International Journal of Coal Geology 138 (2015) 145–157

Contents lists available at ScienceDirect

International Journal of Coal Geology

journal homepage: www.elsevier.com/locate/ijcoalgeo

Paleoclimate reconstruction from petrography and biomarker geochemistry from Permian humic coals in Sydney Coal Basin (Australia)

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ARTICLE INFO

Article history:
Received 3 October 2014
Received in revised form 20 November 2014
Accepted 22 December 2014
Available online 9 January 2015

Keywords:
Molecular geochemistry
Petrography
Coal
Permian
Paleoclimate
Australia

ABSTRACT

The character of the coal in Tomago and Greta coal measures are similar to other coals from the Sydney Coal Basin, with variation from vitrinite-rich to inertinite-rich coal. A type III organic matter (OM) linked to continental higher plants and a perhydrous type III similar to type II were found by Rock-Eval analysis. The coexistence of inertinite with algae (*Botryococcus*) in the Greta coals explains the high HI in the perhydrous type. The *Gangamopteris* flora that is reported in the Greta coal measures, grew after plants in a taiga like the recent birch forests in Russia (Retallack, 1980). The *Glossopteris* flora that is reported in the Tomago coal measures, grew in a swamp forest. Based upon the botanic zonation, this flora was located in the cold temperate biome that was located in Gondwanaland, except for Antarctica which was in the glacial biome. Diterpane analysis results reveal alternation of wet and dry periods existed during the deposition of Lewis coals in the Greta coal measures during the Kungurian, and an increase of dryness is noted from Upper Donaldson to Beresfield in the Tomago coal measures during the Capitanian. Based on analysis of aromatics and diterpanes, the same periods of dryness and wetness alternate during the coal deposition in the Sydney Coal Basin. These climatic changes correspond to high frequency cycles (<100 ka, Goldhammer et al., 1994). The presence of aromatics linked with combustion in the studied samples confirms the hypothesis of fire in peat land to explain high inertinite content. A low to medium biodegradation by bacteria was observed for saturates and aromatics from the studied samples as noted previously in the Sydney and Bowen Basins. This biodegradation concerns short chain *n*-alkanes, naphtalenes and phenanthrenes and does not alter the paleoenvironmental and paleoclimatic interpretation. The comparison between biomarkers from coals and isotopes from marine (Birgenheier et al., 2010) and terrestrial (Retallack et al., 2011) deposits allow us to identify precise dry/wet climate and glacial/interglacial periods during the Permian.

1. Introduction

Integrated studies using organic petrography, geochemistry and isotopes data are rare in coal basins to reconstruct paleoenvironments and paleoclimates. Such integrated studies were done by Izart et al. (2006) from Donets Basin coals and Izart et al. (2012) from coal basins located in Europe under a tropical climate during the Carboniferous and Permian; by Bechtel et al. (2003, 2007, 2014) from Miocene lignites and coals (Austria and Turkey); by Costa da et al. (2014) from Permian Parana Basin coals (Brazil); by Strobl et al. (2014) from Eocene coals (China); by Grice et al. (2007) and Nabbefed et al. (2010a, 2010b) trough the Late Permian event in Australia, China, Greenland, West Canada and Spitsbergen. Recent papers published on isotopic data from the marine (Fielding et al., 2008a, 2008b; Birgenheier et al., 2010) and terrestrial (Retallack et al., 2011; Retallack, 2013) sedimentary rocks from the Sydney Basin allowed us to do an integrated study and propose a paleoclimatic interpretation from the Permian Sydney Basin coals. The Sydney Coal Basin located in eastern Australia (Fig. 1) is a structural depression of retroarc status located in eastern Australia between an older foreland to the West and the New England Fold Belt to the East (Diessel, 1992). The basement that consists of Early Paleozoic Fold Belt, is gently onlapped by Permian sedimentary rocks (Fig. 2). The Permian sequence is 4000 m thick in the East of the Hunter Valley and is 1000 m in the West. In the Hunter Valley, the lithostratigraphy begins by Late Carboniferous rocks, overlain by marine detrital rocks from Sakmarian, terrestrial sediments including coals (Greta coal measures) and then marine sediments from Artinskian and Kungurian, terrestrial sediments with coals and marine sediments (Lower Tomago, Upper Tomago) from Guadalupian and Newcastle coal measures from Lopingian times. After the dating of the Permian formations in Australia by Roberts et al. (1996) and in Russia where the marine stratotypes of Permian are defined (Foster et al., Menning, 1995; Menning and Hendrich, 2002), the Greta coal measures are

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http://dx.doi.org/10.1016/j.coal.2014.12.009
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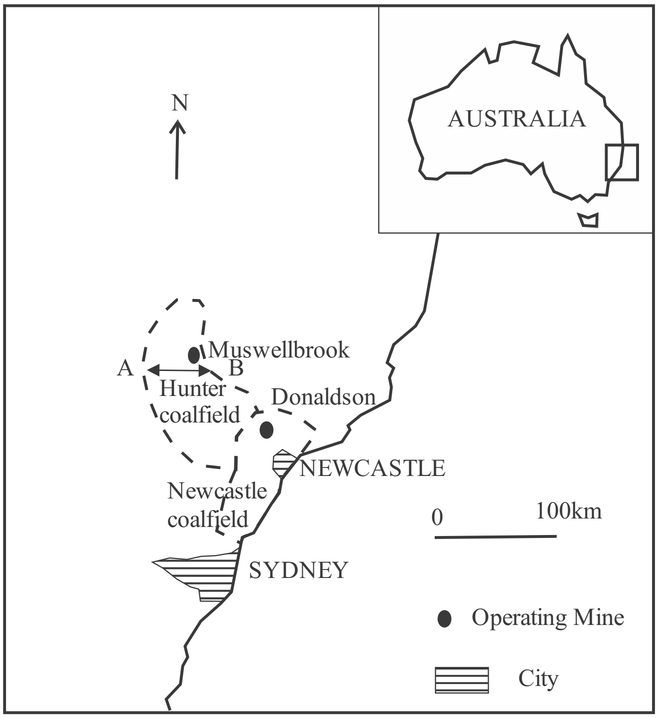

Fig. 1. Sketch map of the Newcastle and Hunter Coalfields (for sections A–B, see Fig. 2).

dated from 277 to 273 Ma, which corresponds to a Late Artinskian and Early Kungurian age (Early to Mid-Permian). These coals are correlated with the upper part of the marine Pebbley Beach Formation (Fielding et al., 2008a, 2008b), and the Tomago coal measures are dated from 262 to 252 Ma, which correspond to the Guadalupian (Wordian and Capitanian) and the Lopingian (Wuchiapingian, Late Permian). The studied Tomago coals are located in the Capitanian under the Wilton Formation and during the deposition of the Erins Vale Formation that are dropstone-bearing mudrocks described by Fielding et al. (2008a, 2008b). There are four glacial periods in Australia (Fig. 3) during the Carboniferous (C1–C4) and four during the Permian (P1–P4) after Fielding et al. (2008a, 2008b). Greta coals are located during the interglacial period between P2 and P3 and Tomago coals during the glacial period P4. The *Gangamopteris* and *Glossopteris* flora are known in Early and Mid-Permian and *Glossopteris* flora during the Late Permian (Retallack, 1980; Lindsay, 1997; Shi et al., 2010). These flora are family of gymnosperms. The *Gangamopteris* flora that is reported in the Greta coal measures, grew in a taiga, like the recent birch forests in Russia (Retallack, 1980). The taiga is a boreal forest composed of conifers and birchs in Russia and conifers in Canada. The *Glossopteris* flora is deciduous during the winter and presents seasonal growth rings. The *Glossopteris* flora that is reported in the Tomago coal measures, grew in a swamp forest (Retallack, 1980). *Glossopteris* was a tree with gymnospermous wood and roots with aerenchyma chambers adapted to waterlogged soil. After the botanic zonation of Ziegler (1990) and Ziegler et al. (1997), this flora was located in the cold temperate biome in Gondwanaland, except for Antarctica which was in the glacial biome. This flora grew at a latitude ranging from 50° to 70° S.

This study investigates the interaction between climate and organic matter (OM) in the Sydney Coal Basin located in eastern Australia in

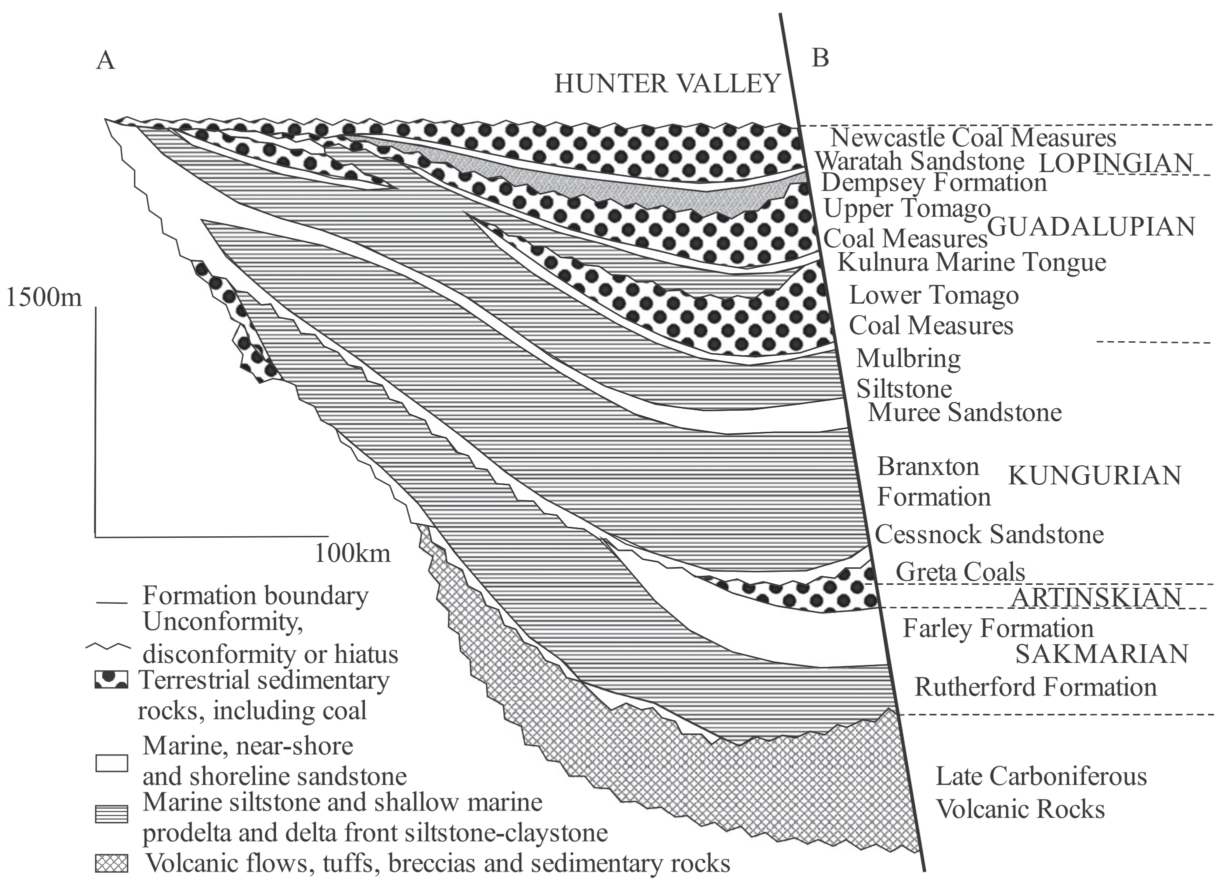

Fig. 2. Section across the Hunter Coalfield.
Modified after Diessel (1992).