AUSTRALIA

Report 276

Review of the Cambrian and Ordovician palaeontology of the Amadeus Basin, central Australia

J. H. Shergold

Bureau of Mineral Resources, Geology & Geophysics

Department of Resources and Energy

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REVIEW OF THE CAMBRIAN AND ORDOVICIAN PALAEONTOLOGY OF THE AMADEUS BASIN, CENTRAL AUSTRALIA

by

J.H. Shergold

Division of Continental Geology

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE

CANBERRA 1986

DEPARTMENT OF RESOURCES AND ENERGY
Minister: Senator the Hon. Gareth Evans, QC
Secretary: G.C. Evans

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
Director: R.W.R. Rutland

Published for the Bureau of Mineral Resources, Geology and Geophysics by the Australian Government Publishing Service

This Report was edited by G.M. Bladon

ISSN 0084-7100
ISBN 0 644 05542 1

Printed by Graphic Services, South Australia.

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ABSTRACT

This Report presents a summary review, with commentary, of what is currently known about the status of Cambrian and Ordovician palaeontological research in the Amadeus Basin. An historical precis of the development of this knowledge is presented, together with brief reviews of all Cambrian and Ordovician formations. Biochronologically dated geological events relevant to the early Palaeozoic history of the Amadeus Basin are documented on the basis of information generated from within the basin, or predicted from better known regions elsewhere. This compilation is intended both as a source of existing information, and as a catalyst for further ideas on the relationships of the Amadeus Basin to other early Palaeozoic basins in central and northern Australia, and their evolution.

INTRODUCTION

The first documented fossils from the Amadeus Basin were found near Tempe Downs by H.Y.L. Brown and F. Thornton in September 1890, and reported by Tate (1891) and Brown (1891). These, and subsequently discovered trilobites, molluscs, and brachiopods from the Horn Valley Siltstone, Stairway Sandstone, and Stokes Siltstone (Fig. 1), were described in a series of papers by Etheridge (1891a, 1891b, 1892, 1893, 1894). Possible sponges were collected from the Stairway Sandstone by Howchin (1893), but never described. Many more fossils were collected during the Horn Expedition of 1894 (Tate & Watt, 1896, 1897), from the same formations, and these were described by Tate (1896).

Relatively little palaeontological research was undertaken in the basin thereafter until the late 1960s. What was done, however, included pioneering investigations on nautiloid cephalopods, described by Teichert (1939), Teichert & Glenister (1952, 1954), and Flower & Teichert (1957); and equally pioneering work by Crespin (1943) which recorded the first conodonts in Australia. Additionally, Crockford (1943) described bryozoans. As with the earlier faunas described by Etheridge and Tate, all of this material was obtained from Ordovician formations of the Larapinta Group.

The first proven Cambrian body fossils (archaeocyathans and hyoliths) were not reported until 1932 (Madigan, 1932a), and none was systematically described until 1967, when Öpik (1967b) described the trilobite Onaraspis. Mawson & Madigan (1930) had previously reported on and illustrated Cambrian algae, and reassigned to the Late Proterozoic the 'Cryptozoön' that Howchin (1914) had presumed to be of Cambrian age.

The period between 1896 and 1967 was one of continuous and expanding geological exploration, and it was during this time that a basis for the lithostratigraphic framework of the Amadeus Basin was laid down by Chewings (1914, 1928, 1931, 1935), Mawson & Madigan (1930), Madigan (1932a, 1932b, 1933, 1938, 1944), Voisey (1939a, 1939b), and Hossfeld (1954); and officers of the Bureau of Mineral Resources, who commenced mapping the margins of the Amadeus Basin in 1949 (in particular Joklik, 1955; Öpik, 1956; Prichard & Quinlan, 1962; Wells & others, 1964, 1965, 1966, 1967, 1970; Ranford & others, 1965; Forman, 1966; Forman & others, 1967).

Large collections of fossils were made by a great number of geologists during the course of the detailed mapping of the Amadeus Basin, which accordingly became the subject of renewed palaeontological interest as the Phanerozoic stratigraphic record was unveiled. As a result, the first descriptions of many fossil groups followed: Late Proterozoic and Early Cambrian ichnofossils (Glaessner & Wade, 1966; Glaessner, 1969; Wade, 1970; and Glaessner & Walter, 1975); Cambrian trilobites (Öpik, 1967a, 1967b, 1970a, 1970b, 1975, 1982); stromatolites (Walter, 1972); Ordovician vertebrates (Ritchie & Gilbert-Tomlinson, 1977); Devonian vertebrates (Gilbert-Tomlinson, 1968); and Devonian palynomorphs (Hodgson, 1968; Playford & others, 1976); also, the first Ordovician graptolites were recorded (Öpik, 1956; Thomas, 1960; Skwarko, 1967), but remain undescribed.

In recent years, further trace fossils have been investigated (Walter & others, 1984), and other fossil forms have been described: Early Cambrian archaeocyathans (Kruse & West, 1980), and phosphatised and phosphatic shelly elements (Laurie & Shergold, 1985; Laurie, in press); Cambrian and Ordovician molluscs (Pojeta & others, 1977; Pojeta & Gilbert-Tomlinson 1977; Stait & Laurie, 1985); further Ordovician conodonts (Cooper, 1981); and Ordovician and Devonian fish (Young, 1985; Young & others, in press).

Accordingly, it is now possible to define more acurately the biochronology of the Cambrian through Devonian formations; identify stratigraphic breaks with greater precision; and identify parts of the stratigraphic column requiring more detailed investigation. It should be emphasised that this account is preliminary, and that work in hand is likely to necessitate revision to some of

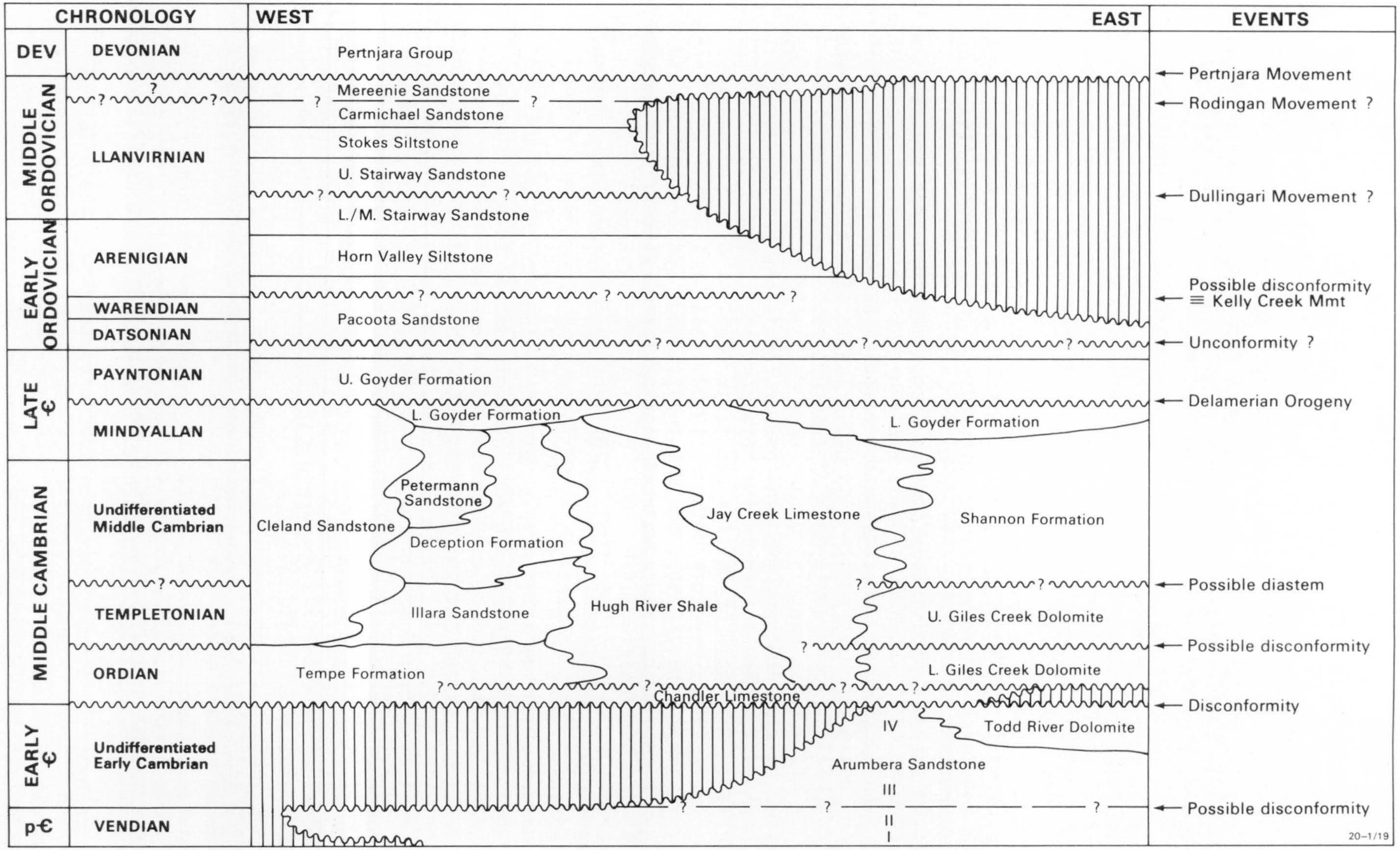

Fig. 1. Diagrammatic relationships of Cambrian and Ordovician formations of the Amadeus Basin (after Wells & others, 1970).

the statements made here. Essentially this is an interim status report in which the biotas of Cambrian and Ordovician formations are summarised as a documentation of their ages. Comparisons are made with better documented sequences, particularly in the adjacent Georgina Basin, and stratigraphic breaks are indicated and correlated as a contribution to palaeontological analysis of the Amadeus Basin. Correlation of the stratigraphic units considered here is based on Webby (1981) and Shergold & others (1985). A palaeontological bibliography of the Amadeus Basin is included in the references. For lithological descriptions of the formations discussed, the reader is mostly referred to the basin synthesis of Wells & others (1970).

Not all of the formations recognised in the Amadeus Basin contain age diagnostic biotas. These formations, which include the Quandong Conglomerate, Eninta Sandstone, Illara Sandstone, Deception Formation, Petermann Sandstone, and Cleland Sandstone, are mostly from the clastic-dominated western part of the Amadeus Basin. With the exception of the Quandong Conglomerate, which is now considered a composite formation, the relationships of these formations shown by Wells & others (1970, fig. 15) are assumed to be correct.

PALAEONTOLOGICAL SYNOPSIS

Pertaoorrta Group

Arumbera Sandstone (Prichard & Quinlan, 1962; Wells & others, 1965, 1967, 1970)

The Arumbera Sandstone (maximum thickness 1200 m) apparently conformably overlies an Upper Proterozoic sequence (Olympic Formation, Pertatataka Formation, Julie Formation) which contains glacigene sedimentary rocks (Preiss & others, 1978). It is traditionally divided into four members, generally alternating siltstones and sandstones with conglomerate occurring locally at the top of the first sandstone member, representing four similar cyclic sequences (Conrad, 1981; Oaks, 1983). Some authors (e.g., Daily, 1972, 1975), however, have divided the Arumbera Sandstone into three members. Daily (1975) has proposed informal nomenclature for the upper two members (in both the sense of Daily and traditionally) -- viz, the 'Box Hole Formation' and 'Allua Formation' -- and restricted the Arumbera Sandstone to the underlying member. Daily (1972, fig. 5) and Burek & others (1979, fig. 3) showed an unconformity between the Arumbera Sandstone (in the sense of Daily) and the 'Box Hole Formation'. Walter & others (1984), however, found no evidence for an hiatus within the Arumbera Sandstone. The controversy is likely to be resolved by seismic stratigraphic analysis (J.F. Lindsay, BMR, personal communication 1986). All parties are agreed that the Arumbera Sandstone contains the Precambrian-Cambrian boundary, that the traditional Arumbera members 1-II are of late Adelaidean age, and that members III-IV contain Early Cambrian ichnofossils.

Arumbera member I. In the basal layers of Arumbera I near Deep Well homestead, Taylor (1959) discovered a single specimen of *Rangea* cf. *longa* Glaessner & Wade, 1966, which is now referred to the genus *Glaessneria* Germs (1973; see also Glaessner, 1969; Glaessner & Wade, 1966; Glaessner & Walter, 1975; Wade, 1970; Daily, 1972). Arumbera I also contains *Hallidaya brueri* Wade, 1969, a component of the Late Adelaidean Ediacara assemblage according to Wade (1969) and Glaessner & Walter (1975). Additionally, unbranched, interwoven horizontal burrows resembling *Phycodes antecedens*, considered a Late Proterozoic form by Webby (1970), have been recorded at the Wyeecha section by Conrad (1981).

Arumbera member II. Wade (1969, 1970) and Kirschvink (1978) have reported medusoid impressions from Arumbera member II at Valley Dam. They may indicate that Arumbera II is also of Late Proterozoic (late Adelaidean) age.

Arumbera member III. According to Walter & others (1984), trace fossils previously attributed to this lithofacies are likely to be surface float derived from the lower part of the cliff-forming Arumbera IV. Its age is therefore uncertain.

Arumbera member IV. A varied ichnofossil assemblage has been reported from the lower part of Arumbera IV by Glaessner (1969), Wade (1970), Daily (1972), Glaessner & Walter (1975), and Walter & others (1984) (those asterisked have been illustrated): Cochlichnus serpens, Didymaulichnus miettensis, *Gordia sp., Gyrochorte sp., Laminites sp., Margaritichnus sp., Monocraterion sp., Monomorphicnus sp., *Phycodes pedum, *Plagiogmus arcuatus, Planolites sp., Psammichnites sp., *Rusophycus-like markings, Skolithos sp., and Taphrhelminthopsis sp. Mostly these came from the Ross River Syncline in the eastern half of the Amadeus Basin. All workers consider member IV of the Arumbera Sandstone to have an Early Cambrian age.

Todd River Dolomite (Wells & others, 1967, 1970)

The Todd River Dolomite (maximum thickness 148 m) is restricted in its distribution to the northeastern portion of the Amadeus Basin, where it appears to conformably overlie the Arumbera Sandstone; the boundary frequently appears transitional (Laurie & Shergold, 1985). According to Daily (1972) a trace-fossil assemblage which includes Rusophycus occurs in the basal part of the formation. Predominantly dolostone, the Todd River Dolomite is characterised by the occurrence of archaeocyathan reefs (Kennard, 1983; Kruse & West, 1980), with which are associated inarticulate brachiopods, molluscs, and hyoliths. Phosphatised molluscs and tubes, and phosphatic 'tommotiid' sclerites (referred to as small shelly fossils and Problematica) have been described by Laurie & Shergold (1985) and Laurie (in press). The total described fauna includes: Archaeocyatha - Aldanocyathus greeni Kruse, Aruntocyathus toddi Kruse, ?Aruntocyathus rossi Kruse, Beltanocyathus wirrialpensis (Taylor), Coscinocyathus bilateralis (Taylor), 'Dictyocyathus' spp., and Radiocyathus minor (Bedford & Bedford); small shelly fossils - Dailyatia ajax Bischoff, Kennardia reticulata Laurie, and Micrina etheridgei (Tate); Problematica - Eccentrotheca cf. kanesia Landing, Nowlan & Fletcher, Paterimitra pyramidalis Laurie, and Chancelloria sp.; inarticulate Brachiopoda - Askepasma toddensis Laurie, Edreja aff. distincta Koneva, and ?Lingulella sp.; Mollusca - Pelagiella sp.; and hyoliths (undet.).

Together, the archaeocyathans, small shelly fossils, and Problematica constitute faunal assemblage 2 of Daily (1956), which that author (1972, fig. 5) considered to have a late Tommotian to Atdabanian (Early Cambrian) age. According to Walter & others (1979) and Kruse & West (1980), the archaeocyathans indicate a younger Early Cambrian age, Atdabanian to Botoman. The younger age is supported by the observations of Laurie & Shergold (1985).

Chandler Limestone (Wells & others, 1967, 1970)

No fossils have been found in the Chandler Limestone (220 m thick), the age of which can only be inferred from its stratigraphic position. Thus no advance can be made on the precise stratigraphic location of the Chandler Limestone over that deduced by Wells & others (1970, fig. 15). The evaporitic Chandler Limestone is significantly situated between the marine Todd River Dolomite in the east and the dominantly clastic Tempe Formation in the west, but these formations are unlikely to be contemporaneous.

Giles Creek Dolomite (Wells & others, 1967, 1970)

The Giles Creek Dolomite (maximum thickness 400 m) is confined to the eastern Amadeus Basin, where it disconformably overlies the Todd River Dolomite - for example, at Ross River near the northeastern margin of the basin - and the Chandler Limestone - for example, in the western part of the Rodinga area near the Deep Well and Ooraminna Anticlines. The Giles Creek Dolomite is prodominantly a limestone/dolostone formation. The lower part is massive and contains *Girvanella*. Unnamed stromatolites were indicated by Walter (1972, fig. 10) to occur near the middle of the formation. Gilbert-Tomlinson (*in* Wells & others, 1967) has recorded the presence of 'hyolithids (including *Biconulites*), brachiopods, gastropods and trilobites'. Only some elements of the trilobite faunas have been described (Öpik, 1967b, 1970a, 1970b, 1975, 1982): *Deiradonyx toddi* Öpik, *Dinesus* sp., *Kootenia* sp., *Nepea*? sp NC, *Onaraspis somniurna* Öpik, *Onaraspis* sp., Pagetiidae? undet., Ptychopariidae undet., *Redlichia amadeana* Öpik, *Xystridura gayladia* Öpik, and *Xystridura* sp. Other fossils include *Biconulites hardmani* (Etheridge), '*Helcionella*', articulate and inarticulate brachiopods, and echinodermal debris.

The recorded fauna of the Giles Creek Dolomite seems to indicate both Ordian and Templetonian (Middle Cambrian) ages. Ordian time is basically characterised by the co-occurrence of *Redlichia* and *Xystridura*, and the early Templetonian by species of *Xystridura* alone. Late Templetonian time is indicated by the occurrence of *Triplagnostus gibbus*. Öpik (1970a, 1975) has attributed an Ordian age to species of *Redlichia* and *Xystridura* which he has recorded in the Amadeus Basin, and Ordian rocks are also indicated by the presence of *Onaraspis* and probably *Biconulites*. Species of *Dinesus*, *Kootenia*, and the ptychopariids range through into the Templetonian, and the nepeid was assigned a Templetonian (*Triplagnostus gibbus* Zone) age by Öpik (1970b). The Giles Creek Dolomite may, therefore, be a direct equivalent of the Thorntonia Limestone *sensu lato*. The Ordian/Templetonian hiatus documented in the Georgina Basin (Shergold & others, 1985) may be expected in the Giles Creek Dolomite, and may be indicated by Klootwijk's (1980) discrepant palaeomagnetic results. Common faunal elements suggest correlation with the lower Jay Creek Limestone of the Waterhouse and MacDonnell Ranges, inferring overstep of both the Todd River Dolomite and Chandler Limestone by the Giles Creek lithofacies.

Tempe Formation (Wells & others, 1965, 1970; Ranford & others, 1965)

The Tempe Formation (maximum thickness 230 m) is confined to the western portion of the Amadeus Basin, where it is considered to be the oldest Palaeozoic formation. It rests unconformably on the Upper Proterozoic (lower Adelaidean) Bitter Springs Formation, and the Areyonga Formation, which contains glacigene rocks of late Adelaidean age (Preiss & others, 1978).

Gilbert-Tomlinson (*in* Wells & others, 1970) recorded brachiopods, trilobites, hyoliths, and gastropods in the Tempe Formation, but these are not yet described. J.R. Laurie (BMR, personal communication 1986) has recorded two genera of hyoliths, species of *Chancelloria*, *Pelagiella*, *Stenothecoides*, ?*Eothele*, *Paterina*, and the bradoriid *Zepaera* sp. in phosphatic residues.

The Tempe Formation has also yielded acritarchs (Owen, 1982b), which include: *Leiosphaeridia* spp., *Micrhystridium ?lanceolatum*/*Micrhystridium* sp. A, and *Timofeevia* sp., all indicative of an early Middle Cambrian age by comparison with Europe.

The biota of the Tempe Formation could be of either Ordian or Templetonian age. An Ordian age seems more likely, considering the sedimentary history of the eastern Amadeus Basin, in which case the Tempe Formation is likely to be a clastic correlative of the lower Giles Creek Dolomite, and equivalent to the lower Hay River Formation and Thorntonia Limestone (*sensu stricto*) of the Georgina Basin.

Hugh River Shale (Prichard & Quinlan, 1962; Wells & others, 1965; Ranford & others, 1965)

Like the Chandler Limestone, the predominantly shaly and sandy Hugh River Shale (485 m thick) is geographically located between the carbonates of the Jay Creek Limestone, Giles Creek Dolomite, and Shannon Formation in the eastern Amadeus Basin, and the sandstone formations (Illara, Deception, Petermann, and Cleland) in the west. In spite of the statement of Wells & others (1970, p. 58), fossils do occur in the Hugh River Shale, particularly in the Gardiner Range in the Mount Liebig Sheet area; at this locality, hyoliths (as yet undetermined) commonly occurring with trilobite fragments and inarticulate brachiopods may suggest that the Hugh River Shale is equivalent to the Tempe Formation immediately to the south, and, as such, would be of Ordian age - at least in its lower part. The occurrence of stromatolites at a higher level in the Hugh River Shale influenced Walter (1972, fig. 10) to correlate it with the middle part of the Giles Creek Dolomite.

Shannon Formation (Wells & others, 1967, 1970)

The Shannon Formation (maximum thickness 710 m) is confined in its distribution to the northeastern portion of the Amadeus Basin, where it comprises predominantly carbonate rocks - frequently stromatolitic and thrombolitic. It rests conformably on the Giles Creek Dolomite, and passes laterally into the Jay Creek Limestone to the west. The only report of macrofossils is that of Gilbert-Tomlinson (*in* Wells & others, 1967), who stated that the fauna of the Shannon Formation is of Late Cambrian - late Mindyallan (*Glyptagnostus stolidotus* Zone) age - as in the lower part of the Goyder Formation and upper Jay Creek Limestone. Walter (1972) has recorded the columnar stromatolite *Madiganites mawsoni* Walter near the middle of the formation. Oncolitic and thrombolitic structures also occur.

Jay Creek Limestone (Prichard & Quinlan, 1962; Wells & others, 1970)

Predominantly carbonate (algal limestone and dolostone), the depocentre of the Jay Creek Limestone (up to 425 m thick) occurs in the middle of the Amadeus Basin, where it is flanked laterally by the Shannon Formation and Giles Creek Dolomite to the east, unfossiliferous sandstone formations (Illara, Deception, and Petermann) to the west, and the Hugh River Shale - which it also conformably overlies - to the north. Relationships of the Jay Creek Limestone with the underlying Chandler Limestone in the southeast are unclear.

The main stromatolitic development of the Amadeus Basin occurs in the Jay Creek Limestone, in which oncolitic grainstone and thrombolitic and stromatolitic limestone and dolostone are common constituents. Walter (1972) has recorded the presence of the columnar stromatolite *Madiganites mawsoni* Walter. Two microfossil assemblages occur in the Jay Creek Limestone, at the base and top of the formation. An early Middle Cambrian (Ordian) trilobite assemblage, including *Onaraspis*, from near Deep Well station in the central part of the Rodinga Sheet area suggests that the base of the Jay Creek Limestone may be roughly equivalent to the lower Giles Creek Dolomite and Tempe Formation. At localities near Jay Creek, The Sisters, and in the Waterhouse Range, the upper part of the Jay Creek Limestone has yielded inarticulate brachiopods, molluscs, and trilobite fragments (not yet described) associated with stromatolitic mudstone and grainstone. Gilbert-Tomlinson (*in* Wells & others, 1970) considered these to have an early Late Cambrian (Mindyallan) age. Thus the Jay Creek Limestone may span the Ordian-Mindyallan interval (early Middle to early Late Cambrian).

Goyder Formation (Prichard & Quinlan, 1962; Wells & others, 1965, 1970; Ranford & others, 1965)

The bicomposite nature of the Goyder Formation (485 m thick) is already implicit in the original definition of the formation by Prichard & Quinlan (1962). The lower (dominantly carbonate) and upper (dominantly clastic) units recognised by Prichard & Quinlan are graphically illustrated in the sections published by Wells & others (1967). A laterite horizon that separates these units at several localities in the Amadeus Basin, and the common ochreous colouration of the higher beds of the lower dolostone unit, may be indicative of a break in sedimentation and a period of Late Cambrian subaerial weathering. As defined by Prichard & Quinlan (*loc. cit.*), the lower unit conformably overlies the Hugh River Shale, Jay Creek Limestone, Petermann Sandstone, and Shannon Formation, and the upper Goyder Formation is conformably overlain by the Pacoota Sandstone, to which it may be partly equivalent. The formation has a reciprocally varying thickness relationship with both underlying and overlying conformable strata, which may indicate lateral facies changes and/or irregularity in sedimentation patterns.

In the Ross River Syncline, the lower Goyder Formation contains a Late Cambrian (Mindyallan) fauna (Öpik, 1967a, appendix 2, p. 16; Gilbert-Tomlinson *in* Pojeta & others, 1977, p. 34) at two levels. The lower level contains the trilobites *Liostracina* cf. *krausei* Monke, *Metopotropis* sp., *Plectrifer*? sp., '*Ammagnostus*' sp.; inarticulate and articulate brachiopods; hyoliths; gastropods; monoplacophorans; and the rostroconch molluscs *Pleuropegma plicatum* Pojeta, Gilbert-Tomlinson & Shergold and *Oepikila cambrica* (Runnegar & Pojeta). The upper level contains mainly trilobites - *Auritama* sp., *Liostracina* cf. *volens* Öpik, and undetermined damesellaceans - associated with inarticulate brachiopods. The acritarch *Leiosphaeridia* sp. occurs in the lower Goyder Formation in Pancontinental Dingo No. 1 well (Owen, 1982a). Similar Mindyallan faunas are now known to be widespread in the lower Goyder Formation, extending from Ross River to at least as far west as the Gardiner Range.

The lower Goyder Formation, therefore appears to be directly equivalent to the upper parts of the Jay Creek Limestone and Shannon Formation as described above.

The upper Goyder Formation is less fossiliferous. In the Waterhouse Range, it has yielded saukiid trilobites of Payntonian aspect, which seem likely to confirm the presence of a hiatus of regional significance within the Goyder Formation. In the eastern Georgina Basin, this hiatus extends from the late Mindyallan to early Payntonian, and is represented by 14 successive trilobite assemblages.

2. Larapinta Group

Pacoota Sandstone (Mawson & Madigan, 1930; Prichard & Quinlan, 1962; Wells & others, 1967, 1970)

The Pacoota Sandstone is a thick clastic formation (maximum about 1000 m) which underlies about 25 000 km^2 of the northern part of the Amadeus Basin, and extends from Lake Hopkins in the west for nearly 700 km to Illogwa Creek in the east. It comprises alternating quartzose sandstone and shale; the sandstone, which is commonly cross-stratified, predominates in the lower part, and the shale is more common in the upper part. Pisolitic iron horizons, phosphate pellets, glauconitic and phosphatic bioclastic sands sheets, and pebbly layers occur in the upper part. Sheets of pipe-rock (*Skolithos*)are particularly well developed low in the Pacoota Sandstone throughout the basin, and then again, in some western areas, at the top. Ferruginised and glauconitic carbonate is said to develop locally in the eastern part of the basin at the base of the formation (Prichard & Quinlan, 1962; Wells & others, 1967), but in this area the distinction between the Pacoota Sandstone and Goyder Formation is not clear.

Thin carbonate or calcareous sandstone may occur at the transition between the Pacoota Sandstone and the overlying Horn Valley Siltstone. East of longitude 134°E the top of the Pacoota Sandstone has been removed, along with younger Ordovician rocks, during pre-Devonian diastrophism (Rodingan Movement). The N'Dahla Member (Wells & others, 1967), formerly thought to lie within the uppermost Pacoota Sandstone, is now considered to be a much younger product of this diastrophism (Young & others, in press.)

The Pacoota Sandstone conformably and gradationally overlies the Goyder Formation to the east of longitude 130°E. To the west of that meridian, the Pacoota Sandstone and upper Goyder Formation are not readily separable, and together disconformably overlie the Cleland Sandstone, of unknown age.

Gilbert-Tomlinson (_in_ Pojeta & others, 1977; Pojeta & Gilbert-Tomlinson, 1977) has given the most up-to-date listings of the faunas of the Pacoota Sandstone in the Alice Springs, Henbury, Hermannsberg, and Rodinga Sheet areas. These include undescribed species of the trilobites referable to _Calvinella?_, _Coreanocephalus?_, '_Kayseraspis_', _Koraipsis_, _Kaolishania?_, _Lophosaukia_, _Micragnostus_, _Mictosaukia_, _Psilocephalina_, _Quadraticephalus_, and _Tellerina_, and to genera of asaphid, kainellid, nepeiid, and tsinaniid families. Additionally, there are undescribed gastropods, cephalopods, monoplacophorans, '_Hypseloconus_', inarticulate and articulate brachiopods, and ichnofossils (_Cruziana_, _Diplocraterion_, _Skolithos_). Rostroconch and bivalve molluscs have been described. The rostroconch molluscs (Pojeta & others, 1977) include _Cymatopegma semiplicatum_ Pojeta & others, _Kimopegma pinnatum_ Pojeta & others, _Pinnocaris robusta_ Pojeta & others, _P. wellsi_ Pojeta & others, _Pinnocaris_ sp. A, _Ribeiria csiro_ Pojeta & others, _R. jonesi_ Pojeta & others, _Technophorus nicolli_ Pojeta & others, and _T. walteri_ Pojeta & others. The bivalves (Pojeta & Gilbert-Tomlinson, 1977) comprise _Colpantyx woolleyi_ Pojeta & Tomlinson, _Cyrtodonta hadzeli_ Pojeta & Tomlinson, _Deceptryx?_ sp. A., _Pharcidoconcha raupi_ Pojeta & Tomlinson, and _Xestoconcha kraciukae_ Pojeta & Tomlinson. The chitinozoan _Fustichitina pervulgata_ (Umnova) has been determined in Pancontinental Tent Hill No. 1 well by M. Owen (BMR, personal communication 1984).

The fossils indicate an age span from Late Cambrian (Payntonian) to Early Ordovician (early Arenigian). Gilbert-Tomlinson (_in_ Wells & others, 1970) has proposed recognition of three biostratigraphic units within the Pacoota Sandstone (based on faunal assemblages labelled Pacoota I-III from the base up). Research since 1970 indicates that the Pacoota I assemblage has a Late Cambrian (Payntonian) to Early Ordovician (Datsonian) age, Pacoota II is Early Ordovician (Warendian), and Pacoota III is Early Ordovician (early Arenig). The main trace-fossil development is interposed between the Payntonian and Warendian faunal assemblages. It may therefore be indicative of a late Payntonian or Datsonian regressive event predating the Warendian, or represent an early Warendian transgressive event. The trace-fossil sequence itself yields no age diagnostic body fossils. If this sequence is indicative of a late Payntonian or Datsonian regression, then a hiatus is to be expected between the trace-fossil sequence and the overlying Pacoota Sandstone with a Warendian fauna. Some support for this suggestion may be the persistent occurrence, basin-wide, of phosphatic and glauconitic sand sheets at about this stratigraphic level. Alternatively, if the trace-fossil sequence represents a Warendian transgression, a stratigraphic break may occur at the base of the sequence. This is not yet supported by sedimentological observations in the Amadeus Basin, but _Skolithos_ sands occur immediately above disconformity surfaces at the bases of Lower and Middle Cambrian and Arenig successions in Wales according to Crimes (1970). Detailed analysis of undescribed faunas may clarify the age relationships of the trace-fossil sequence, as may comparison with contemporaneous formations elsewhere.

Horn Valley Siltstone (Madigan, 1932a; Prichard & Quinlan, 1962; Wells & others, 1967, 1970; Cooper, 1981)

The Horn Valley Siltstone has a distribution across the Amadeus Basin which is much the same as that of the Pacoota Sandstone. Like the latter formation, the Horn Valley Siltstone thickens northwards (to 422 m), but has been removed by Rodingan diastrophism from those parts of the basin east of longitude 133°30'E. Largely composed of poorly outcropping shale, organic rich in the subsurface, and subordinate limestone with interbedded sandy phosphatic and glauconitic layers, the Horn Valley Siltstone is regarded as a major petroleum source rock unit.

The Horn Valley Siltstone mostly overlies the Pacoota Sandstone conformably, although some overstepping has been recorded locally in the south of the basin (Wells & others, 1970).

The Horn Valley Siltstone is very fossiliferous and contains a varied biota. It was one of the first formations in the Amadeus Basin to be palaeontologically investigated, during the Horn Expedition of 1894 (Tate, 1896), and for many years was one of the main sources of knowledge of the Ordovician fossils in northern and central Australia.

According to Gilbert-Tomlinson (*in* Wells & others, 1970), the formation contains trilobites, brachiopods, pelecypods, nautiloids, ostracodes, graptolites, gastropods, and conodonts. A few of the trilobites were described by Etheridge (1893, 1894) and Tate (1896), and the occurrence of others has been noted in passing by Prichard & Quinlan (1962) and Gilbert-Tomlinson (*in* Ritchie & Gilbert-Tomlinson, 1977). Etheridge (1891a, 1891b, 1893, 1894) and Tate (1896) also described brachiopods, gastropods, and nautiloid cephalopods. The last have been thoroughly revised since by Teichert (1939), Teichert & Glenister (1952, 1954), and Stait & Laurie (1985). Graptolites have been noted by Öpik (1956), Thomas (1960), and Skwarko (1967), and conodonts by Crespin (1943) and Cooper (1981). More recently acritarchs and chitinozoans have been determined by Owen (1982a, 1982b) in Pancontinental Dingo No. 1 and Mount Winter No. 1 wells. The revised biotic lists follow.
Trilobita: *'Asaphus' illarensis* Etheridge, ?*'Asaphus' lissopeltis* Tate, *Lycophron howchini* (Etheridge), *Ampyx* sp., *Carolinites* sp., aff. *Prosopiscus* sp., and aff. *Ptychopyge* sp. Brachiopoda: *Aporthophyla dichotomalis* (Tate) and *Tritoechia* sp. Pelecypoda: *Ctenodonta* sp. and *Cyrtodonta* sp. Gastropoda: *'Ophileta' gilesi* Etheridge and *'Raphistoma' brownii* Etheridge. Cephalopoda: *Anthoceras warburtoni* (Etheridge), *Aphetoceras delectans* Teichert & Glenister, *Bactroceras gossei* (Etheridge), *Bathmoceras australe* Teichert, *Endoceras? arenarium* Tate, *Lobendoceras emanuelense* Teichert & Glenister, *Madiganella tatei* (Etheridge), Tarphycerida indet. (=*Trochoceras recticostatum* Tate), and a cyrtoconic discosorid. Graptolithina: *Didymograptus nitidus* Hall and *D. patulus* Thomas. Conodontophorida: *Acodus buetefeuri* Cooper, *A. emanuelensis* McTavish, *Baltionodus navis* (Lindstrom), *Belodella jemtlandica* Lofgren, *Bergstroemognathus extensus* (Graves & Ellison), *Cornuodus longibasis* (Lindstrom), *Drepanoistodus pitjanti* Cooper, *D. suberectus* (Branson & Mehl), *Erratocodon patu* Cooper, *Jumudontus gananda* Cooper, *Microzarkodina flabellum* (Lindstrom), *Oepikodus evae* (Lindstrom), *Oistodus scalenocarinatus* Mound, *Oneotodus* sp., *Prioniodus amadeus* Cooper, *P. nyinti* Cooper, *P. yapu* Cooper, *Protopanderosus primitivus* Druce, *Scalpellodus latus* (van Wamel), and *Trigonodus larapintensis* (Crespin). Acritarcha: *Baltisphaeridium* sp., *Dactylofusa simplex* Combaz, *Leiosphaeridia granulata* Eisenack, *L.* cf. *wenlockia* Downie, *Leiosphaeridia* spp., *Peteinosphaeridium palmatum* Combaz & Peniguel, *P. pilatum* Combaz & Peniguel, and *Veryhachium* cf. *lairdi* Deunff. Chitinozoa: *Conochitina langei* Combaz & Peniguel *C. micracantha*? Eisenack, *C. minnesotensis* (Stauffer), *C. poumoti* Combaz & Peniguel, *Lagenochitina esthonica*? Eisenack, and *L. ovoidea* Benoit & Tougourdeau.

Evidence for the age of the Horn Valley Siltstone is discussed by Pojeta & others (1977), Pojeta & Gilbert-Tomlinson (1977), and Cooper (1981). All are agreed that an Early Ordovician (late Arenig) age is most likely.

Stairway Sandstone (Chewings, 1935; Prichard & Quinlan, 1962; Wells & others, 1965; Cook, 1972)

The Stairway Sandstone is distributed throughout the Amadeus Basin, with the exception of its northeastern corner, where it was eroded before the Late Devonian. It underlies 50 000 km^2 according to Cook (1972). Like the Pacoota Sandstone and Horn Valley Siltstone below, it thickens to the north (to a maximum of 544 m). Basically the Stairway Sandstone comprises two arenite units separated by fine clastics, phosphorites, and carbonates (Cook, 1972). The basal sandstone is massive, cross-stratified, and pebbly, and contains pyritised oolitic beds, and sheets of pipe-rock (Skolithos) not readily distinguishable from those of the Pacoota Sandstone. The middle unit is organic rich in the subsurface, and comprises mostly siltstone and mudstone interbedded with sandstone and nodular phosphorite layers which pass laterally into mudstone-carbonate to the southeast and redbeds to the east. The upper sandstone is conglomeratic at the base, and contains phosphorite nodules and manganiferous layers, and Diplocraterian and Cruziana ichnocoenoses.

The Stairway Sandstone conformably overlies the Horn Valley Siltstone, except in the south and west of the Amadeus Basin, where it oversteps on to progressively older rocks.

The first fossils of Ordovician age described from central Australia were obtained by F. Thornton of Tempe Downs station in about 1890, and described by Etheridge 1891, 1894). They included large asaphid trilobite fragments which originate in the Stairway Sandstone. Subsequently, Howchin (1893) exhibited the presumed sponge Hyalostelia, and Tate (1896) described molluscs. No further research was undertaken on the faunas of the Stairway Sandstone until Pojeta & Gilbert-Tomlinson (1977) described the bivalve molluscan fauna, and Ritchie & Gilbert-Tomlinson (1977) described the vertebrates. Nevertheless, Gilbert-Tomlinson (in both joint publications) has alluded to the occurrence of various other fossils: trilobites, brachiopods, rostroconchs, gastropods, nautiloids, monoplacophorans and ichnofossils, as listed below. A microflora (acritarchs) has been recorded by Owen (1982b) in Pancontinental Mount Winter No. 1 well. Trilobita: 'Asaphus' thorntoni Etheridge, Carolinites sp., Annamitella sp., ?leiostegiid, aff. Prosopiscus, and ?Ptyocephalus sp. Brachiopoda: Aporthophyla-like form, Orthambonites sp. (='Orthis' aff. leviensis Etheridge), and a plectambonitid. Spongia: Hyalostelia australis Howchin. Rostroconchia: Pinnocaris sp. A., Ribeiria sp., R. csiro Pojeta & others, and Technophorus sp. Gastropoda: Clathrospira? sp. and Helicotoma? sp. Cephalopoda: Armenoceras sp. Monoplacophora: indet. Pelecypoda: Alococoncha crassatellaeformis (Tate), ambonychiid gen. B. sp. A Pojeta & Gilbert-Tomlinson, Cyrtodonta carberryi Pojeta & Gilbert-Tomlinson, C. staffordae Pojeta & Gilbert-Tomlinson, C. wattii (Tate), Cyrtodonta sp., Ctenodonta youngi Pojeta & Gilbert-Tomlinson, Denticelox tortuosa (Tate), Eritropsis opiformis (Tate), Eritropsis sp. A., Inaequidens campbelli Pojeta & Gilbert-Tomlinson, Johnmartinia cordata Pojeta & Gilbert-Tomlinson, J. orbicularis (Tate), Modiolopsis sp. A., Palaeoneilo smithi Pojeta & Gilbert-Tomlinson, Pteronychia haupti Pojeta & Gilbert-Tomlinson, Sphenosolen draperi Pojeta & Gilbert-Tomlinson, and Sthenodonta eastii (Tate). Ichnofossils: Skolithos sp., Cruziana sp., and Diplocraterion sp. Agnatha: Arandaspis prionotolepis Ritchie & Gilbert-Tomlinson and Porophoraspis crenulata Ritchie & Gilbert-Tomlinson. Acritarcha: Leiofusa spp. and Leiosphaeridia sp.

On the basis of the agnathans, Gilbert-Tomlinson has suggested an age for the Stairway Sandstone 'no younger than early Middle Ordovician' (in Ritchie & Gilbert-Tomlinson, 1977), and considered the Lower-Middle Ordovician boundary to fall within the Stairway Sandstone. The pelecypod molluscs are attributed a

'Llanvirnian-Llandeilian' age by Pojeta & Gilbert-Tomlinson (1977), and a similar age is indicated by the rostroconch molluscs (Pojeta & others, 1977). Webby & others (1981) settled for an early Llanvirnian age. However, these age determinations depend very much on from which part of the tripartite Stairway Sandstone the fossils have been collected.

Stokes Siltstone (Prichard & Quinlan, 1962; Wells & others, 1970)

Wells & others, (1970, fig. 29) illustrated a distribution for the Stokes Siltstone (maximum thickness 610 m) almost as extensive as that of the Stairway Sandstone. However, the Stokes Siltstone is poorly exposed. It is composed of a lower siltstone/limestone lithofacies, and an upper red and purple sandstone and shale lithofacies. The upper Stairway Sandstone passes gradationally upwards into the Stokes Siltstone wherever these formations are in superposition. In the west of the Amadeus Basin, however, the Stokes Siltstone is unconformable on Proterozoic formations.

The Horn Expedition (1894) confused the Stokes Siltstone and the Horn Valley Siltstone, even though the faunas are relatively distinctive and the former is definitely younger. Relatively few fossils, however, have been described from the formation : gastropods (Tate, 1896), a brachiopod (Etheridge, 1891), a bryozoan (Crockford, 1943), rostroconch molluscs (Pojeta & others, 1977), and bivalve molluscs (Pojeta & Gilbert Tomlinson, 1977). Nautiloid cephalopods, trilobites, and conodonts are known to occur but have not yet been described. The list below is mainly from Pojeta & Gilbert-Tomlinson (1977). Trilobita: asaphid trilobites undetermined. Brachiopoda: Dinorthis leviensis (Etheridge), strophomenoid, and inarticulate brachiopods undetermined. Cephalopoda: nautiloid cephalopod undetermined. Rostroconchia: conocardioid rostroconch sp. A. Gastropoda: Eunema larapinta Tate, Pleurotomaria? larapinta Tate, and Scalites eremos Tate. Bivalvia: Cyrtodonta sp., Lophoconcha corrugata (Tate), Palaeonelo smithi Pojeta & Gilbert-Tomlinson, and Sthenodonta eastii (Tate), S. etheridgei (Tate), S. jelli Pojeta & Gilbert-Tomlinson, and Sthenodonta? sp. A. Bryozoa: Batostoma sp. Echinodermata: undetermined debris.

The brachiopod Dinorthis leviensis (Etheridge, 1891) was the first species to yield evidence for the Ordovician age of sediments in the Tempe Downs area. Gilbert-Tomlinson (in Wells & others, 1970) suggested a Middle-Late Ordovician (Caradocian) age for the Stokes Siltstone. Subsequently, Pojeta & Gilbert-Tomlinson (1977) considered that the brachiopods and bryozoans were more likely to indicate a Middle Ordovician age, and even suggested partial equivalence of the Stokes Siltstone and Stairway Sandstone. Undescribed conodonts support a Middle Ordovician age (R.S. Nicoll, BMR, personal communication 1985).

Carmichael Sandstone (Wells & others, 1970)

The Carmichael Sandstone (152 m thick) is the uppermost lithological unit of the Larapinta Group (in the sense of Wells & others, 1970). It comprises sandstone and siltstone of wide distribution west of longitude 133°30' (Wells & others, 1970, fig. 31). Unlike older Larapinta Group formations, the Carmichael Sandstone thickens to the south. Nevertheless, it is considered to conformably overlie the Stokes Siltstone.

The only fossils that occur in the Carmichael Sandstone are ichnofossils 'Cruziana and other trace fossils' (Wells & others, 1970, p. 81) and the skeletal plates of primitive fish which are too fragmentary to determine (Ritchie & Gilbert-Tomlinson, 1977). The age of the Carmichael Sandstone is therefore not accurately known, but is likely to be no older than late Middle Ordovician and possibly Llandeilian. It could, however, be genetically related to the Mereenie Sandstone, which overlies it and is generally considered to have a Devonian age. But the Mereenie Sandstone (sensu stricto) is not accurately dated, and both formations could equally be regarded as Ordovician as shown in Figure 1.

3. Post-Ordovician Palaeozoic

A stratigraphic hiatus representing a long period of time is supposed to separate the Carmichael Sandstone from the unconformably overlying Mereenie Sandstone and the Pertnjara Group (Parke Siltstone, Hermannsburg Sandstone, and Brewer Conglomerate). These formations have been lithologically documented by Wells & others (1970) and Jones (1972); their vertebrate faunas have been summarised by Young (1985), and floras described by Hodgson (1968) and Playford & others (1976). A late Early Devonian (Emsian) age is assumed for the Mereenie Sandstone by correlation with the Georgina Basin and western New South Wales. The Pertnjara Group ranges in age from the Middle Devonian (Givetian-Frasnian) for the Parke Siltstone, to Late Devonian (Frasnian to pre-late Famennian) for the Brewer Conglomerate.

PROVISIONAL PALAEONTOLOGICAL ANALYSIS

The palaeontological sciences (taxonomic palaeontology, biostratigraphy, biochronology, palaeobiology, palaeoecology, etc.) play a major role in basin analysis, in which they complement the sedimentological sciences on the one hand - assisting in the diagnosis of environments - and the geochemical sciences on the other - particularly organic geochemistry, chemostratigraphic mapping, and the use of biogenic substances (especially apatite) in a range of isotopic evaluations.

Taxonomic palaeontology eventually produces a biostratigraphy without which outcropping rocks cannot be thoroughly interpreted. A biostratigraphy, at almost any level of resolution, is necessary and essential to basin study analysis because it establishes an easily obtainable, generally readily checkable, and refinable chronological framework for the dating and correlation of a variety of geological and geophysical events.

As is evident from the above review, the Amadeus Basin in the Cambrian and Ordovician - dominated by peritidal carbonates, evaporites, and inner detrital, commonly deltaic, and in places fluviatile clastic rocks - is palaeontologically impoverished.

In the Cambrian, the basin's faunal and floral data are generally infrequent, both spatially and temporally. Even in the Early and Middle Ordovician, when organic activity was more prolific, biotas mostly are of low diversity. Consequently, the biostratigraphy of the Amadeus Basin remains poorly defined.

Accordingly, correlations of Cambrian and Ordovician events, both within and outside the Amadeus Basin, have to be made mainly with reference to biostratigraphic scales established in the Georgina Basin, where the faunal stratigraphy is most highly resolved and at certain times becomes a standard for the north Australian craton (Shergold & others, 1985). The exception is in the Early Cambrian, which is developed only in the southwestern quardrant of the Georgina Basin to any extent. At this time, correlation must be effected through the more completely developed open-marine sequences of the Adelaide Geosyncline.

Palaeontologically recognised events in the Amadeus Basin, and as yet unrecognised but anticipated events based on correlation, are suggested below and summarised in Figure 1.

1. All available evidence currently suggests that the Precambrian-Cambrian boundary lies within the Arumbera Sandstone, since its units I and II contain what are generally considered to be Late Proterozoic trace fossils, contrasting with those of units III and IV which are undisputedly Cambrian. The lack of body fossils does not permit evaluation of an exact age for any of the Arumbera lithofacies. The formation apparently passes conformably

into the Todd River Dolomite, which is dated as Atdabanian or even Botoman (Early Cambrian). If Arumbera units I and II are late Adelaidean, then units III and IV must span the Tommotian-early Atdabanian interval, since the cyclicity of sedimentation observed by Conrad (1981) and Oaks (1983) would argue against a diastem of significant duration. If, however, it is necessary to postulate such a stratigraphic break, it is most likely to be expected between Arumbera II and III, as shown by Laurie & Shergold (1985, fig. 1). The possibility of the entire Arumbera Sandstone being of Cambrian age has not yet been seriously entertained.

The deposition of sand sheets at the Precambrian-Cambrian boundary was apparently very widespread in the Australian sector of the Cambrian Gondwanaland. Correlatives, in toto or in part, of the Arumbera Sandstone (undifferentiated) are probably the Buckingham Bay Sandstone of the Arafura Basin, the Bukalara Sandstone of the McArthur Basin, the Mount Baldwin Formation (southwest) and Mount Birnie Formation (pars; east) of the Georgina Basin, the Yuendumu Sandstone of the Ngalia Basin, the Observatory Hill beds of the Officer Basin, and the Uratanna, Parachilna, and Mount Terrible Formations of the Adelaide Geosyncline. The level of correlation is not highly resolved, nor is the timing of onset of sedimentation.

2. Archaeocyathan-bearing carbonate reefs typical of the Todd River Dolomite are also common to the Errarra Formation and Red Heart Dolomite of the southwestern Georgina Basin, Ajax Limestone of the Flinders Ranges, and Wangkonda through Fork Tree Limestones of the Fleurieu Peninsula, South Australia. In the east-central Amadeus Basin, the Todd River Dolomite is disconformally overlain by evaporitic (halite) sediments (Chandler Limestone), which mark a brief period of desiccation that was widespread in central Australia - extending also into the southwestern Georgina Basin - at the end of the Early Cambrian. Highly alkaline environments in the Observatory Hill beds of the Officer Basin may have been contemporaneous with the Chandler Limestone, but direct evidence is not available. In the Georgina Basin, an erosion surface has been recorded (Walter & others, 1979) between archaeocyathan-bearing carbonates and younger (Ordian) sediments. The suggested overstepping of the Todd River Dolomite and Chandler Limestone by the lower Giles Creek Dolomite (=basal Jay Creek Limestone and Tempe Formation) appears to reflect the early Middle Cambrian (Ordian) transgression, which is so widespread in northern and central Australia (see Shergold & others, 1985).

3. In the Georgina, Daly River, and Wiso Basins, an erosion surface occurs between rocks of Ordian and Templetonian ages. Evidence of this event in the Amadeus Basin is not yet documented, but is likely to lie above the basal dominantly dolostone unit of the Giles Creek Dolomite and lower Jay Creek Limstone in the eastern part of the basin, and the succeeding Templetonian transgression may be reflected in clastic intervals (undated) occurring higher within these formations, and by the inception of arenitic sedimentation at the bases of the Illara and Cleland Sandstones in the western part of the basin.

4. The biostratigraphy of the upper part of the Giles Creek Dolomite, most of the Jay Creek Limestone, the Shannon Formation, the Hugh River Shale, and sandstones to the west of longitude 132°E is poorly known. Although this stratigraphic package contains at its maximum development 500-1000 m of sediment, only a single time line - uniting the tops of the Shannon Formation and Jay Creek Limestone, and lower part of the Goyder Formation - has been identified. This time line is defined by fossils diagnostic of the late Mindyallan (Late Cambrian) Glyptagnostus stolidotus Zone, which is

widespread (globally). Between the Templetonian and Mindyallan, biotas characteristic of 10 zones and three further late Middle Cambrian stages are known in the eastern Georgina Basin, but so far are totally unrecognised in the algal-dominated Amadeus Basin. Consequently, discontinuities which may be predicted within the Giles Creek Dolomite and Jay Creek Limestone correlating with events found near the top of the Templetonian at the base of the <u>Triplagnostus gibbus</u> Zone, at or near the <u>Euagnostus opinus</u> Zone, and at or near the <u>Goniagnostus nathorsti</u> Zone in the Georgina Basin are also unrecognised.

5. Correlation of the Goyder Formation, within the constraints of existing information, has been discussed above. The hiatus developed within this formation can be directly correlated stratigraphically with that between the Tomahawk beds (Payntonian and younger) and Arrinthrunga Formation (Mindyallan) in the southern and western parts of the Georgina Basin. In the Burke River area of the eastern Georgina Basin, however, continuous sedimentation throughout the pre-Payntonian to initial Datsonian is indicated by the extremely shallow-water Lily Creek Sandstone Member of the Chatsworth Limestone. A similar stratigraphic break is found, expressed in one way or another, throughout the Australian cratonic sector of Gondwanaland (Webby, 1978; Shergold & others, 1985). Evidence for its occurrence is coming to light in Antarctica (Wright & others, 1984). Hiatuses of similar magnitude have been known for a long time on the Sino-Korean Platform (e.g., Kobayashi, 1931), peninsular Thailand (Kobayashi, 1957), and Burma (see Wolfart & others, 1984). This widespread pan-Gondwanaland event - Delamerian Orogeny in Australia, the Ross Orogeny in Antarctica - may represent a peripheral effect of the final phases of the Pan-African Orogenic crust-forming event (Kroner, 1980).

6. Outside the Amadeus Basin, the Pacoota Sandstone is the time and rock equivalent of the Nootumbulla Sandstone and Bynguano and Yandaminta Quartzites of the Bancannia Trough, and the time equivalent of the clastic Tomahawk beds of the western Georgina Basin and carbonate Ninmaroo Formation of the eastern Georgina Basin. In the Ninmaroo Formation, Miller (1984, based on data from Druce & others, 1982) has recognised two eustatic events, which are closely dated by conodonts and can be globally correlated. The earliest of these events, the Lange Ranch Eustatic Event, is represented by the Unbunmaroo Member of the Ninmaroo Formation, which has an immediate post-Payntonian (Datsonian) age. The second, the Black Mountain Eustatic Event, is represented by the Corrie Member of the Ninmaroo Formation, and is of early Warendian age. These events in the Amadeus Basin apparently coincide with the major development of trace fossils, particularly <u>Skolithos</u>, in the lower Pacoota Sandstone. At the top of the Pacoota Sandstone in the northwest of the Amadeus Basin, a second development of <u>Skolithos</u> sand sheets, which are dated on the basis of trilobites (Pacoota III of Gilbert-Tomlinson <u>in</u> Wells & others, 1970) as early Arenig, may be a response to the Kelly Creek Movement (Webby, 1978), which is recognised by local uplift, erosion, and regolith development in the eastern Georgina Basin.

7. There is no major discontinuity between the faunas of the upper Pacoota Sandstone and lower Horn Valley Siltstone, nor essentially between those of the upper Horn Valley Siltstone and lower Stairway Sandstone. The closest documented correlative of the Horn Valley Siltstone on present knowledge would appear to be the Nora Formation of the southern Georgina Basin (Fortey & Shergold, 1984) or upper Prices Creek Group of the Canning Basin (Legg, 1976), but the exact degree of correspondence awaits the detailed description of the Horn Valley trilobite and conodont faunas.

8. Gilbert-Tomlinson (in Cook, 1972) placed a major biostratigraphic division within the Stairway Sandstone, at the base of the upper sandstone unit. Although no faunal diagnosis has been published to justify such an action, the faunas of the overlying Stokes Siltstone are noticeably different from those of the lower Stairway Sandstone.

The Early Ordovician biostratigraphy of the Amadeus Basin is too poorly documented to permit any more than tentative correlation of the upper Larapinta Group. Contrary to Webby's (1978, 1981) correlations, the lower Stairway Sandstone may equate directly with the Nora Formation-Carlo Sandstone interval of the southern Georgina Basin, and the middle part of the Stairway Sandstone with the Mithaka Formation, which is similarly phosphatic: in both the Amadeus and Georgina Basins, similar lithofacies are juxtaposed, and similar faunas characterised by unusually large trilobites, pelecypods, and cephalopods have been found (Draper, 1980a; Shergold & Druce, 1980). A correlation of the upper Stairway Sandstone with part of the Ethabuka Formation (Draper, 1980b) cannot be maintained for lack of faunal evidence from the Georgina Basin. Correlatives of the Stokes Siltstone and Carmichael Sandstone determined palaeontologically are not definitely known outside the Amadeus Basin. An event within the Stairway Sandstone reflecting the Dullingari Movement (Webby, 1978) is suspected, but cannot be adequately documented at the present time.

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R85/681(14) Cat. No. 86 2049 6