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

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5The organic geochemistry in this paper 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). 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.

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 (Morant, 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., 2012). In this study samples from that core and a second location from the northern Sydney Basin (core WL2 from near Woyong: Figs. 1, 3) have been analysed organic geochemically in order to determine variations in source input and depositional environment that might be related to the PTME.

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 anoxicoxic 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 C21 tricyclic and C29 tetracyclic terpanes, typical of terrigenous settings, and in the Wombarra Claystone C21 tricyclic terpane, an algal biomarker, becomes dominant immediately after the isotope excursion (Fig. 4). Steranes are generally dominated by C29 homologues, but these are reduced relative to C28 steranes immediately after the PTME. In contrast, the WL2 section is characterised by higher relative amounts of the terrigenous pyrene, chrysene, phycenoanthracenes, and fluoranthene. This probably is due to the transport of debris from extensive forest fires into the depositional system. Pyrene co-varies with these PAH, and likely reflects a “fiangal spike”, consistent with the hypothesised collapse of terrestrial vegetation, as has been noted in other marine PTME sections such as Meishan in China (Nabielefeld et al., 2010). However, dibenzofuran does not show a similar spike above the PTME, so at this location may be controlled by inputs other than soil polysaccharides (Wang and Vischer, 2007).

 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 cytochiral 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 ratio and a lower content of methylophanes. This suggests that this fresh water, non-marine environment was shielded from the violent environmental perturbations that the oceans at the PTME experienced.

### References


### Variation of TOC and δ13C

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 0.8 m 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).

### Aromatic hydrocarbons

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