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**Palaeoichnology of the terminal Proterozoic-Early
Cambrian transition in central Australia:
interregional correlation and palaeoecology**

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Abstract

The Precambrian-Cambrian time interval in central Australia is well represented by successions of siliciclastic sediments cropping out along the northern margin of the Amadeus Basin and southwestern part of the Georgina Basin. These strata were deposited in a shallow water environment as a part of large delta system. In the Amadeus Basin, these clastic successions occur between two carbonate intervals (Julie Formation below and Todd River Dolomite and its equivalent calcareous deposition above) and are known as Arumbera Sandstone (Wells *et al.*, 1967). In its lower part, this unit includes a few simple, horizontal trace fossils such as *Cochlichnus*, *Intrites*, *Palaeophycus*, and *Planolites* along with rare occurrences of Ediacaran body fossil remains. In contrast, the lithologically similar upper part, generally considered of Early Cambrian age, yields abundant occurrences of complex and diverse trace fossils.

A substantial collection of trace fossil in the Department of Geology and Geophysics collected from the above succession provided a unique opportunity to establish the bed by bed distribution of trace fossils through the Precambrian-Cambrian transition. The significance of trace fossils in the biostratigraphy of this interval of time was emphasised when the Precambrian-Cambrian Working Group (PCCWG) decided that the first appearance of *Treptichnus pedum* indicated the base of the Cambrian System in the Global Stratotype Section and Point (GSSP) of the Precambrian-Cambrian, Newfoundland Canada. This study has resulted in the identification of about 45 ichnogenera comprising 70 ichnospecies. Several new ichnotaxa have been described for the first time from central Australia (e.g. *Asaphoidichnus ?trifidum*, *Asteriacites* isp., *Phycodes coronatum*, *?Hormosiroidea pollardi*, *Planolites bulbus*, and *Planolites ferrovittatus*). *Hormosiroidea arumbera*, *Plagiogmus arcuatus* and *Taphrhelminthoida convoluta* were analysed morphologically resulting in the recognition of new structural elements. Several changes regarding classification of some ichnogenera such as *Hormosiroidea*, *Phycodes*, *Plagiogmus*, and *Saerichnites* are proposed.

A new stratigraphic division is proposed for the Precambrian-Cambrian interval in the Amadeus Basin. Following Daily (1976), the Arumbera Sandstone *sensu lato*, is divided into three units comprising the Arumbera, Box Hole and Allua Formations from older to younger respectively. It is suggested that the name Arumbera Sandstone *sensu lato* to be discarded to avoid any further confusion. The Arumbera Formation (restricted) embraces Units I and II, and in some localities the lower part of Unit III of Wells *et al.* (1967). The Box Hole Formation is considered to be an equivalent of the upper part of Unit III and the Allua Formation comprises Unit IV of Wells *et al.* (1967). A regional, diachronous erosional surface separates the Box Hole Formation and the underlying Arumbera formation in all studied sections. A granular band occurring at the base of the Allua Formation in the Ross River area probably indicates another erosional surface at the base of that formation. However, the lateral extent of this surface is not established.

Three ichnozones are recognised based on the distribution of trace fossils in the studied sections: Ichnozone I contains simple horizontal burrows reported from the Arumbera Formation including *Bilinichnus*, ?*Helminthoidea*, *Intrites*, *Palaeophycus*, and *Planolites*. This ichnozone is correlated with the *Harlaniella podolica* Zone of Narbonne *et al.* (1987) reported from Newfoundland. Ichnozone II comprises some complex trace fossils which commonly occur throughout the Phanerozoic including *Arenicolites*, *Curvolithus*, *Diplichnites*, *Didymaulichnus*, *Glockerichnus*, *Gyrolithes*, *Hormosiroidea*, *Laevicyclus*, *Monocraterion*, *Phycodes*, *Protopaleodictyon*, *Psammichnites*, *Rusophycus*, *Saerichnites*, *Skolithos*, and *Treptichnus*. Contrary to the situation in the Newfoundland sections, the ichnospecies *Rusophycus avalonensis* first occurs with or prior to the ichnospecies *T. pedum* in the studied sections from central Australia. Ichnozone III occurs in the Allua Formation and comprises *Asteriacites* isp., *Palaeophycus canalis*, *Palaeophycus ferrovittatus*, *Plagiogmus arcuatus*, *Rusophycus bonnarensis*, *Skolithos ramosus*, and *Taphrhelminthopsis circularis*, among which *P. arcuatus* and *T. circularis* have apparently a restricted stratigraphic range. Ichnozones II and III are correlated with the *Rusophycus avalonensis* Zone of Narbonne *et al.* (1987). It is concluded that the *Treptichnus pedum* Zone of Narbonne *et al.* (1987) is absent from the studied sections probably indicating a major hiatus prior to deposition of the Box Hole Formation.

Ichnozone I is correlated with Zone 1B of Crimes (1994) which is attributed to the post-Ediacaran pre-Cambrian and considered to be latest Vendian in age. The trace fossil *Intrites*

reported from the Arumbera Formation (McIlroy *et al.*, 1997) is apparently restricted to this Ichnozone. Ichnozones II and III are considered to be equivalent to Zone III of Crimes (1994). *Taphrhelminthopsis circularis* and *Plagiogmus arcuatus*, apparently restricted to Crimes' Zone III, are common in the studied sections from central Australia. The occurrence of *?Vendichnus* in association with other trace fossils of Cambrian aspect is significant. This ichnogenus is reported to be restricted to Zone IB of Crimes (1994) and if the identification proves true, will extend its stratigraphic range upto Zone III.

The correlation of the Box Hole and Allua Formations with the *R. avalonensis* zone indicates a middle Tommotian to Atdabanian age. However, there is no definite information as to how much of the lower portion of this zone is missing because of the erosional surface at the base of the Box Hole Formation. The appearance of *R. avalonensis* before *T. circularis* which is in contradiction to their order of appearance in the Newfoundland stratotype, is likely due to this hiatus. It is considered that the Box Hole Formation is late Tommotian.

The occurrence of Ichnozone III in the Allua Formation with its diagnostic trace fossils, *R. bonnarensis* and *P. arcuatus* correlates with the upper part of the *R. avalonensis* zone (with the exception of *T. circularis*), indicating an atdabanian age for the Allua Formation.

The correlation between the Precambrian-Cambrian successions of central and South Australia reveals that the trace fossil assemblage within the lower Uratanna Formation, Flinders Ranges (Gauld, 1976) contains *Cochlichnus*, *Curvolithus*, *Planolites*, and *Skolithos* and can be correlated with Ichnozone I. This may also be correlative with the lower part of Ichnozone II for which the basal extent is not clear in the studied sections from central Australia due to the regional erosional surface at the base of the Box Hole Formation.

The middle and upper part of the Uratanna Formation contains *Cochlichnus*, *Curvolithus*, *Didymaulichnus*, *Monocraterion*, *Neonereites*, *?Palaeophycus*, *Planolites*, *Rusophycus avalonensis*, *Skolithos*, *Treptichnus* isp., and *Treptichnus pedum* as documented by Gauld, (1976). This trace fossil assemblage is considered to be correlative with Ichnozone II in central Australia.

As recorded by Glaessner (1969), Daily (1972, 1973), and Gauld (1976), the overlying Parachilna Formation yields *Diplocraterion parallelum*, *Palaeophycus* isp., *Phycodes* isp., *Rusophycus bonnarensis*, *Plagiogmus arcuatus*, *Phycodes palmatus*, and *Treptichnus pedum*

and is correlated with the Ichnozone III in central Australia. Accordingly, the Uratanna Formation may be correlated with the upper part of the Arumbera Formation (restricted). However, the lower part of the Uratanna Formation evidently postdates the Ediacaran soft-bodied fauna reported from the Arumbera Formation. The middle and upper parts of the Uratanna Formation are correlated with the Box Hole Formation. The succeeding Parachilna Formation containing the diagnostic trace fossil, *Plagiogmus arcuatus* is considered correlative with the Allua Formation. *P. arcuatus* is restricted to Zone III of Crimes (1994) which implies an Atdabanian age for the formation.

Analysis of distribution of trace fossils in the studied sections indicates the presence of the *Cruziana* ichnofacies in alternating fine- to medium-grained sandstone and siltstone dominated by horizontal burrows such as *Palaeophycus* and *Planolites*. The *Skolithos* ichnofacies occurs in medium to coarse grained, medium to thick bedded sandstone layers with dominant *Skolithos* and *Arenicolites* burrows.