Palaeogeography, Palaeoclimatology, Palaeoecology 386 (2013) 501–511

Contents lists available at SciVerse ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

High latitude Albian climate variability: Palynological evidence for long-term drying in a greenhouse world

Barbara E. Wagstaff [a,*], Stephen J. Gallagher [a], Martin S. Norvick [a], David J. Cantrill [b], Malcolm W. Wallace [a]

[a] School of Earth Sciences, The University of Melbourne, Victoria 3010, Australia
[b] National Herbarium of Victoria, Royal Botanic Gardens Melbourne, South Yarra, Victoria 3141, Australia

ARTICLE INFO

Article history:
Received 5 March 2013
Received in revised form 30 May 2013
Accepted 12 June 2013
Available online 22 June 2013

Keywords:
Albian
Palynology
Palaeoclimate
Gippsland Basin
Australia

ABSTRACT

Detailed "Quaternary-style" quantitative spore–pollen counts, with a pollen sum based on total non-angiosperm seed plants, from a southern high palaeolatitude (60–65°) terrestrial sequence in Gippsland, southeast Australia has revealed strong vegetation and climate variability during the Albian. This variability is more pronounced than previously suggested in global Early Cretaceous vegetation and climate reconstructions. The quantitative spore–pollen record shows drying throughout the Albian based on upward decreasing total ferns and variation in podocarp and total *Alisporites/Vitreisporites* pollen. This record suggests that although global climate during the Albian is considered to have been warm, stable and equable, regional factors such as water availability and continentality were the main drivers of this vegetation change.

1. Introduction

Presence–absence data and (semi-quantitative) acme spore–pollen zones are typically used to date Early Cretaceous strata in Australia (Helby et al., 1987). Reconstructions of past vegetation and climate in these basins using pollen and spore records are usually broad summaries of the difference between regions (on a basin scale) and over long periods (10s millions of years) (e.g. Dettmann, 1994). "Quaternary-style" palynomorph analyses to reconstruct climate history (Moore and Webb, 1983) of Cretaceous strata are rare (Wagstaff et al., 2006). In Australia, Burger (1974, 1980) used detailed quantitative palynomorph assemblage data (spores, pollen, dinoflagellates and acritarchs) to correlate Early Cretaceous strata in the Surat Basin (Fig. 1). Using these data, Burger (1980) reconstructed the palaeogeography of the region and classified some taxa into coastal (humid) and inland (dry) species and also interpreted a cool-temperate climate. Dettmann (1986) used quantitative data from six Aptian samples from the Leongatha borehole in the Gippsland Basin in southeast Australia (Fig. 1) to interpret a cool climate with high humidity and seasonality and the presence of a mosaic of plant community associations that were regionally distributed.

In this paper, we present the first detailed "Quaternary-style" palynomorph assemblage analyses of high palaeolatitude Albian terrestrial strata from the Gippsland Basin in southeast Australia (Fig. 1). These data reveal considerable climate variability at 60 to 65°S palaeolatitude reflecting a more dynamic Albian climate than previously interpreted (Clarke and Jenkyns, 1999).

2. Depositional setting

This study concentrates on two hydrocarbon exploration wells (Wombat-1 and Wombat-3) with strata of Albian age (the Strzelecki Group) in the Gippsland Basin, Victoria, Australia (Fig. 2). The Strzelecki Group was deposited as a series of fluvial systems in a high latitude rift valley between Australia and Antarctica (Wagstaff et al., 2012). In a gross sense wireline log data for the wells in this study showed that the sedimentary style was braided (low sinuosity) fluvial throughout the section examined. The source of the sediments and the direction of current flow in the Bass Strait basins has long been a matter for conjecture. The current consensus is that the rivers flow from the east (O'Sullivan et al., 2000) and that the volcanogenic sediments are sourced from contemporaneous volcanism (Duddy, 2003) from a volcanic arc along the eastern margin of the continent (Bryan et al., 1997) or from volcanic centres within the main rift (Duddy, 2003).

3. Albian vegetation of Victoria

Dettmann (1981) described the palynological record of the region as dominated by podocarpacean saccate grains, including those attributable to *Podocarpidites* spp. and *Microcachrydites antarcticus* with minor genera such as *Araucariacites*, *Classopollis* and *Cycadopites*. The Albian mega and microflora records show that the forests were dominated by podocarps and araucarians, with rare ginkgoes and the first angiosperms coinciding with the disappearance of bennettitaleans, taeniopterids and

* Corresponding author at: School of Earth Sciences, The University of Melbourne, Victoria 3100, Australia. Tel.: +61 3 8344 6537; fax: +61 3 8344 7761.
E-mail address: wagstaff@unimelb.edu.au (B.E. Wagstaff).

0031-0182/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.palaeo.2013.06.018

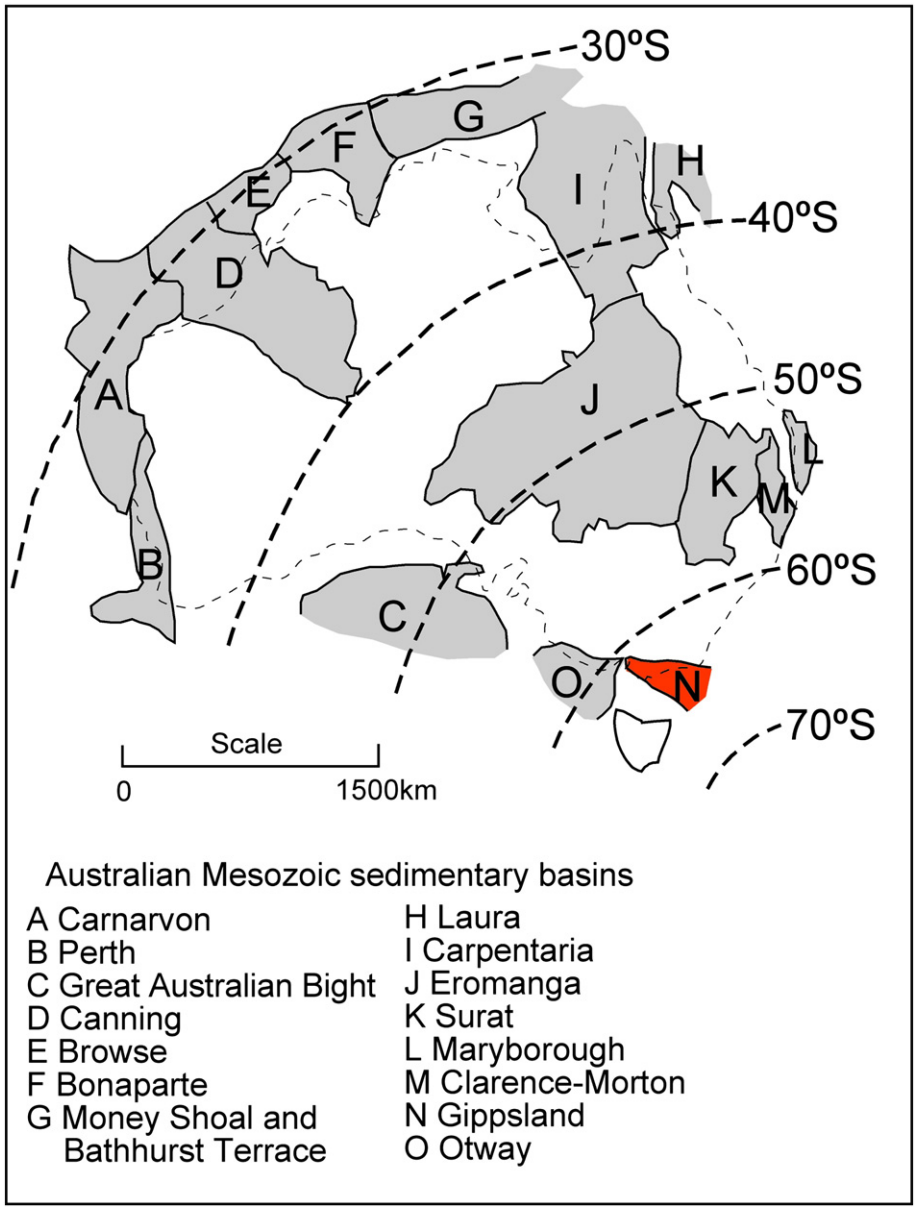

Fig. 1. Australian Mesozoic sedimentary basins.
Palaeolatitudes derived from Li and Powell (2001).

sphenopsids (Dettmann et al., 1992). In Australia these non-conifer seed plant groups are thought to have declined during the Albian as angiosperms increased (McLoughlin et al., 2010). In Victoria osmundaceous ferns were common in the understorey and in general fern communities were less diverse and lycopod spores were more common than in basins to the north (Dettmann et al., 1992). By the mid-Albian the angiosperm flora had a higher diversity (Dettmann, 1994) and included a wider range of pollen morphologies (when tricolpate and tricolporoidate types appeared and joined the taxa: *Clavatipollenites* and *Asteropollis*).

4. Palaeoenvironmental interpretation of spore–pollen records

The first assumption when making an interpretation of a spore–pollen diagram is that the pollen assemblage reflects the surrounding vegetation. The second assumption is that the vegetation reflects environmental conditions (Moore and Webb, 1983). There are many factors that can influence the presence of a particular plant in the landscape (e.g. soil, altitude). However, the overriding factor that controls regional vegetation is climate. To aid in the understanding of the methods used in this study, the basis for palaeoenvironmental analyses using spores and pollen is reviewed below.

There are two main ways that Quaternary pollen distribution is interpreted. (i) Pollen and spores can be used to reconstruct past vegetation and (ii) assemblages can be used to make ecologic interpretations of palaeovegetation in terms of past environments, in particular, climate (Macphail and McQueen, 1983). Assigning pollen or spores to a parent-plant is a key part of this interpretation (Faegri and Iverson, 1975; Moore and Webb, 1983) and is fairly straightforward in such "near modern" floral assemblages.

Distinguishing the source of the flora is essential in palaeoenvironmental interpretation. Two main source areas are:

- Regional: These are plants that define the vegetation of the region at any time and are controlled by climate. Regional pollen is sourced from more than several hundred metres from the site of deposition (Traverse, 1988).
- Local: These are plants growing on (e.g. a bog) or in (e.g. aquatic plants in a lake) or near (e.g. reeds around a lake) the site of