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Palynofacies changes and their reflection on preservation of peat accumulation stages in the Late Permian coal measures of the Bowen Basin, Australia: A new system for coal palynofacies characterisation

Nikola Van de Wetering [a,*], João Graciano Mendonça Filho [b], Joan Esterle [a]

[a] Department of Earth Sciences, The University of Queensland, Steele Building, St Lucia, Brisbane, Qld 4072, Australia

[b] Palynofacies and Organic Facies Laboratory (LAFO)/DEGL/IGEO/CCMN/UFRJ, Av. Athos da Silveira, 274, Prédio do CCMN, Sala JI-020, Cidade Universitária, CEP 21.941-916 Rio de Janeiro, RJ, Brazil

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ABSTRACT

A high-resolution study (n = 66) was conducted on Late Permian coal measures of the Bowen Basin, Australia, to observe palynofacies changes during peat accumulation over time. Palynofacies were determined using polytopic vector analysis (PVA) to derive end members with variable compositions that reflected fine scale environmental changes, within and between seams, of the Kaloola Member. Palynofacies reflect a three-stage succession within the palaeo- peat-forming environments from stable, anoxic conditions at the base, progressing to variable, oxic conditions toward the top of each seam. In cases where a seam was capped by tuff, rather than siliciclastic sediment, anoxic conditions similar to the bottom of each seam occurred. The results corroborate previous interpretations of palaeofloral communities and provide a new palynofacies model that integrates environmental progression within the coal seams in the Late Permian coal measures of the Bowen Basin. A complementary study of palynological assemblages recognised a shift from *Dulhuntyspora* sp., to *Protohaploxypinus* sp. in the lower Kaloola Member, indicating a change in pollen/spore source. Associations between dispersed palynomorphs and coal phyterals of parent flora remain tenuous beyond class rank, due to poor preservation and taxonomic bias inherent within the sample space. This is the first such palynofacies study to be conducted in the Bowen–Sydney–Gunnedah basin complex, thus opening the way for future work examining regional changes in palynofacies, expressed in both coal and siliciclastic sediments.

1. Introduction

Identification of changes in coal palynofacies gives an insight into shifting depositional and environmental regimes that occur in palaeo-peat-forming environments (Blandón and Gorin, 2012; Kumar et al., 2012; Sweet and Cameron, 1991). These depositional regimes are intrinsically linked to variables such as redox conditions, base level, salinity and pH (Jones, 1987; Tyson, 1995). Botanical communities in wetlands are also controlled by these environmental variables, which change in succession during the wetland's lifetime (Czerepko, 2008; Mitsch and Gosselink, 2007). These botanical changes are recorded in coal through preservation of identifiable plant matter as phyterals (Moore and Swanson, 1993; Van de Wetering et al., 2013), and expressed in palynological assemblages (Prevec et al., 2010; Rimmer et al., 2000). Thus, palynofacies can be used to interpret the environmental and depositional changes that control vegetational succession.

Currently, research into the application of recent palynofacies techniques in coal deposits is limited (Blandón and Gorin, 2012; Kumar et al., 2012; Mendonça Filho et al., 2012b). This study aims to use palynofacies as a proxy for fine-scale environmental change in coal by characterising relationships between phytoclasts, palynomorphs and amorphous organic matter (AOM). A series of coal seams were sampled from the Late Permian succession of the Bowen Basin, eastern Australia. Continuous coal samples were taken from these seams to gain a high-resolution perspective into changing depositional environments both within, and between seams. The Late Permian stratigraphy also represents a period of significant climatic and tectonic change for terrestrial ecosystems (Fielding et al., 2001; Retallack and Krull, 1999), both within the Bowen Basin and globally (Benton and Newell, 2012). This study is the first to investigate palynofacies changes in the Bowen–Gunnedah–Sydney basin complex, and opens up the potential for future comparative studies within eastern Australia.

In contrast to palynofacies research, numerous palynological studies for both biostratigraphic and botanical affinity have been conducted in the Bowen Basin (Balme and Hennelly, 1955; De Jersey, 1968; Foster, 1982). Foster (1982) was first to recognise a difference between the macrofossil and palynological record within the Bowen Basin, particularly when approaching the Permian–Triassic (P–T) boundary. Whilst the macrofossil record shows an abrupt change in composition at generic level, the palynological record shows a more gradual transition between the Permian and Triassic floras (Foster, 1982). The difficulty in coordinating macrofossil and microfossil records has

* Corresponding author. Tel.: +61 407773785.
E-mail address: n.vandewetering@uq.edu.au (N. Van de Wetering).

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significant implications when attempting to form an interpretation of palaeobotanical communities (Prevec et al., 2010; Traverse, 2007a).

Previous studies considered the direct comparison between the coal forming flora and palynofloral content of the coal to be unviable due to the differential preservation caused by diagenesis and compaction on peat during coalification (Winston, 1989). However, petrographic recognition of the original parent flora from phyterals allows improved comparisons to effectively record macrofossil and microfossil constituents of the coal (Lapo and Drozdova, 1989; Moore and Swanson, 1993; Van de Wetering et al., 2013). Using an integrated approach, this study aims to compare both stratigraphic changes in palynological assemblages, with previously identified coal flora from phyterals, and characterise changes in depositional environments recognised from palynofacies.

2. Geological setting and lithostratigraphy

The core sampled in this study intersects Permian to Triassic age strata in the Bowen Basin (Fig. 1). A 325 m thick succession of Permian strata, containing 24 individual coal seams, with a cumulative thickness of 24.6 m, was selected for sampling (Fig. 2).

The Bowen Basin incorporates ~10 km of Permian to Triassic strata deposited primarily in non-marine settings, including thick coal accumulations (Fielding et al., 1993; Veevers, 2006). Late Permian stratigraphy of the study site (from oldest to youngest) includes the Tinowon Formation, Black Alley Shale Formation, Kaloola Member (as part of the greater Baralaba Coal Measures Formation) and Bandanna Formation (Fielding et al., 2001). The Tinowon Formation and Black Alley Shale Formation were deposited in proximal, deltaic to lacustrine systems (Fielding et al., 2001; Veevers, 2006). The depositional environment later shifted into a fluvial setting, depositing the Kaloola Member and Bandanna Formation. During this period of sedimentation, deposition of tuff also occurred throughout the basin, associated with forearc volcanism and increasing atmospheric CO_2 (Grevenitz et al., 2003; Retallack and Krull, 2006). Significant changes in tectonic setting, driving changes in depositional environment preceded the extinction of the Permian peat-forming flora (Benton and Newell, 2012; Michaelsen, 2002). Prior to the P–T extinction event, the Permian flora was dominated by *Glossopteris*, which has an extensive fossil record within the Bowen Basin sediments and is also recognised as a major constituent of the coals (Anderson et al., 1989; Pigg and McLoughlin, 1997; Van de Wetering et al., 2013).

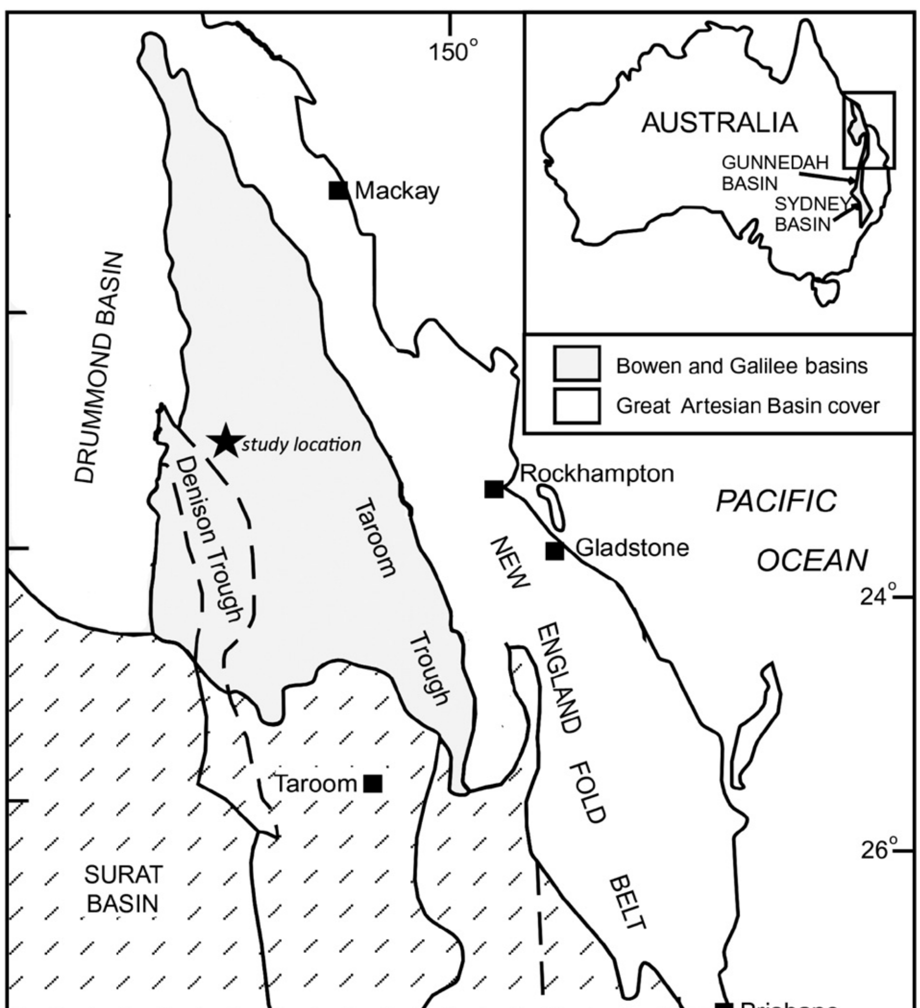

Fig. 1. Map of the Bowen–Gunnedah–Sydney Basin, showing major troughs and structural features, and overlying Surat and Clarence-Moreton basins (shown by dashed zones). Black star indicates the location of the core used for this study. Black squares indicate major regional towns or cities. After Uysal et al. (2011) and Van de Wetering et al. (2013).