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Cretaceous faunas and events, northern Eromanga Basin, Queensland

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The stratigraphy, sedimentary history and paleontology of the northern Eromanga Basin are reviewed in the light of extensive field effort, searching for Cretaceous vertebrate fossils, in particular dinosaurs. Prolonged non-marine deposition throughout the Jurassic was followed by Lower Cretaceous marine incursions which extended to the late Albian. Whilst biostratigraphy is underpinned by microfloral assemblages there are three distinct marine faunas preserved from the late Aptian, early middle Albian and late Albian. Effective regression caused by sediment oversupply in the latest Albian heralded the final phase of non-marine deposition in the Eromanga Basin which continued into the Cenomanian. A distinct floral assemblage is accompanied by a modest fossil vertebrate assemblage.

Introduction

The Eromanga Basin is a large, continental basin which, with the interconnected Surat Basin in the southeast, and Carpentaria Basin to the north, forms the Great Australian Basin (GAB) that further connects with the Laura Basin in the northeast and the Clarence-Moreton, Nambour and Maryborough basins in the southeast to form the Great Australian Superbasin and dominate the continental geology of northeastern Australia (Figure 1). Each basin of the GAB contains a near flat-lying Jurassic to Cretaceous sequence which records basin subsidence and the varying roles of sea-level change and sediment supply throughout the GAB's history. Geological summaries are available for the Carpentaria Basin (McConachie et al., 1997), the Surat Basin (Green 1997), the southern and central Eromanga Basin (Gray et al. 2002) and the northern Eromanga Basin (Green et al. 1992).

The Eromanga Basin extends from South Australia and New South Wales into northern Queensland. It is separated from the Carpentaria Basin by the Euroka Arch, a basement high with structural drape, and by a similar feature, the Nebine Ridge, from the Surat Basin. The northern Eromanga Basin overlies the late Paleozoic Galilee Basin, and Paleozoic basement, and onlaps Proterozoic provinces to the north and northwest.

Lithostratigraphy of the Eromanga Basin has been elucidated by regional mapping and by water and petroleum exploration wells. In the north of the basin, these wells are less common, but

have been supplemented by government sponsored stratigraphic wells.

The stratigraphy for the northern Eromanga is summarised in Figure 2. Identified depositional phases include Early Jurassic dominantly coarse-grained fluvial deposition, followed by more subdued Mid-Upper Jurassic–Lower Cretaceous fluvio-lacustrine sedimentation. In the Lower Cretaceous a succession of marine transgressions and regressions resulted in a series of shallow marine, varying fossiliferous deposits, the youngest of which is late Albian. Concomitant volcanism to the east which had been active since the Jurassic was more prevalent in the Lower Cretaceous, and was dominated by the Whitsunday Island Volcanic Province (Bryan et

Figure 1 The Great Australian Basin in northeastern Australia.

Figure 2 Stratigraphy of the northern Eromanga Basin modified after Green et al. (1992) and Gray et al. (2002).

al., 2000), situated near the east coast. Volcanogenic sediment oversupply peaked in the late Albian to Cenomanian, to the extent that it caused effective regression with nonmarine deposition. The globally recognised Cenomanian sea level rise did not manifest within the Great Australian Basin. Non-marine sedimentation ceased in the Upper Cretaceous, and was followed by three cycles of deep weathering and erosion which extended until at least the Miocene, with accompanying tectonic flexure along pre-existing structures.

Principal stratigraphic divisions

Jurassic stratigraphy in the northern Eromanga Basin comprises a basal Jurassic coarse fluvial unit, now referred to the Poolowanna Formation. This is overlain by the extensive coarse-grained fluvial, Hutton Sandstone and subsequent Birkhead Formation which was deposited in fluvio-lacustrine settings with strong supply of volcanogenic detritus from the east. The Adori Sandstone overlies this and represents braided fluvial systems. The fluvio-lacustrine Westbourne Formation, and overlying fluvial Hooray Sandstone are overlain by the Cadna-owie Formation which represents transition to marginal marine conditions during Valanginian–Barremian transgression. Rapid continued transgression in the Aptian resulted in deposition of the Doncaster Member of the Wallumbilla Formation, a widespread unit which represents maximum flooding of the continent. Effective but subdued regression-transgression in the early middle Albian is represented by deposition of the Ranmoor Member of the Wallumbilla Formation. Transgression renewed rapidly in the late Albian with deposition of the Toolebuc Formation, representing maximum flooding within a partly anoxic restricted basin, resulting in a mixed limestone-oil shale unit which is isochronous across the basin. The unit correlates with the global Oceanic anoxic event (OAE) 1c. Renewal of sediment supply from the east prompted deposition of the Allaru Mudstone and overlying Mackunda Formation which are late Albian regressive units. Sediment supply exceeded subsidence choking the basin during this time, and this continued into the Cenomanian, which is represented by an entirely non-marine sedimentary package.

Biostratigraphy within the basin is primarily controlled by rich palynofloras (Dettmann and Playford 1969; Price 1997), but also by ammonites, foraminifera and locally recognised molluscan assemblages (Day, 1969).

Palynomorph stratigraphy developed for continental Australia has been summarised for the southern Eromanga and Surat basins by Price (1997), and Draper (2002). Marine and marginal marine units span Australian Palynological units APK2.1 to APK6, with the upper nonmarine Winton Formation belonging within APK7 (Figure 2). Dinocyst zones of Helby et al. (1987) indicate the Cadna-owie Formation extending to include an unnamed zone, and the basal *O. operculata* zone, with the youngest marine units in the *P. ludbrookiae* zone (see Branagan (2012) for more on Nell Ludbrook). Price (1997) replaced zones with dinocyst units, the upper Cadna-owie in ADK17, and the Mackunda Formation within ADK22. Foraminifera have been evaluated in some units (Haig, 1979; Haig and Lynch, 1993) and some investigations of nannofossils have been undertaken by Shafik (1985). The relation of palynology to local and global cyclicity has been addressed by Burger (1986), who could not identify all Jurassic global cycles within the Eromanga and Surat basins.

Fossil Assemblages

Three principal marine fossil assemblages and an upper non-marine fossil faunal assemblage within the northern Eromanga Basin correspond to the late Aptian, early middle Albian, late Albian and late Albian to Cenomanian, respectively.

Late Aptian assemblage

The Late Aptian marine incursion that brought maximum flooding of the continent, is represented by the Doncaster Member of the Wallumbilla Formation across the GAB, with equivalents in the Laura Basin. The diverse and distinctive fauna of the Doncaster Member that was locally named the Roma Fauna (Whitehouse, 1926) contains ammonites (Etheridge, 1880, 1892, 1909; Whitehouse, 1926; Day, 1974), predominantly heteromorphs including *Tropaeum*,

Figure 3 Typical Late Aptian assemblage of macrofossils from the Doncaster Member, Wallumbilla Formation. (A). *Tropaeum undatum*; (B). *Australiceras irregulare*; (C). *Tonohamites taylori*; (D). *Aconeceras* sp.; (E). *Sanmartinoceras olene*; (F). *Australiceras jacki*; (G). *Fissilunula clarkei*; (H). *Eyrena palmerensis*; (I). *Maccoyella barkleyi*; (J). *Pseudavicula anomala*; (K). *Pinna* sp. (Scale bar = 2cm).

Australiceras, *Tonohamites*, *Toxoceratoides*, *Sanmartinoceras* and *Aconeceras*. The more than 30 species of bivalves include locally stratigraphically important *Maccoyella barkleyi*, *Fissilunula clarkei*, *Pseudavicula anomala* and *Eyrena palmerensis*. In addition *Panopaea*, *Pinna*, scaphopods, the crinoid *Isocrinus australis* and gastropods are locally abundant. *Purisiphonia clarkei* is the only known sponge (Jell et al., 2011). *Kronosaurus queenslandicus*,

undescribed plesiosaurs and rare ichthyosaurs are known from the unit. In the northern Eromanga Basin algal build-ups resembling stromatolites form elongate ridges of tens of metres scale, or isolated domal, conical and lamellar forms. Commonly, build-ups are found around large marine reptile specimens. This is surprising given the high latitude position of the basin during the late Aptian, glendonites and dropstones elsewhere in the basin during this time.

Early Middle Albian assemblage

The macrofaunas of the Ranmoor Member are depauperate, reflecting its subdued outcrop patterns. Fauna recovered from the Ranmoor Member includes the ammonites *Beudanticeras flindersi*, *Falciferella* sp. and several undescribed species. Bivalves such as *Aucellina* and *Inoceramus* are in smaller numbers than in the overlying Toolebuc Formation.

Late Albian assemblages (Figure 4)

The Toolebuc Formation, Allaru Mudstone and overlying Mackunda Formation have similar, but not identical faunas, which include vertebrates, ammonites, bivalves and other molluscs. The Toolebuc Formation is dominated by a restricted benthic assemblage

of *Inoceramus sutherlandi* and *Aucellina hughendensis*, but a diverse nektonic assemblage of fishes, marine reptiles and molluscs, including large ichthyosaur skeletons (Wade, 1990) of *Platypterygius australis*, the pliosaur *Kronosaurus queenslandicus*, elasmosaurs and at least one species of polycotyloid, three turtles, being the giant *Cratochelone*, known from a single specimen, the common *Notochelone* and *Bouliachelys* Kear and Lee (2006). Abundant fish fossils include amiids, aspidorhynchids, chimaeroids, lamnids, dipnoans, (Lees, 1986, 1990, Lees and Bartholomai, 1987, Bartholomai, 1969, 2004, 2008). Ammonites include *Beudanticeras flindersi*, *Myloceras* spp., *Labeceras* spp., *Idanoceras*, and possibly *Worthoceras* with the nautiloid *Eutrephoceras hendersoni* also common. The teuthids *Trachyteuthis willisi*, *Meunsterella tonii* and *Boreopeltis soniae* were described from the Toolebuc Formation and overlying basal Allaru Mudstone (Wade, 1993). Abundant belemnites have received scant

Figure 4 Typical Late Albian assemblage of macrofossils from the northern Eromanga Basin. (A) *Beudanticeras flindersi*; (B) *Goodhallites goodhalli*; (C) *Eutrephoceras hendersoni*; (D) *Myloceras ammonoides*; (E) *Myloceras intermedium*; (F) *Myloceras auritulum*; (G) *Labeceras compressum*; (H) *Homolopsis etheridgei* (Scale bar = 2cm).

Figure 5 Winton Formation floral assemblage and dinosaurs. (A) *Araucaria* cf. *A. mesozoica*; (B) *Araucaria* cf. *A. mesozoica*; (C) *Cladophlebis* sp.; (D) *Phyllopteroides mcllymontae*; (E) *Conifer* foliage; (F) Male sporangiate cone; (G) Angiosperm leaf; (H) Small cones cf. *Austrosequioa wintonensis*; (I) *Diamantinasaurus matildae*; (J) *Australovenator wintonensis*; (K) *Wintonotitan wattsi* (Dinosaur silhouettes after Hocknull et al. (2009)).

attention. Terrestrial and associated faunal elements have also been recovered from the Toolebuc Formation including the dinosaurs *Minmi* sp., and *Muttaburrasaurus langdoni*, a small number of pterosaur elements, the bird *Nanatius eos* and sauropod bones.

The Allaru Mudstone has yielded common ammonites, *Beudanticeras*, *Myloceras* spp. and *Labeceras* spp. with lesser *Idanoceras* (Henderson and McKenzie, 2002), and *Goodhallites goodhalli* (Henderson and Kennedy, 2002), and a small fauna of undescribed micromorphs. Bivalve diversity is still low in the unit with *Inoceramus* dominant, alongside *Aucellina*. Crustacea are locally abundant. Rare ophiuroids and monasterid seastars are known. A single

faviid coral recovered from the unit (Jell et al., 2011) attests to relatively warm conditions during deposition even at mid-high latitudes. There is some disparity between faunas in the lower parts of the unit compared to the upper, supported by seismic evidence of a break in the lower Allaru Mudstone, but this faunal disparity has yet to be investigated fully.

The Mackunda Formation is the uppermost marine unit and has a diverse benthic and nektonic fauna. Benthic elements include bivalves with the ubiquitous *Inoceramus* and *Aucellina* accompanying *Maccoyella rookwoodensis*, *Panopaea*, *Acesta*, *Tatella*, and solemyiids among other taxa. Belemnites are abundant, but ammonites

are much less common. Small naticiid and higher spired gastropods are common in some of the shell beds which are common in the formation. Teleosts are less common, but shark's teeth are abundant.

Winton terrestrial assemblage

The Winton Formation contains a diverse and abundant fossil macroflora (Peters and Christophel, 1978; Dettmann et al., 1992, 2009; McLoughlin et al., 1995; Pole and Douglas, 1999; Pole, 2000a, b; McLoughlin et al., 2010; Dettmann and Clifford, 2000; Clifford and Dettmann, 2005) including conifers, ferns, cycadophytes, angiosperms and ginkgos. Undescribed insects are known in collections. A modest dinosaur fauna (Figure 5); Coombs and Molnar, 1981; Hocknull et al., 2009) includes the genera *Australovenator*, *Wintonotitan*, and *Diamantinasaurus*. *Australovenator* is a medium-sized allosauroid, neovenatorid taxon, whilst *Diamantinasaurus* is a lithostrotian titanosaurian and *Wintonotitan* a titanosauriform. More discoveries of dinosaurian material in 2010 and 2011 extend the diversity. Other elements include crocodylians (Salisbury et al., 2006), fishes, lungfish (Kemp, 1991), a dolichosaur, turtles, and pterosaur remains. Of outstanding importance is the dinosaurian ichnofauna which is exemplified by the Dinosaur Stampede National Monument, Lark Quarry (Thulborn and Wade, 1979, 1984). The dinosaurian and marine reptile finds support an economically important tourism industry in the northern Eromanga Basin.

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