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Palaeoenvironments and palaeocommunities from Lower Cretaceous high-latitude sites, Otway Basin, southeastern Australia☆

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ABSTRACT

Lower Cretaceous (Barremian to Albian) fossil plant assemblages are preserved in sediments of the Otway Group, Otway Basin, and contemporaneous Strzelecki Group, Gippsland Basin, southeastern Australia. Detailed lithofacies and biofacies analyses of terrestrial strata within the upper Eumeralla Formation (Albian), Otway Group, allow fine-scale interpretation of braided fluvial and paludal depositional environments throughout the succession. The previously described flora is re-assessed in light of changes in depositional style and plant communities to describe six Albian biofacies. Forests in the highlands are dominated by Araucariaceae conifers, which turn over to Podocarpaceae and Cheirolepidiaceae forests on the dry, raised areas in the lowlands. Ferns and angiosperms inhabit the moist floodplains and water ferns and lycophytes dwell in the ox-bow lakes.

Significant changes occur between floral communities characteristic of riparian, levee and floodbasin settings through the Early Cretaceous. Albian floras are characterized by the dominance of broad-leafed araucarian conifers, an understory of diverse ferns and a dearth of seedferns and angiosperms. There is a notable absence of macrofossil ginkgoaleans in the Eumeralla Formation, although they reappear in younger (Turonian) deposits in southeastern Australia, but angiosperms are extremely scarce as macrofossils compared to the diversity recently recorded in the pollen record. Abundant charcoal demonstrates that fire continued to be a significant environmental factor at high latitudes during the middle to late Albian. The discovery of dinoflagellate species supports an earlier marine incursion and increased coastal environments, probably inhabited by cheirolepids, across the Otway Basin. Palaeontological, palynological and sedimentological data has provided a synthesis of the region's warm, high-latitude, palaeoclimatic setting in the Albian stage of the Early Cretaceous when compared to the cooler Barremian to Aptian.

1. Introduction

The Otway and Strzelecki groups within the Otway and Gippsland basins, respectively, in southeastern Australia (Figs. 1, 2), host some of the richest Early Cretaceous terrestrial ecosystems in Gondwana (McLoughlin et al., 2010). Forests flourished in Early Cretaceous high-latitude settings (68°–85°S; Norvick and Smith, 2001; 70°–75°S, Veevers, 2006) that were subject to polar climates, high in CO_2 (e.g., ~500–1100 ppmv at 140 Ma, by Franks et al., 2014, using a combination of geochemical and palaeobotanical data) under greenhouse conditions. The floras were adapted to warm, humid conditions, with low-angled light during much of the year and were able to survive winter twilight or darkness (Read and Francis, 1992).

Floral assemblages from the Otway Group are typical of Gondwanan Early Cretaceous floras (Douglas, 1969, 1973; Drinnan and Chambers, 1986; McLoughlin et al., 2002). They record one of the oldest macrofloral angiosperms in Gondwana (Taylor and Hickey, 1990), but are dominated by conifers (Cantrill, 1991, 1992; Tosolini et al., 2015) and are rich in lycophytes and ferns (Douglas, 1973; Tosolini et al., 2002; Nagalingum et al., 2002; Nagalingum, 2007). This contrasts with more northerly floras such as the Albian-Cenomanian Winton Formation that contain Ginkgoales, Bennettitales and a greater diversity of angiosperms (McLoughlin et al., 1995; Pole and Douglas, 1999b; McLoughlin et al., 2010) or the Cenomanian Clarence River assemblage from New Zealand, situated at 80° latitude, that contain Bennettitales and angiosperms (Parrish et al., 1998).

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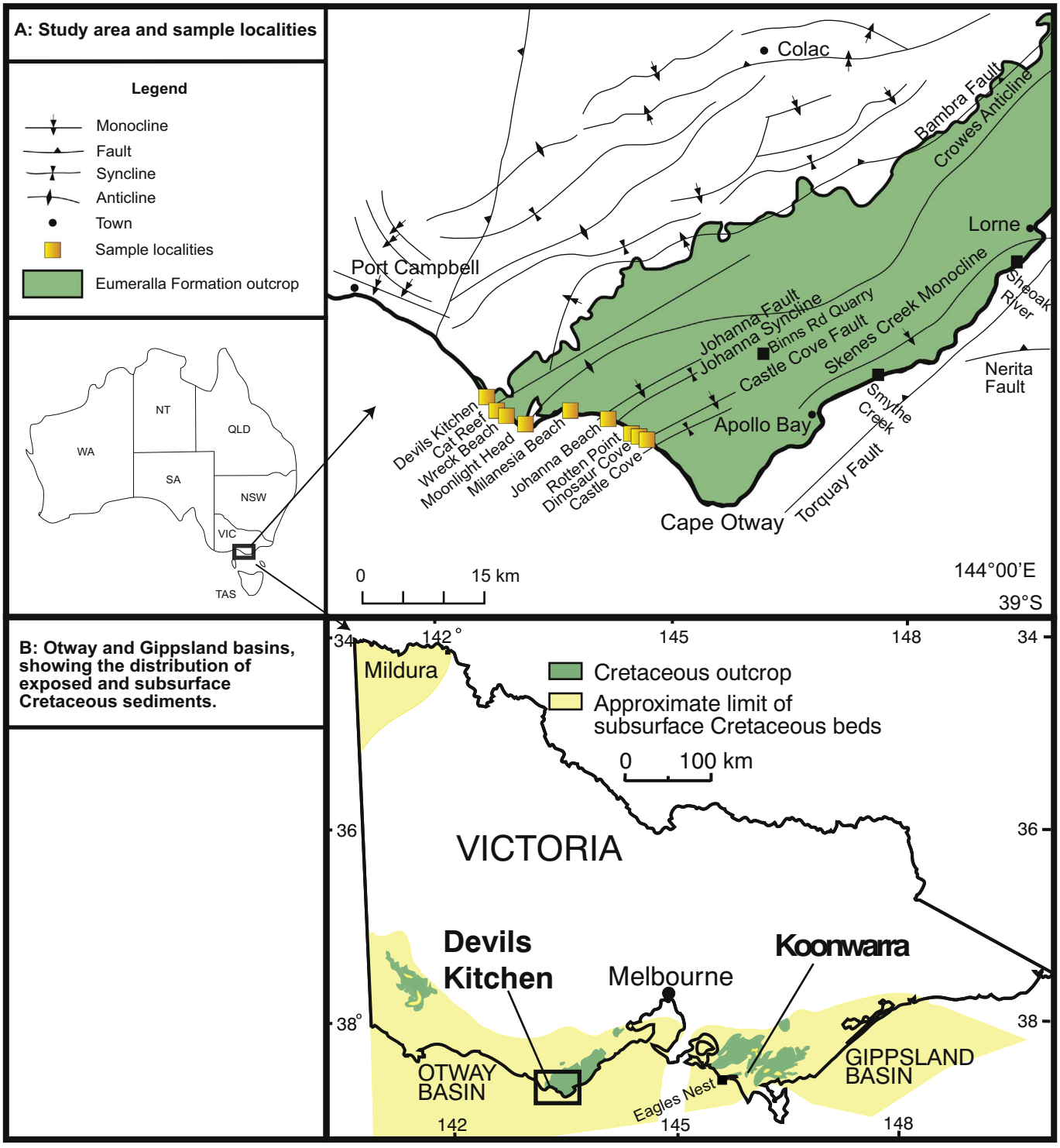

Fig. 1. Map of Southeast Australia where this study was undertaken. A: Study area, Albian sample localities (orange squares to west of Cape Otway) examined in this study and structural features of the Port Campbell to Lorne area, Otway Basin, southeastern Australia (after Korasidis et al., 2016). Younging direction is from east to west, but is often disrupted by faults. Aptian localities mentioned in Fig. S.3 (black squares to east of Cape Otway). B: Otway and Gippsland basins showing the distribution of exposed and subsurface Cretaceous sediments, with the Eumeralla Formation (Otway Group), Otway Basin and Strzelecki Group, Gippsland Basin (after Tosolini et al., 1999). GPS readings were taken in 2011 and 2014 at previously collected old sites: Dinosaur Cove (Lat. −38.4648; Long. 143.2418), Rotten Point (Lat. −38.781111; Long. 143.4), Johanna Beach (Lat. −38.765833 to −38.75; Long. 143.35 to 143.428889) and Cat Reef (Lat. −38.743333, Long. 143.215); and new sites: Castle Cove (CC, Lat. −38.782222, Long. 143.425 to 143.427222), Moonlight Head (MH, Lat. −38.4501 to −38.4451, Long. 143.1212 to 143.1234), Wreck Beach (WB, Lat. −38.755833 to −38.750833, Long. 143.207222 to 143.213889) and Devils Kitchen (DK, Lat. −38.7426833, Long. 143.197). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Palynological (Dettmann, 1986; Wagstaff and McEwen Mason, 1989; Wagstaff et al., 2012, 2013; Korasidis et al., 2016) and mesofossil assemblages (McLoughlin et al., 2002; Tosolini et al., 2002; Tosolini et al., 2015) highlight the rapid and relatively abrupt transition from gymnosperm-dominated floras in the Barremian to Aptian of the Otway and Gippsland basins to angiosperm-dominated floras in the Albian, occurring within the *Phimopollenites pannosus* Zone (Korasidis et al., 2016), of the Otway Basin. Recent significant findings from