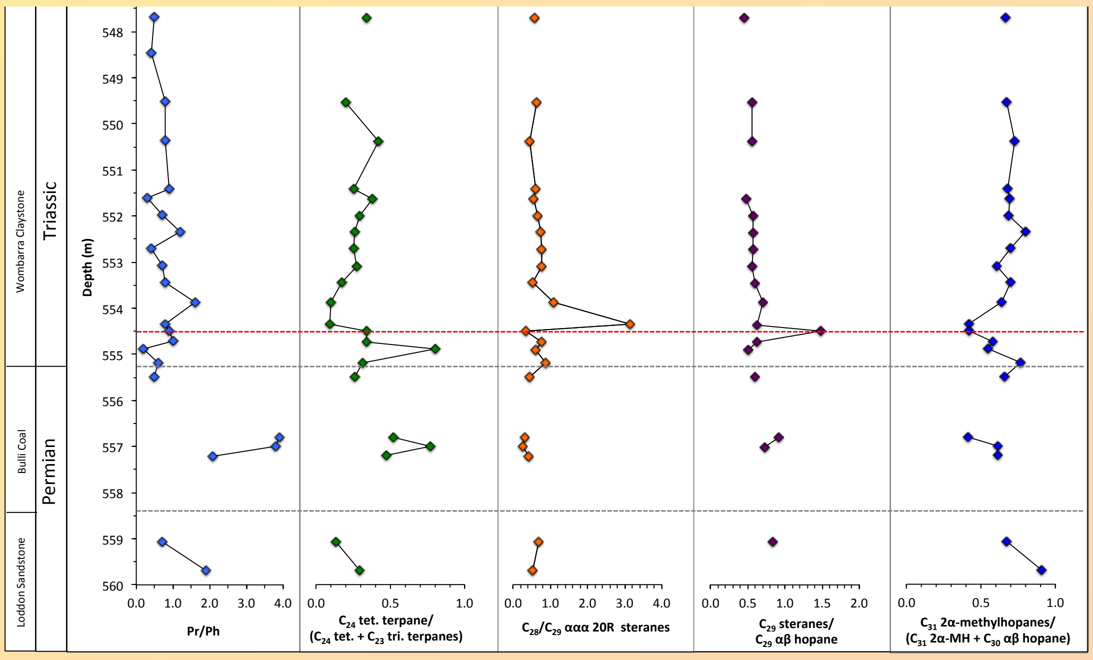

Fig. 4. Biomarker variation through the Permian-Triassic in the DDH15 core. The dashed red line marks the PTME as defined by carbon isotopes (Fig. 2). The three biomarker values for the Bulli Coal are published values from different gas drainage boreholes from the Tahmoor and Metropolitan mines in the same general area as DDH15, and are shown diagramatically in this diagram (Ahmed *et al.*, 2009).

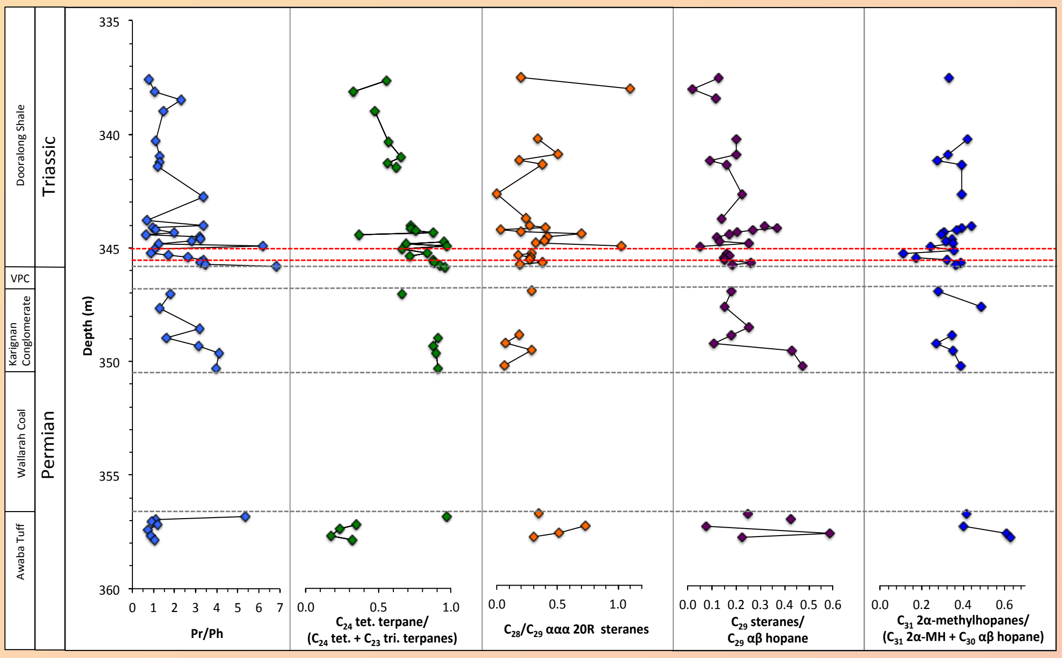

Fig. 5. Biomarker variation through the Permian-Triassic in the WL2 core. The dashed red line marks possible location of the PTME as defined by carbon isotopes (Fig. 3).

Biomarkers

Pristane/phytane (Pr/Ph) is generally high (>3) in Australian Permian coals, and in DDH15 drops to an average of 0.7 in the Triassic Wombarra Claystone (Fig. 4), suggest anoxic-suboxic conditions. In WL2 Pr/Ph varies more widely, from >6 to <0.8, especially near the isotope excursion (Fig. 5). The higher values likely reflect re-worked coaly input from eroded Permian sediments. Generally the Dooralong Shale can be interpreted to have been deposited under suboxic conditions, and the anoxic conditions in this non-marine section were only short-lived. The distribution of terpanes and steranes helps assess variation in organic matter input to the sections. In DDH15 the Permian section contains moderate amounts of C_{19} tricyclic and C_{24} tetracyclic terpanes, typical of terrigenous settings, and in the Wombarra Claystone C_{23} tricyclic terpane, an algal biomarker, becomes dominant immediately after the isotope excursion (Fig. 4). Steranes are generally dominated by C_{29} homologues, but these are reduced relative to C_{28} steranes immediately after the PTME. In contrast, the WL2 section is characterised by higher relative amounts of the terrigenous biomarkers, and these remains abundant through the PTME and into the Dooralong Shale. This is consistent with the sedimentology and trace element geochemistry of the sections which indicate a predominantly low energy fluvial or lacustrine environment for the Dooralong Shale and the Wombarra Claystone (Williams, 2012; Williams *et al.*, 2012a). There is no indication of lacustrine conditions from the biomarkers (low C_{26} tricyclic terpanes; little gammacerane), so a fluvial environment is more likely.

Importantly, there is no evidence from the sterane/hopane ratio for a strong depletion in eukaryotic organic matter at the PTME, nor for a pulse of dominant cyanobacterial productivity, as might be indicated by elevated 2α-methylhopane/hopane ratios (Figs 4 ,5). Indeed in DDH15 the sample immediately after the isotope excursion has a higher sterane/hopane ration and and a lower content of methylhopanes. **This suggests that this fresh water, non-marine environment was shielded from the violent environmental perturbations that the oceans at the PTME experienced.**

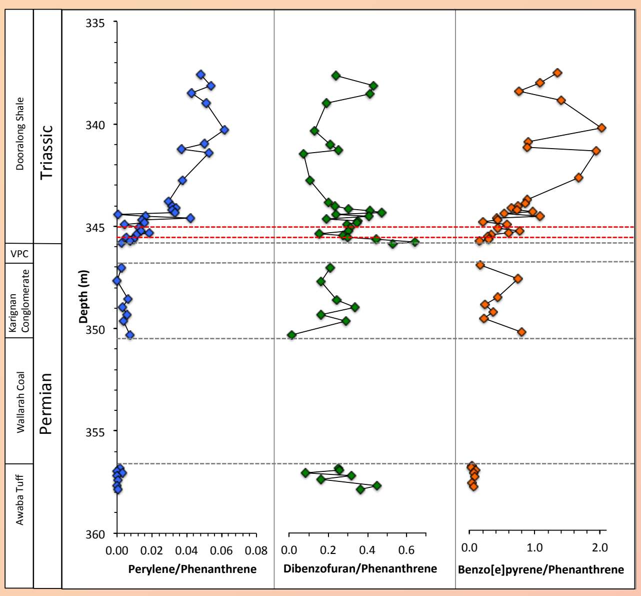

Fig. 6. Aromatic hydrocarbon variation through the Permian-Triassic in the WL2 core. The dashed red line marks possible location of the PTME as defined by carbon isotopes (Fig. 3).

Aromatic hydrocarbons

There is a large increase in the relative amounts of combustion-related PAH above the PETM, including benzo[ghi]perylene, indeno[1,2,3-cd]pyrene, coronene, benzopyrenes (Fig. 6), benzofluoranthenes, chrysene and triphenylene. This probably is due to the transport of debris from extensive forest fires into the depositional system. Perylene co-varies with these PAH, and likely reflects a "fungal spike", consistent with the hypothesised collapse of terrestrial vegetation, as has been noted in other marine PETM sections such as Meishan in China (Nabbefeld *et al.*, 2010). However, dibenzofuran does not show a similar spike above the PETM, so at this location may be controlled by inputs other than soil polysaccharides (Wang and Visscher, 2007).

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