Copy 4

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Record Number

1993/4

SUMMARY OF PHANEROZOIC BIOSTRATIGRAPHY AND PALAEONTOLOGY OF THE CANNING BASIN (LENNARD SHELF)

by

P.J. JONES & G.C. YOUNG

AGSO

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

1993/4

SUMMARY OF PHANEROZOIC BIOSTRATIGRAPHY AND PALAEONTOLOGY OF THE CANNING BASIN (LENNARD SHELF)

by

P.J. JONES & G.C. YOUNG

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

Minister for Resources: The Hon. Alan Griffiths
Secretary: Geoff Miller

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION
(formerly BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS)

Executive Director: Roye Rutland

ISSN: 1039-0073

ISBN: 0 642 18847 5

CONTENTS

ABSTRACT

Palaeontological and biostratigraphic studies for each Phanerozoic system are briefly summarised for the entire Canning Basin, with emphasis on the Palaeozoic. Biostratigraphic analysis of six key wells on the Lennard Shelf (May River 1, Langoora 1, Meda 1, Meda 2, Blackstone 1 and Mimosa 1) are given in an Appendix. A synthesis of this information has led to the identification of ten major stratigraphic breaks within the Palaeozoic succession on the Lennard Shelf:

1. The entire Cambrian Period and most of the Tremadocian.
2. Much of the Silurian and the Early Devonian (resulting from an Early Silurian age for the Worral Formation, and a Late Ordovician - earliest Silurian age for the underlying Carribuddy Group).
3. Within the early Famennian (a break of variable duration in different parts of the study area).
4. Within the late Famennian (corresponding to the Upper *postera*, and Lower *expansa* conodont Zones).
5. Within the latest Famennian (Strunian - possibly representing the global sea-level fall in the Middle *praesulcata Zone*, just prior to the D/C boundary).
6. Within the latest Tournaisian-early Visean (between the Laurel Formation and the Anderson Formation; the least plausible stratigraphic break).
7. Within the latest Visean-early Namurian (representing the *maculosa* assemblage).
8. The late Westphalian and most or all of the Stephanian (representing the *birkheadensis* Zone).
9. The early part of the Sterlitamakian Stage (between the base of the Nura Nura Member of the Poole Sandstone, and the top of the Grant Group.
10. The latest Permian (Dorashamian = Changhsingian) Stage (representing the *Protohaploxypinus microcorpus* Zone; between the upper part of the Hardman Formation and the lower part of the Blina Shale).

Biostratigraphic control provided by conodonts, ostracods, microvertebrates and spores has underpinned AGSO sequence analyses of seismic and well data for a new interpretation of the outcropping and subsurface Late Devonian reef complexes. Revised ages effect the understanding of the petroleum resource potential in the Ordovician sequence. Some formations within the Carribuddy Group may behave as effective seals to source and reservoir rocks in the Nita Goldwyer Formations.

INTRODUCTION

Palaeontological determinations, and the chronological framework they provided, contributed to the earliest investigations of the geology of the Canning Basin. Fossils collected by E.T. Hardman in 1883-84, and described by Foord (1890), indicated a probable Devonian age for strata exposed at Mt. Pierre, and a Carboniferous age for strata exposed in the Oscar and Napier Ranges. Apart from the descriptions of a nautiloid and stromatoporoids by Etheridge (1897, 1918), no further publications on Devonian fossils appeared until Hosking (1933) described some Devonian brachiopods, and used them in a preliminary systematic account of the Devonian rocks of the Kimberley region. There remained some problems concerning the supposed Carboniferous age of limestones in the Napier and Rough Ranges, from which both Devonian and Carboniferous fossils had been described. These were resolved when a more detailed palaeontological investigation by Thomas (1957) was able to distinguish, on the basis of fossil content, a formation of Carboniferous age (the 'Laurel Beds'), in the Laurel Downs area, from the Devonian strata nearby. Another problem concerned the rocks in the Prices Creek area south of Gap Creek, originally interpreted (Blatchford 1927) as Carboniferous on the basis of earlier work, and supported by supposed Carboniferous brachiopods (Prendergast 1935). Redeterminations by A.A. Opik, of fossils from limestones in the Prices Creek area, led to strata of Ordovician age being recognised for the first time from the Canning Basin (Guppy & Opik 1950).

More detailed palaeontological investigations of several groups of Devonian fossils (Delepine 1935; Hill 1936, 1939; Ripper 1937, Fletcher 1943; Teichert 1939, 1940, 1941) led to the resolution of Givetian, Frasnian and Famennian age strata, and a preliminary biostratigraphic zonation for some groups. Without this palaeontological work Teichert's (1943, 1947, 1949) elucidation of the stratigraphic framework of the Devonian sequences in the Canning Basin would not have been possible. The same is true of course for all the other systems of the Phanerozoic, in which age control is provided primarily by fossil data.

Over the past 40 years a steady accumulation of published palaeontological data has provided a stratigraphic framework for mapping and other geological and geophysical work in the basin. Much of this work was conducted by BMR between 1949 and 1972 (Brunnschweiler 1954, 1957, 1960; Guppy *et al.* 1958; Veevers & Wells 1961; Druce & Radke 1979; Forman & Wales 1981). The work by the Geological Survey of Western Australia was mainly on the Lennard Shelf (Playford & Lowry 1966; Playford *et al.* 1975; Playford 1980). Towner & Gibson (1983) and Yeates *et al.* (1984) summarised the results of basin-wide mapping carried out by BMR and GSWA, and Wells (1980) provided a useful summary of subsurface evaporite sequences. More recent general summaries of the geology of the Canning Basin are provided by Purcell (1984) and Middleton (1990). Devonian geology of the Canning Basin was summarised in the review of the Devonian of Western Australia by Cockbain & Playford (1988).

The present investigation is part of palaeontological support for the Canning Basin Project, within the AGSO Onshore Sedimentary and Petroleum Geology Program. It provides an up-to-date review of the biostratigraphy and palaeontology, to establish a reliable time-framework, which is vital pre-requisite for the interpretative studies of the sequence stratigraphy and tectonostratigraphy of the Basin (Jackson *et al.*, 1992; Kennard *et al.*, 1992; Southgate *et al.*, in

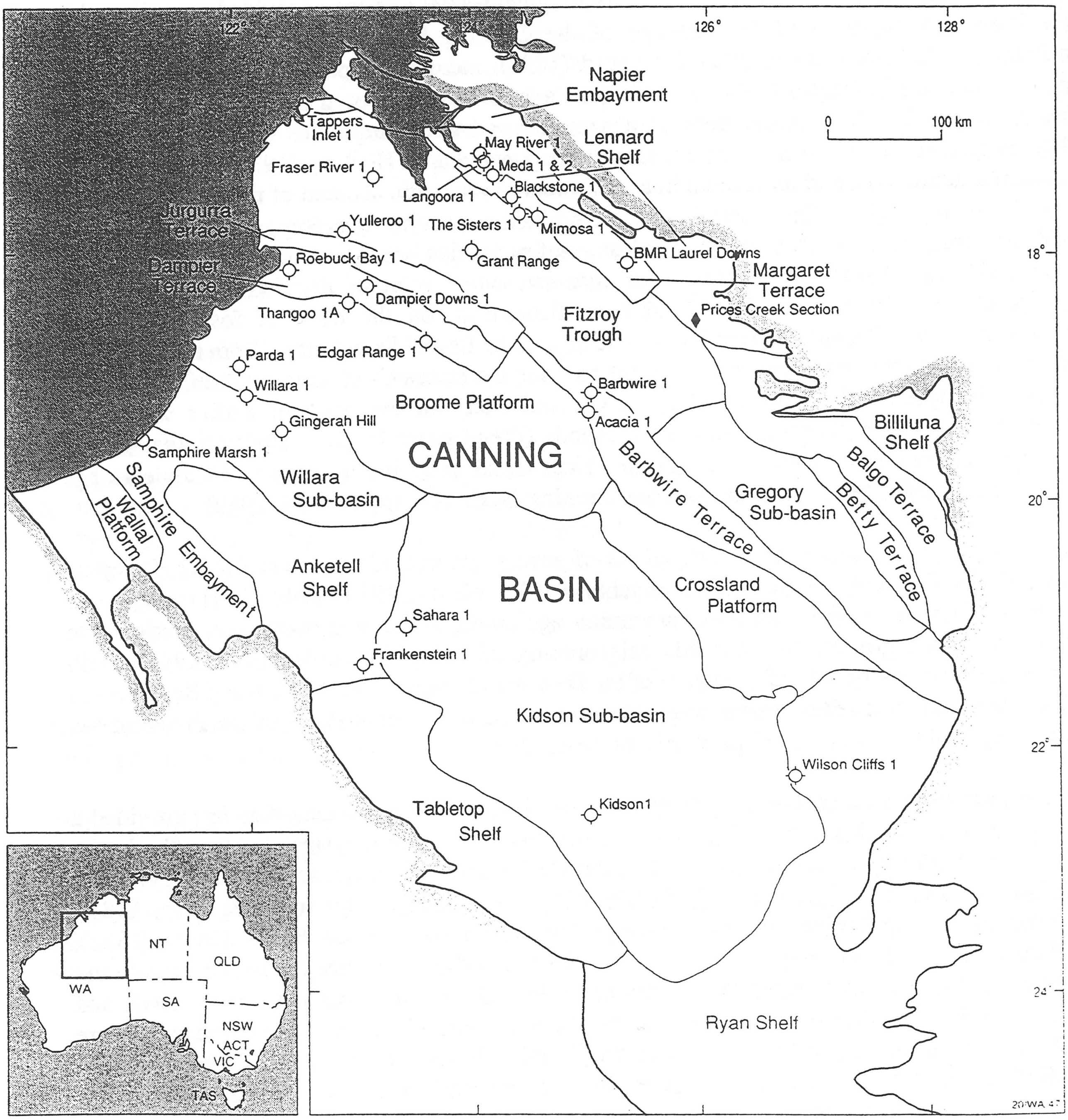


Fig. 1. Locality map for the Canning Basin, showing location of all wells mentioned in the text. Structural subdivisions after Shaw *et al.* (in prep.).

press). A major objective was to identify and date major stratigraphic breaks. Dating precision depend on sampling interval in wells, and whether samples were taken from cores, side wall cores or cuttings, and the positions of many stratigraphic breaks were approximated to the nearest formational boundary. The review is based on a literature-search, with previous data updated in terms of present understanding of palaeontological and biostratigraphic research. In addition, some significant samples have been re-examined.

In this record we present a brief summary of palaeontological and biostratigraphic studies for each Phanerozoic system for the whole basin (Fig.1). This is followed by a synthesis of results from biostratigraphic analysis of six key wells on the Lennard Shelf previously presented (Jones & Young 1990-92; Jones, Foster & Young 1991), which have already been applied to investigations of sequence stratigraphy on the Lennard Shelf (e.g. Jackson *et al.* 1992). This synthesis summarises evidence for 10 major breaks identified in the Palaeozoic succession on the Lennard Shelf. Palaeontological data from these wells, previously summarised by Jones & Young (1990-92) and Jones, Foster & Young (1991), are updated in the appendix. In some cases samples have been re-examined and redetermined, for conodonts (by R.S. Nicoll and G. Klapper), ostracods (P.J. Jones), palynomorphs (C.B. Foster) and microvertebrates (G.C. Young), however a comprehensive re-examination of palaeontological samples has not been attempted. Nevertheless the age significance of many fossil determinations done over 20 years ago has changed with refinements in the biostratigraphic control of Australian sequences generally, and such information is incorporated in the new interpretations presented here.

Initially, paleontological data from well completion reports for 27 wells, many outside the Lennard Shelf(Fig. 1), were summarised. These data were used with new data produced by AGSO, to construct a generalised stratigraphic column for the entire Basin (Fig. 2). The dominant fossil groups used for biostratigraphic control are conodonts for the Ordovician to Devonian, and palynomorphs for the Carboniferous to Tertiary. Many other groups are also useful (eg., ostracods, microvertebrates, foraminifera), especially in samples without conodonts and palynomorphs. The Phanerozoic Timescale used in Figures 2, 3, 5 and 9 are based on the AGSO Australian Phanerozoic Timescales Series (1989-1991).

PALAEOZOIC SYSTEMS

1. Cambrian

Cambrian rocks have not been identified in the Canning Basin, making it the only sedimentary basin on the Australian craton lacking strata of this age. It has been suggested that Cambrian sediments may be found with more detailed work (Shaw *et al.* 1992).

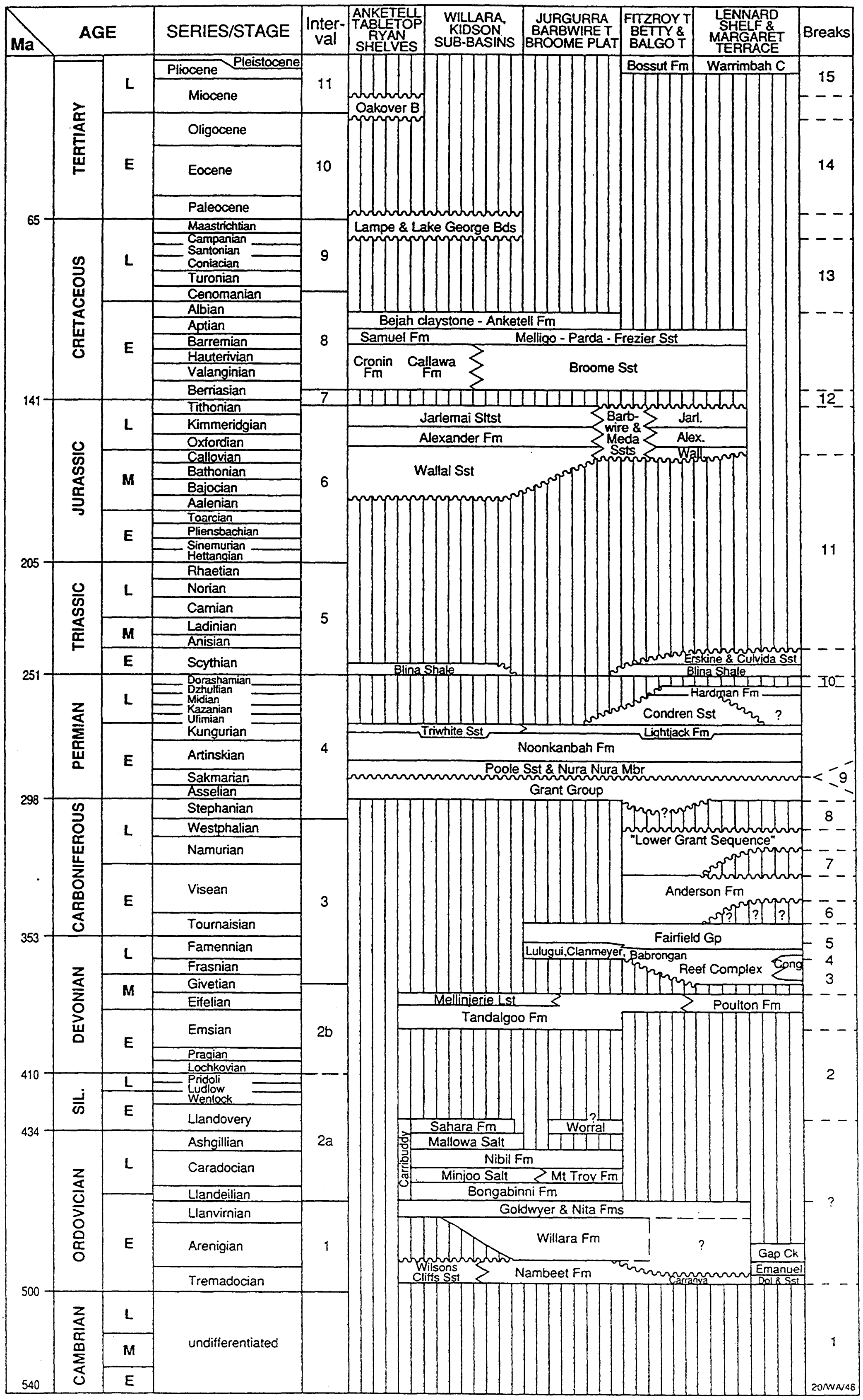
2. Ordovician (Fig. 3)

The review of the Ordovician of the Canning Basin presented by McTavish & Legg (1976) has been updated by more recent work. Watson (1988), reanalysed the Ordovician conodont biostratigraphy, and Nicoll *et al.* (1992) have summarised correlation and sealevel curves from the Early Ordovician part of the Canning sequence. Gorter (1992) shows generalised interbasinal correlation of the Canning with other Australian Ordovician sequences.

The first Ordovician fossil described from the Canning Basin (from the Prices Creek area; Fig. 1) was the brachiopod *Spanodonta hoskingae* Prendergast 1935, later revised by Laurie (1987). The sequence in this area was then believed to be of Late Palaeozoic age until detailed palaeontological work by Guppy & Opik (1950) led to the recognition of Ordovician faunas. They named the Early to Middle Ordovician sequence the Prices Creek Group, consisting of the Emanuel Limestone and the Gap Creek Dolomite. Since then, the palaeontology of the nautiloids (Teichert & Glenister 1952, 1954; Collins 1959), conodonts (McTavish 1961, 1971, 1973; Lindstrom *et al.* 1972), a cystoid (Brown 1964), and trilobites and graptolites (Legg 1976, 1978) has been investigated. Recent investigations (Nicoll *et al.* in press) have recognised two new formations within the Prices Creek Group: a basal Kunian Sandstone, overlain by the Kudata Dolomite and a revised Emanuel Formation (Fig. 3). In the northeastern corner of the Canning Basin Casey & Wells (1964) figured a dikelocephalinid trilobite from Ordovician sandstones, assigned by McTavish (in Playford *et al.* 1975) to the Carranya Beds.

The presence of Ordovician strata in the subsurface was first recognized when Glenister & Glenister (1958) identified Ordovician conodonts in the Roebuck Bay 1 (Fig. 1) and Dampier Downs 1 Wells. Ordovician sediments are now known in subsurface sequences in numerous wells drilled south and west of the Fitzroy Trough. The oldest subsurface Ordovician unit, the Nambeet Formation, was first recognized and defined in Samphire Marsh No. 1 Well (type section, 1240-2015 m), where it was dated as late Tremadocian-early Arenigian on the basis of conodonts (Glenister & Furnish 1961), graptolites, trilobites, and ostracods (Tomlinson 1961). It correlates with the outcropping Emanuel Formation and Kudata Dolomite, and subsurface Kunian Sandstone (Fig. 3). The Willara Formation (type section 2510-3142 m in Willara 1 Well) conformably overlies the Nambeet Formation, and was first defined by McTavish (in Playford *et al.* 1975) to replace the invalid name 'Thangoo Limestone' (a junior homonym of the Devonian Thangoo Calcarenite). In the Kidson Sub-basin the Wilsons Cliff Sandstone was proposed by McTavish & Legg (1976) as a Willara equivalent. Recent work on conodonts (Nicoll, in prep.) shows the Willara Formation to have an Arenigian to earliest Llanvirnian age. The Goldwyer Formation is incomplete in its type section (Thangoo 1A, 848-1060 m), but thicker sequences are present elsewhere, e.g. in Willara 1 (736 m), where it conformably overlies the Willara Formation, and in Blackstone 1 (739 m), the only well of the six dealt with here where the Ordovician has been intercepted.

Fig. 2. Generalised stratigraphic column for lithostratigraphic units in the Canning Basin. The third column gives numbered 'sedimentary intervals' as used by Forman & Wales (1981; modified to accommodate age revisions for the Carribuddy Group as discussed in the text). The column on the right side numbers major breaks in the Phanerozoic sequence from 1-15. Palaeozoic breaks (1-10) are discussed in the text based on their occurrence in six wells analysed for the Lennard Shelf (see Fig. 10). Biostratigraphic evidence indicates that some breaks (e.g. 6,7) do not extend into the Fitzroy Trough. Note that some stratigraphic relationships cannot be depicted on a generalised figure: in parts of the Lennard Shelf (e.g. Blackstone 1) the Anderson Formation is missing, and in Mimosa 1 both the Anderson and the Lower Grant Sequence are missing (see Fig. 10). The age of the Sahara Formation is uncertain, and some strata referred to it in the literature are known to be Devonian in age (see text).



Ma
AGE
SERIES/STAGE
Inter-val
ANKETELL TABLETOP RYAN SHELVES
WILLARA, KIDSON SUB-BASINS
JURGURRA BARBWIRE T BROOME PLAT
FITZROY T BETTY & BALGO T
LENNARD SHELF & MARGARET TERRACE
Breaks
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SIL.
ORDOVICIAN
CAMBRIAN
65
141
205
251
298
353
410
434
500
540
Pliocene
Pleistocene
Miocene
Oligocene
Eocene
Paleocene
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Barremian
Hauterivian
Valanginian
Berriasian
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Norian
Carnian
Ladinian
Anisian
Scythian
Dorashamian
Dzhulfian
Midian
Kazanian
Ufimian
Kungurian
Artinskian
Sakmarian
Asselian
Stephanian
Westphalian
Namurian
Visean
Tournaisian
Famennian
Frasnian
Givetian
Eifelian
Emsian
Pragian
Lochkovian
Pridoli
Ludlow
Wenlock
Llandovery
Ashgillian
Caradocian
Llandeilian
Llanvirnian
Arenigian
Tremadocian
undifferentiated
Bossut Fm
Warrimbah C
Oakover B
Lampe & Lake George Bds
Bejah claystone - Anketell Fm
Samuel Fm
Melligo - Parda - Frezier Sst
Cronin Fm
Callawa Fm
Broome Sst
Jarlemai Sltst
Alexander Fm
Barb-wire & Meda Ssts
Jarl.
Alex.
Wall
Wallal Sst
Blina Shale
Erskine & Culvida Sst
Blina Shale
Hardman Fm
Condren Sst
Triwhite Sst
Lightjack Fm
Noonkanbah Fm
Poole Sst & Nura Nura Mbr
Grant Group
"Lower Grant Sequence"
Anderson Fm
Fairfield Gp
Lulugui,Clanmeyer
Babrongan
Reef Complex
Cong
Mellinjerie Lst
Poulton Fm
Tandalgoo Fm
Sahara Fm
Worral
Mallowa Salt
Carribuddy
Nibil Fm
Minjoo Salt
Mt Troy Fm
Bongabinni Fm
Goldwyer & Nita Fms
Willara Fm
Gap Ck
Wilsons Cliffs Sst
Nambeet Fm
Carranya
Emanuel
Dol & Sst
20/WA/46

The Goldwyer is conformably overlain by the Nita Formation (type section in Parda 1, 1184-1270 m), which is well dated (on conodonts, graptolites, trilobites etc.) as of late Llanvirnian age. Watson (1988) has monographed the Ordovician conodonts (mainly the Barbwire Terrace), and other groups investigated include graptolites (Thomas 1960; Skwarko 1967, 1974; Legg, 1976), acritarchs (Combaz & Peniguel 1972; Playford & Martin 1984), and palynomorphs (Foster & Williams 1991). An adaptation of Watson's conodont zonation as it applies to the Ordovician sequence in Blackstone 1 is given in Fig. 4. However recent restudy of the conodont samples from this well, in the context of more detailed biostratigraphic analysis of the Australian conodont succession, now suggests an older (?Arenigian) age than determined by Watson (R.S. Nicoll, pers. comm.).

On the Barbwire Terrace-Broome Platform, and in the Willara Sub-basin (e.g. Gingerah Hill 1) the Nita is overlain by the Carribuddy Group, apparently without a major break (see discussion below). The name Carribuddy Formation was first proposed by Koop (1966: 108) for a basal claystone-evaporite unit 393 m thick in Sahara 1, but Lehmann (1984) raised it to group status, using the much thicker evaporitic sequence in Kidson 1 (1710 m) as a standard reference section, within which five new formations were defined. The age of the lower part of the Carribuddy as redefined is poorly constrained, with a few conodonts (Nicoll, in prep.) and fish remains (Young *et al.* in prep.) of Ordovician aspect from the Bongabinni Formation or equivalents (in Frankenstein 1), which is consistent with the evidence of Foster & Williams (1991) of a latest Ordovician (Ashgillian)-Early Silurian age range for the Mallowa Salt (upper Carribuddy). These new data indicate that much of the Carribuddy is Ordovician (Figs 2,3), rather than Siluro-Devonian as interpreted by Lehmann (1984).

3. Silurian (Fig. 3)

As just noted, the Late Silurian age for the lower part of the Carribuddy Group, presumed by Purcell (1984) and Middleton (1990) based on seismic and lithological correlations of Lehmann (1984), is controverted by new palaeontological data. In the Willara Sub-basin, a unit identified as equivalent to the Mallowa Salt of the upper Carribuddy (in Gingerah Hill 1) may range up into the Early Silurian (Foster & Williams 1991), and on the Barbwire Terrace earliest Silurian conodonts are known from strata referred to the 'Worral Formation' in Acacia 1 (Nicoll & Jones 1982). The Worral Formation was defined by Lehmann (1984: 274), with its type section (457-613 m) in Barbwire 1, where it unconformably overlies the Nibil Formation of the Carribuddy Group (type section 3501-3905 m in Kidson 1), and is unconformably overlain by the Tandalgoo Formation (see below). However, both the Mallowa Salt and the overlying Sahara Formation lack fossils in their type sections (in Kidson 1) as defined by Lehmann (1984), and some strata interpreted as 'Sahara Formation' are known to be of Devonian age (see below). However we cannot exclude that the type Sahara in the Kidson Sub-basin is the equivalent of the Worral on the Barbwire Terrace. An attempt to illustrate these various uncertain stratigraphic relationships is given in Figs 2 and 3. Additional Silurian sediments may be identified with more detailed biostratigraphic analysis of strata referred to the 'Carribuddy Group', which are widespread south of the Barbwire Terrace (e.g. Wells 1980, fig. 48).

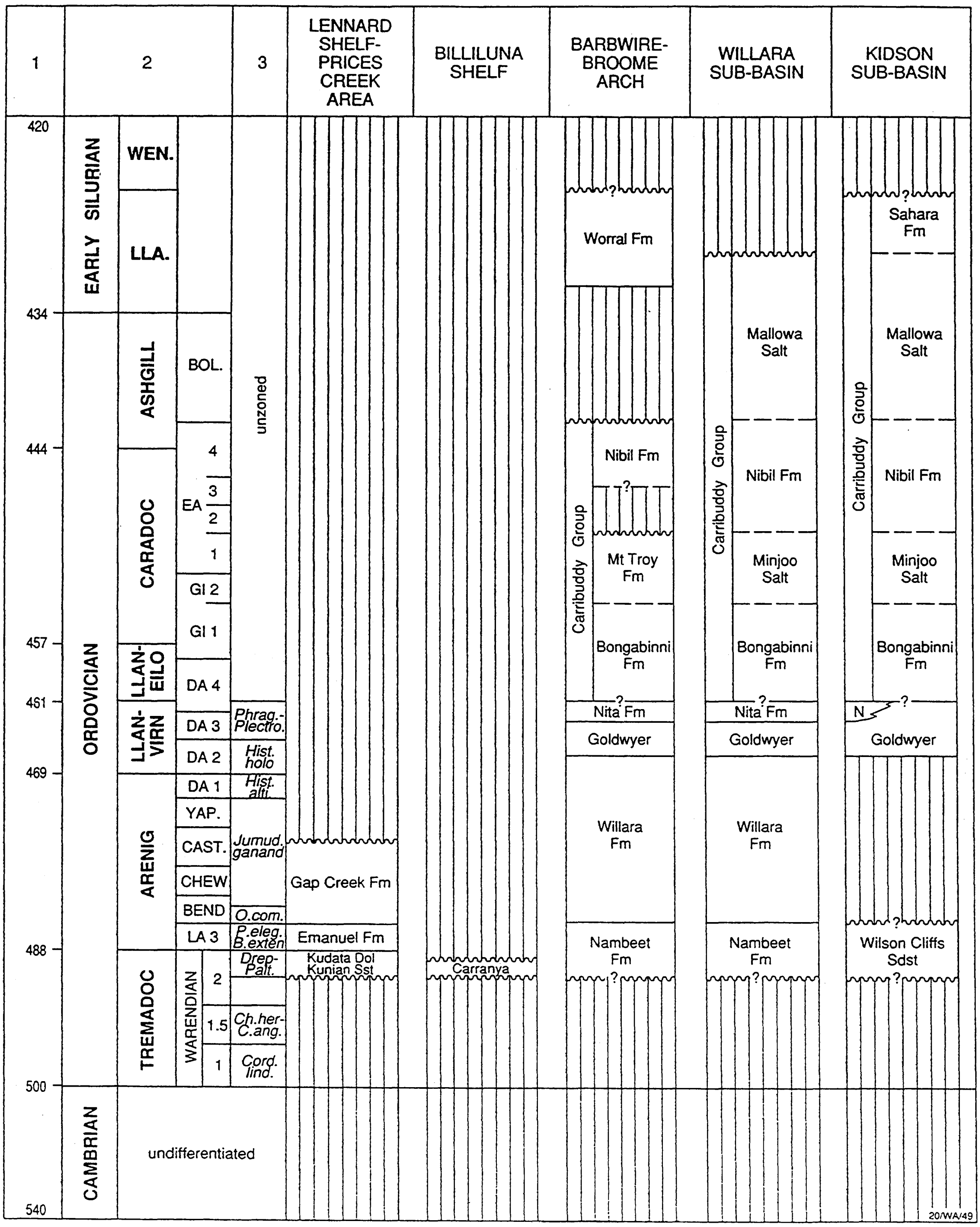


Fig. 3. Summary stratigraphic column for the Ordovician and Silurian of the Canning Basin. Timescale calibration (column 1) is from Webby & Nicoll (1989). Column 2 shows standard series against the Australian graptolite stages (abbreviated in ascending order: Lancefieldian, Bendigonian, Chewtonian, Castlemainian, Yapeenian, Darriwilian, Gisbornian, Eastonian, Bolindian). Abbreviations in column 3 represent Australian conodont zones (after Nicoll *et al.* 1992, Nicoll in prep.).

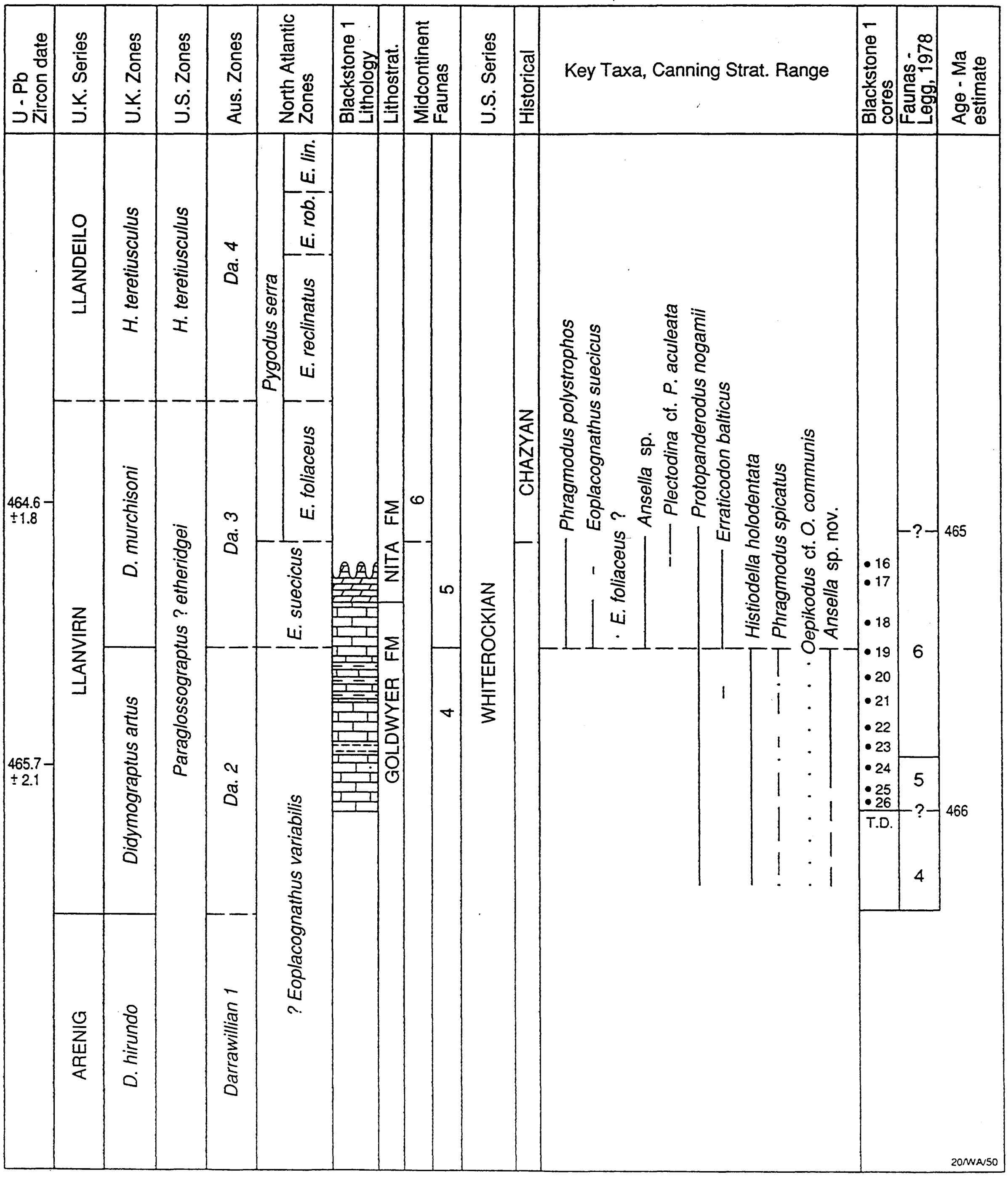


Fig. 4. Correlation of conodonts from the upper Goldwyer and Nita Formations with established graptolite and conodont biozones. Adapted from Watson (1988) and modified from Jones & Young (1990c; see caption to their fig. 2 for more details). Nicoll (in prep.) has identified the *Histiodella holodentata* conodont zone from the uppermost Willara and lower Goldwyer, and the *Phragmodus-Plectodina* zone from the upper Goldwyer and Nita Formations. The boundary between these zones approximates to the Da2/Da3 boundary of the Victorian graptolite sequence.

4. Devonian (Fig. 5)

Since Teichert's studies mentioned above there have been many major systematic and biostratigraphic contributions on the Devonian of the Canning Basin, including brachiopods (Veevers 1959a, Strusz 1992), bryzoans (Ross, 1961), corals (Hill 1936, 1954; Hill & Jell 1970), stromatoporoids (Cockbain 1984), conodonts (Glenister & Klapper 1966; Seddon 1970; Druce 1976; Nicoll & Druce 1979; Nicoll 1980), ammonoids (Delepine 1935; Glenister 1958c, 1960; Petersen 1975), foraminiferids (Crespin 1961), radiolarians (Glenister & Crespin 1959; Nazarov, Cockbain & Playford 1982), sponges (Howell 1952; 1956; 1957), fish (Gross 1971, Miles 1971, Miles & Young 1977, Miles & Dennis 1979, Dennis & Miles 1979-1983, Gardiner & Miles 1975, Gardiner 1984, Long 1985-1988, Young 1984, 1987, Young *et al.* 1989), crustaceans (Briggs & Rolfe 1983), plant microfossils (Playford 1976; Balme 1988, Grey 1991, 1992). and phytoplankton (Colbath 1990).

Major Devonian formations are summarised in Fig. 5. As just noted, some beds previously regarded as equivalent to the upper part of the Carribuddy Group ('Carribuddy A', equivalent to the Sahara Formation of Lehmann, 1984), are shown by microvertebrate and conodont evidence to be Devonian in age (Nicoll & Young 1987; Nicoll, in prep., Young *et al.* in prep.). These may be equivalent to the Tandalgoo Sandstone on the Broome Platform (type section 1128-1727 m in Sahara 1; Koop 1966), and/or the Poulton Formation (type section in Blackstone 1; see appendix) on the Lennard Shelf (Foster & Williams 1991; see also Wells 1980). The age of the Tandalgoo is based on microvertebrate remains from Wilson Cliffs 1 (Gross 1971), from a level considered by Creevey (1971) to be Tandalgoo Formation.

Age control for the Devonian is based primarily on conodonts. The biostratigraphic evidence afforded by this group (e.g. Seddon 1970) led to a major revision (Roberts et al. 1972) of the earlier brachiopod zonation of Veevers (1959). The brachipods of the *Crurithyris apena Zone* were shown to be late Frasnian, rather than earliest Frasnian (Roberts et al. 1972), and Strusz (1992) recently indicated some Oscar Range localities, in which the conodont evidence (Nicoll 1980) showed they range into early Famennian. Figure 6 shows the range of biostratigraphically useful conodont species from the Late Devonian of the Canning Basin against the standard conodont zonations of Ziegler & Sandberg (1984) and Austin *et al.* (1985).

A detailed ostracod zonation for the Middle-Late Devonian of Europe and South China has been developed using entomozoacean ostracods (Groos-Uffenorde & Wang 1989). This group, reported from wells on the Lennard Shelf in Napier 5 (Jones, in Roberts *et al.* 1972) and recently in Mimosa 1 (Jones & Young 1992), has considerable correlation potential for the Canning Basin. The entomozoacean zonation is shown in Fig. 7 against the standard conodont zonation.

Ammonoids have also been widely used for biozonation in the Devonian. Using new data from the Canning Basin, Becker *et al.* (1991b) have developed a detailed goniatite biostratigraphy for the Frasnian, consisting of 12 divisions for international correlation, and a finer division (21 biozones) for regional correlation within the basin. Their scheme, integrated with conodont zones and sealevel changes within the Canning, is reproduced in Fig. 8.

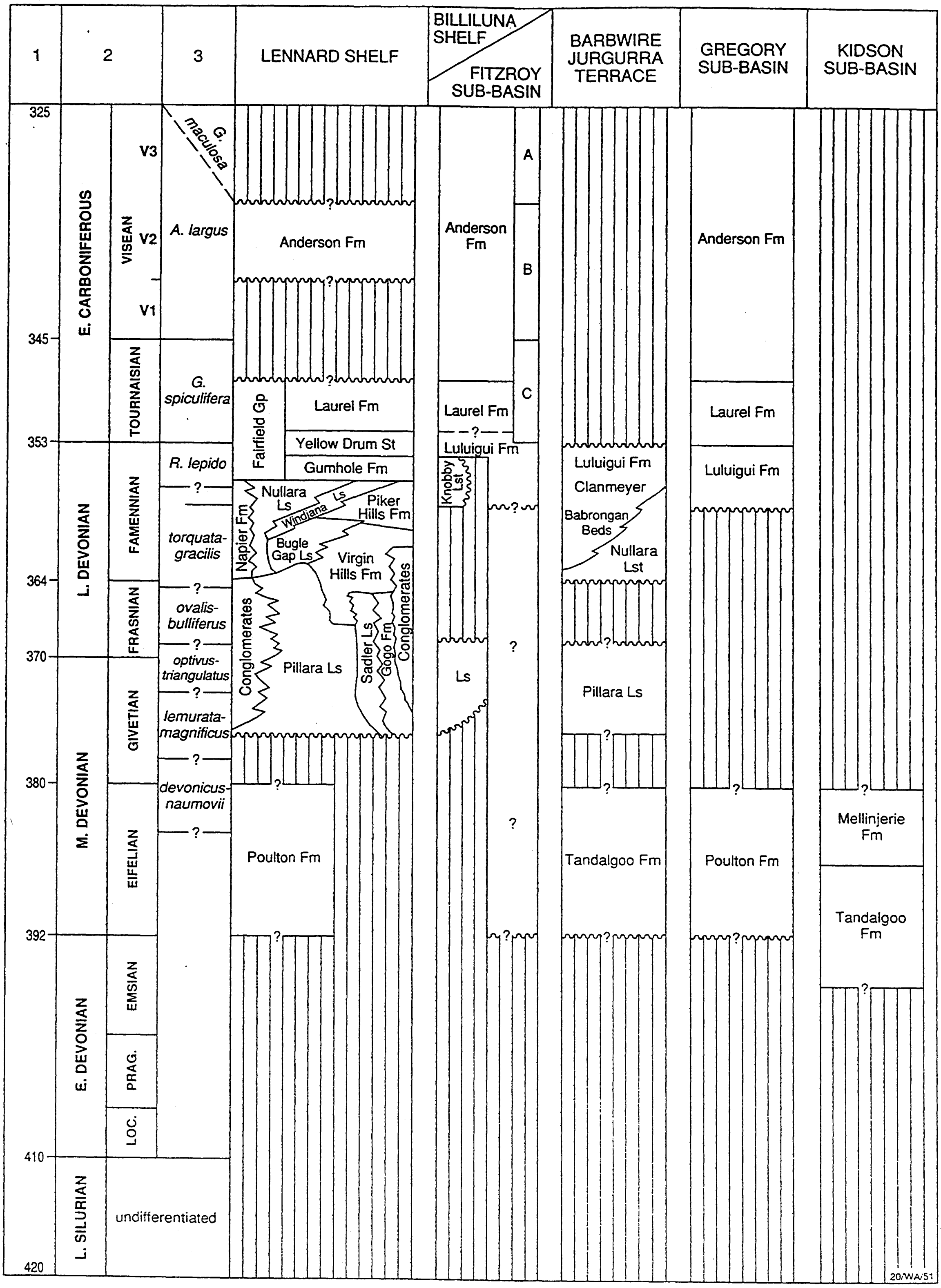


Fig. 5. Summary stratigraphic column for the Middle Palaeozoic (Eifelian-Visean) of the Canning Basin. Palynological zonation for the Givetian-Frasnian after Young (1989) and Grey (1991); for the Famennian and younger based on Kemp *et al.* (1977).

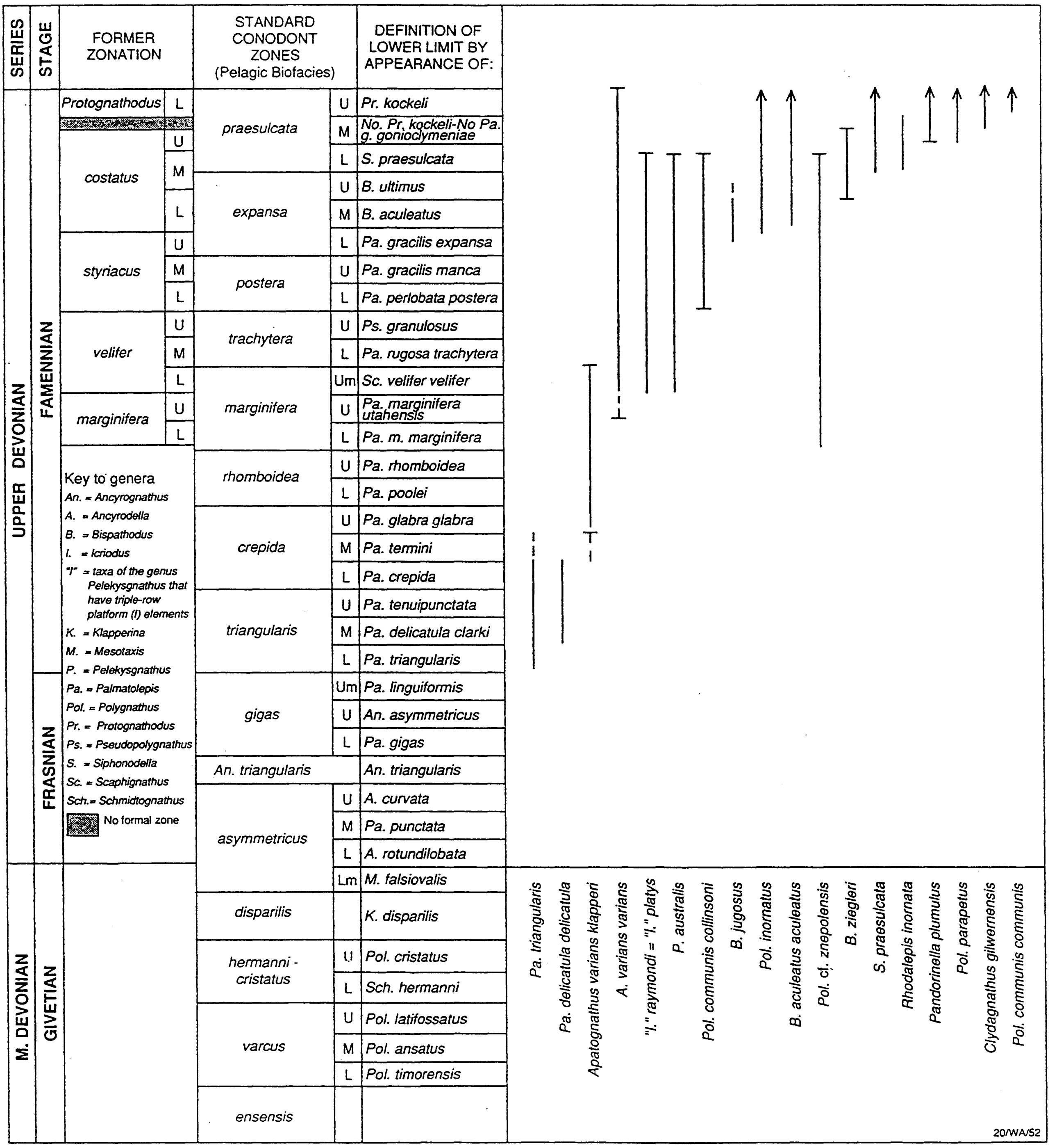


Fig. 6. Biostratigraphically useful conodont species from the Late Devonian of the Canning Basin shown against the standard conodont zonation (modified from Jones & Young 1990a, fig. 3). The conodont zonation is based on Ziegler & Sandberg (1984) and Austin *et al.* (1985). There is a more recent revision of the zonal subdivision for the Frasnian proposed by Ziegler & Sandberg (1990), which is shown in Fig. 8.

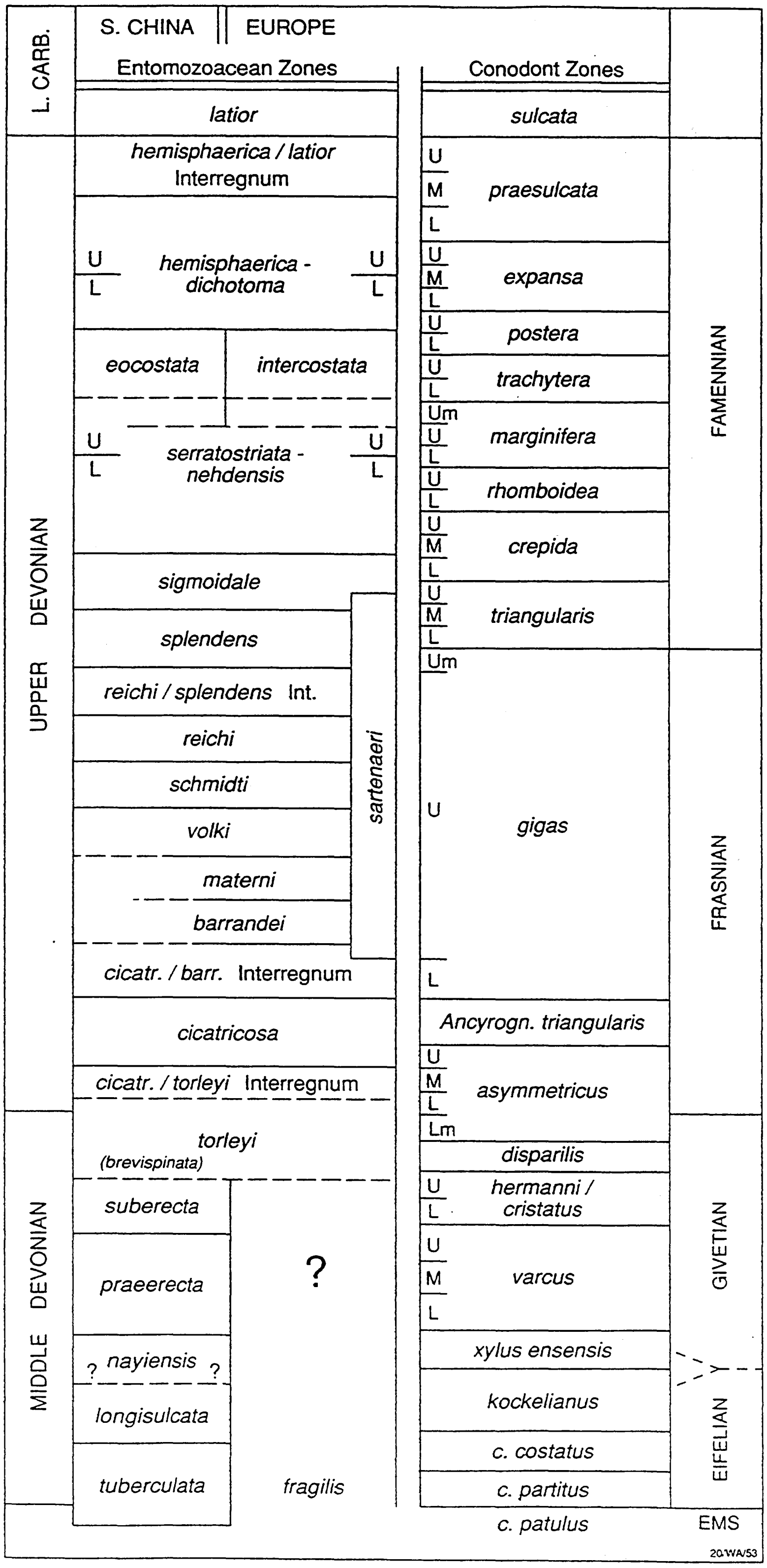


Fig. 7. Summary entomozoacean zonation for the Middle-Late Devonian based on Groos-Uffenorde & Wang (1989). Alternative positions for the base of the *intercostata* Zone are from Buggisch *et al.* (1986: 28; coarsely dashed line) and Buggisch *et al.* (1978: 109; finely dashed line). From Jones & Young (1992, fig. 2).

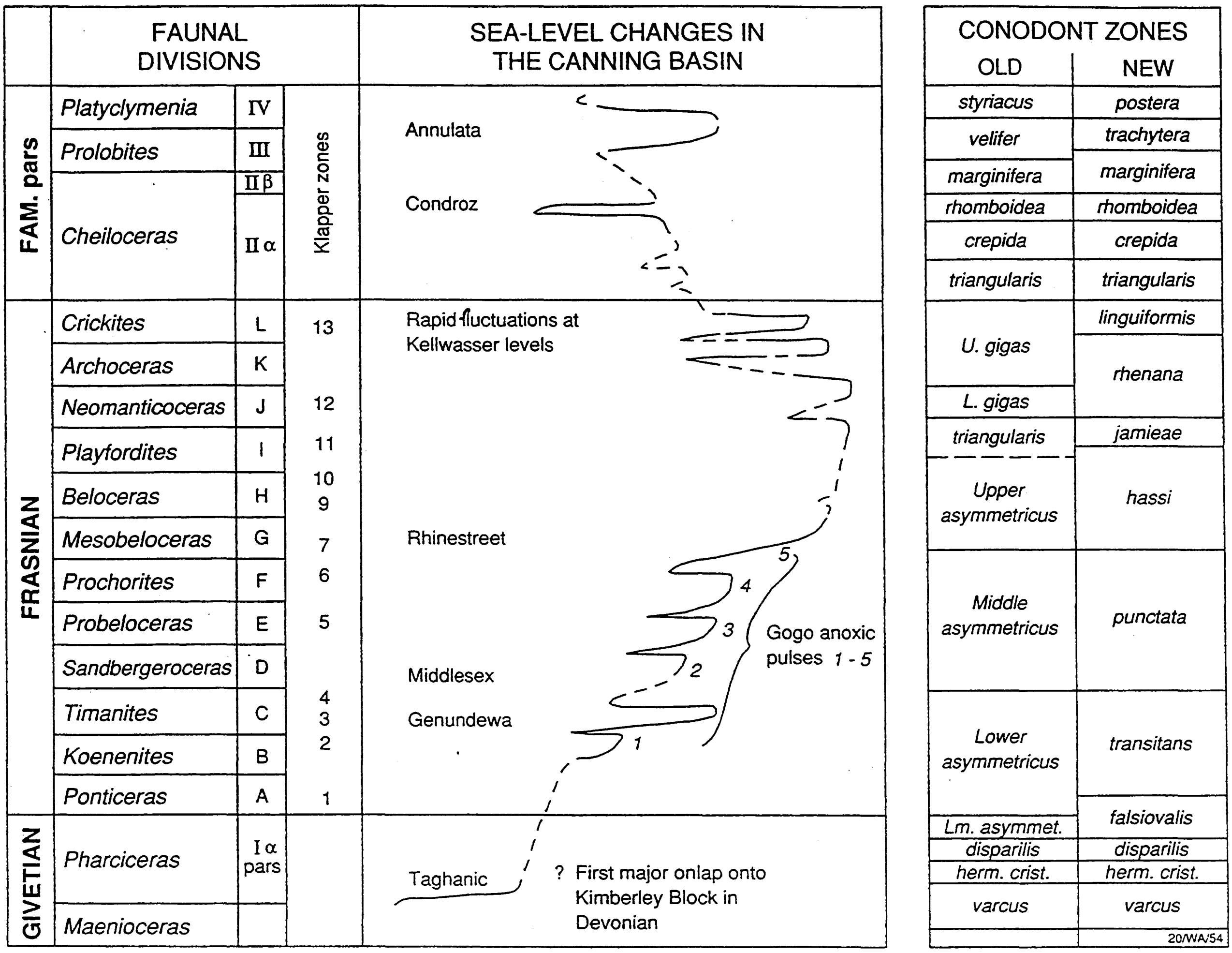


Fig. 8. Suggested eustatic facies movements which affected reef development in the Canning Basin (adapted from Becker *et al.* 1992, fig. 10, with their faunal divisions for ammonoids and conodonts shown in the left column). Conodont zonations of Ziegler (1962) and Ziegler & Sandberg (1990) shown on the right for comparison.

5. Carboniferous (Figs. 5,9)

Prior to 1935, the investigations of field geologists E.T. Hardman (1884, 1885) and T. Blatchford (1927) had indicated that most of the outcropping limestone of the Fitzroy Basin was Carboniferous in age. However the first detailed palaeontological studies, of goniatites by Delepine (1935) and corals by Hill (1936), showed that in fact most of the limestone is Devonian. Authentic Carboniferous rocks were later recognized in 1955 from subsurface (Anderson Formation) by Opik (in McWhae *et al.* 1958), and in 1956 from outcrop (Laurel Formation) by Thomas (1957; 1959c).

Several fossil groups have since been studied in the Carboniferous part of the sequence, including brachiopods (Veevers 1959b; Thomas 1971), bryozoans (Ross 1961), corals (Hill 1954; Hill & Jell 1970), conodonts (Glenister 1960; Nicoll & Druce 1979), ammonoids (Glenister 1960), foraminiferids (Crespin 1961), 1982), sponges (Howell 1952; 1956; 1957), and plant microfossils (Playford 1976; Balme 1988). Ostracods were used to provide correlations for Carboniferous and Late Devonian rocks encountered in petroleum exploration wells in the Canning Basin (Jones, 1959, 1961a, 1962a,b). Three Tournaisian zones derived from study of Carboniferous ostracods from the Bonaparte Basin (Jones 1989) can be applied in the Canning (Jones 1991, chart 1), and a summary conodont zonation for the Carboniferous is given by Jones (1991, chart 2). Lithostratigraphic units of Carboniferous age are shown in Figs. 5 and 9.

6. Permian (Fig. 9)

The earliest record of Permian brachiopods from the Canning Basin was by Hosking (1932), who described two orthotetaceans, *Streptorhynchus luluigui*, now regarded as an index fossil for the Hardman Member of the Liveringa Formation (Thomas, 1958, p.565), and a *Derbyia*-like form. Since then, Permian brachiopods have been monographed by Coleman (1957), Thomas (1958, 1971), Archbold (1988), and Archbold & Thomas (1984, 1985a,b, 1986, 1987). Dickins (1963) described the Permian pelecypod and gastropod faunas of the Canning Basin, bryozoan faunas were described by Crockford (1957), and crinoid faunas by Teichert (1949) and Webster & Jell (1992). The palynological zonation for the Permian of Western Australia given in Fig. 9 (Kemp *et al.* 1977; Foster & Waterhouse 1988) is based largely on the succession in Blackstone 1 worked out by Balme (1968). Recently Archbold & Dickins (1991) have summarised the Permian stratigraphy of the Canning Basin against ammonoid, bivalve, brachiopod and palynomorph zonations, and Jones & Truswell (1992) have correlated a new palynomorph zonation from eastern Australia with Late Carboniferous-Early Permian sequences in the west, including those from the Canning.

MESOZOIC AND CAINOZOIC SYSTEMS

7. Triassic to Cretaceous (Figs. 2,9).

The earliest Triassic formations include the Millyit Sandstone (probably crossing the Permian/Triassic boundary on unpublished palynological data), and the Blina Shale. The latter is well dated on its flora (palynomorphs reported by Balme 1962) and diverse fauna, including fish remains, forams, conchostracans, lingulid brachiopods (Tasch & Jones 1979), and amphibian

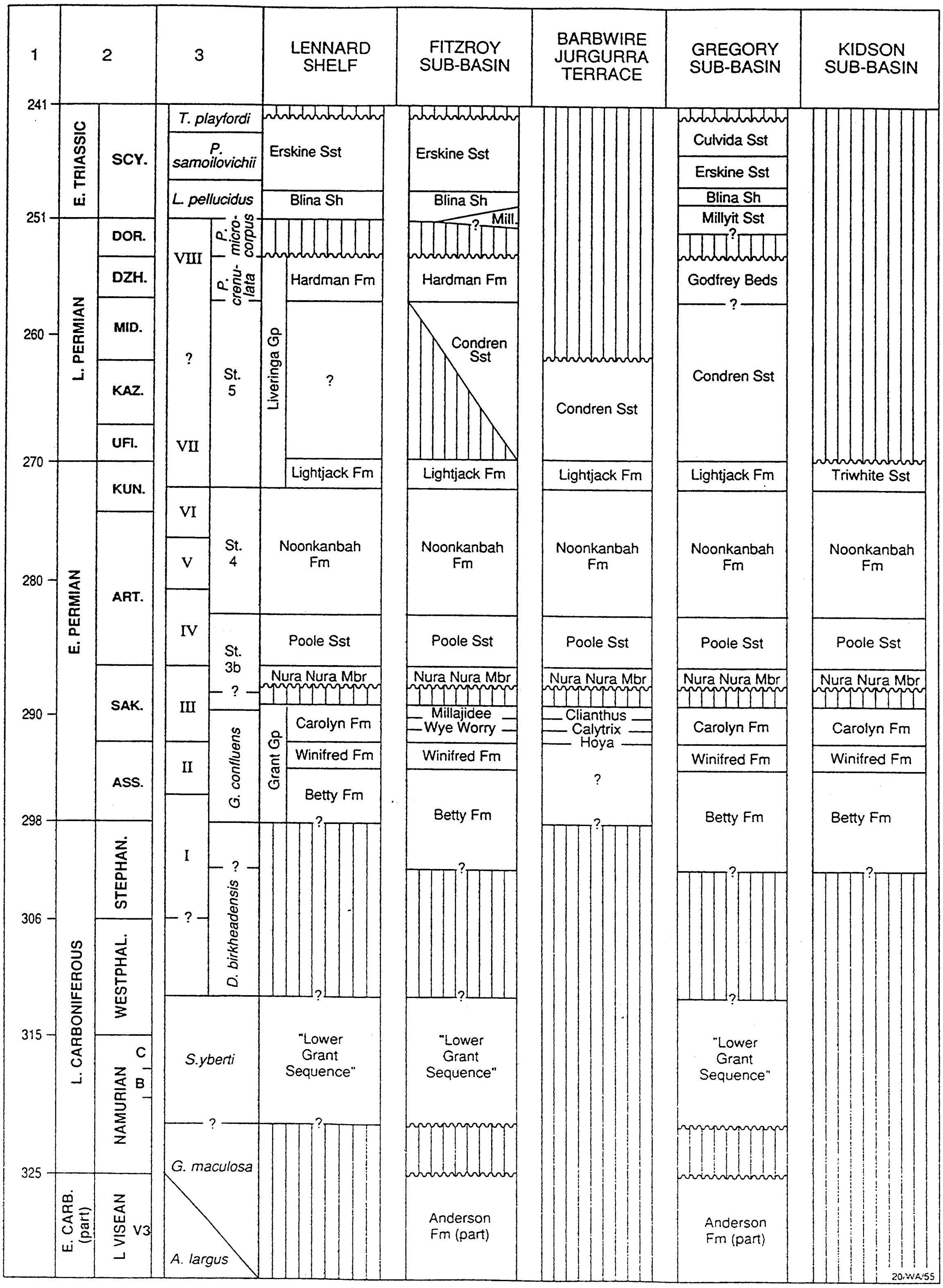


Fig. 9. Summary stratigraphic column for the Late Carboniferous to earliest Triassic of the Canning Basin. Palynomorph zonation after Kemp *et al.* (1977) and Foster & Waterhouse (1988).

remains (e.g. Cosgriff 1965). The overlying Culvida and Erskine Sandstones are dated on macrofloral remains (Yeates *et al.* 1975; White & Yeates 1976).

Palaeontological publications on the Late Jurassic - Early Cretaceous include Brunnschweiler's (1960) systematic study of a Jurassic marine fauna from the Dampier Peninsula, the Late Jurassic forams reported from Yulleroo 1 by Bischoff (1968), and a diverse marine fauna of brachiopods, bivalves and ammonoids reported from the Alexander Formation (see Towner & Gibson 1980). The Jurassic-Cretaceous Broome Sandstone contains dinosaur footprints (Long 1990).

The overlying formations (Parda-Ankertell Sandstones) have yielded microfaunas and belemnites, and the Bejah Formation contains Radiolaria (Veevers & Wells 1961), of Early Cretaceous (Aptian/Albian) age.

8. Cainozoic (Fig. 2).

Forams, ostracod, vertebrate and macroplant remains occur in various formations which are poorly constrained biostratigraphically. Fossiliferous deposits include the Oakover Beds (with undetermined ostracods), and the Warrimbah Conglomerate, with macropod and crocodilian bones including *Diprotodon australis* recorded by Hardman (1884) from the Lennard River (Veevers & Wells, 1961). Crocodilian and turtle remains from the same area were described by Gorter & Nicoll (1978).

MAJOR STRATIGRAPHIC BREAKS IDENTIFIED ON THE LENNARD SHELF

Detailed biostratigraphic analyses of six wells on the Lennard Shelf were presented previously (Jones & Young 1990a-c, 1991, 1992; Jones, Foster & Young 1991). These indicated the presence of a number of major gaps in the sedimentary sequence. In three of these wells (May River 1, Langoora 1 and Meda 1) Devonian rocks rest unconformably on Precambrian basement, two (Meda 2 and Mimosa 1) were terminated in the Devonian, and only Blackstone 1 encountered Ordovician rocks, but did not reach Precambrian basement.

Here we summarise and update conclusions of previous professional opinions in a synthesis which shows ten major gaps in the Palaeozoic sequence on the Lennard Shelf, as numbered (from oldest to youngest) in Fig. 10.

Stratigraphic break 1

The oldest stratigraphic break in the Basin (1, Fig. 2) brackets the entire Cambrian Period, and most of the Tremadocian, and is included in the long (pre-Devonian) hiatus represented in May River 1, Langoora 1, and Meda 1 (Fig. 10).

Lehmann (1984) postulated a major stratigraphic break between the top of the Nita Formation and the base of the Carribuddy Group (Bongabinni Formation). There is no palaeontological evidence to support this opinion, and subsurface data from the Willara Sub-basin indicate gradational contact between the Nita and 'Carribuddy', which presumably reflects changes in relative sealevel, from onlap to offlap, marking a transition to non-marine deposition (Nicoll *et al.* 1988).

Stratigraphic break 2

A major break (2, Fig. 2) occurs between the top of the Upper Ordovician Carribuddy Group and the base of the Middle Devonian Poulton Formation (or its equivalent, the Tandalgoo Formation, in the Kidson and Willara Sub-basins). Blackstone 1 is the only well of those examined by us that penetrated a pre-Devonian sequence, and as this well contains the type section of the Poulton Formation, we place the break at 7285 ft (in the top of core 16), at the base of the formation as originally defined by McTavish (in Playford *et al.* 1975).

Stratigraphic break 3

Jones & Young (1990a) noted good palaeontological evidence in Meda 1 for a break within the 6175-6686' interval, between cores 11 and 13, which is probably equivalent to the *crepida* and *rhomboidea* conodont zones of the early Famennian (Fig. 6). This is consistent with sequence boundaries used by Southgate *et al.* (in press), placed by them at the 6621' level (see Fig. 10 inset). However the overlying conodont assemblage could be as young as lower *expansa* zone (Jones & Young 1990a). In Mimosa 1 the equivalent break is more extensive because all of the early Famennian is missing, and the underlying strata contain Frasnian conodonts. The ostracod evidence above the break (*eocostata* zone) corresponds to the uppermost *marginifera*-lower *postera* conodont zone (Fig. 7), that is, within the range of the conodont fauna from Meda 1. In

May River 1 and Blackstone 1 the break may be more extensive (duration of at least 14 m.y. suggested by Jones & Young 1990c), but this depends on the age control of the underlying Poulton Formation, which is unconfirmed in its type section (Blackstone 1; see appendix), and unfossiliferous in May River 1 (called 'Poulton' by Forman & Wales 1981, but perhaps a correlative of the May River Conglomerate, which is also unfossiliferous in its type section in Meda 1). In Meda 2 Jones & Young (1990b) identified a major gap between two levels (7506', 7628') dated on conodonts by McTavish (1968a), but the older of these dates (referred to the middle Givetian '*Polygnathus cristata* Zone') remains unconfirmed, and may be incorrect (based on re-examination of a conodont slide from 7509' level; see appendix). There is strong evidence from sequence stratigraphy that Stratigraphic Break 3 is not present in Meda 2, because strata below the supposed break is interpreted as the lowstand systems tract at the base of the 'Fam 1' sequence of Southgate *et al.* (in press). This new interpretation is followed in Fig. 10.

In Meda 1 there is stratigraphic evidence of a break at the top of the May River Conglomerate, which if present must be an older and separate event to the one in the early Famennian. However age control is so uncertain that for the present we infer only one break in the Meda 1 succession (Fig. 10). We note that Grey (1991) reports miospore and conodont evidence of a mid-Givetian (or older?) commencement of Pillara cycle reef development on the Lennard Shelf (left side of Figs. 2,5). The stratigraphic interpretation of an underlying Poulton Formation would thus imply an early Givetian or older age for this formation.

Stratigraphic break 4

The evidence for this break comes from Mimosa 1, where the oldest confirmed Famennian horizon is the mid-Famennian ostracod fauna at 2385 m mentioned above, which occurs just below a major seismic reflector placed at the 2376 m level (Jones & Young 1992). The lowest accepted occurrence of the late Famennian spore *Retispora lepidophyta* is 13 m higher than the ostracod horizon, and above this reflector, at 2372 m. The highest occurrence of *R. lepidophyta* is at 1294 m. The base of *lepidophyta* zone approximates to the middle *expansa* conodont zone (Young 1989), so this seismic reflector could represent a break of two conodont zones (upper *postera*, lower *expansa*), or possibly more if the spore occurrence does not represent the base of the lepidophyta zone in this well. However *lepidophyta* ranges over a 1078 m interval up to the interpreted D/C boundary in this well at 1290 m, so duration of the break was probably short.

We note that this interpretation is at the current limits of biostratigraphic resolution, and the possibility that the identified ostracod zone corresponds to the first occurrence of *lepidophyta* in our region cannot be excluded. Since an equivalent break is not manifested in other wells, this interpretation is heavily reliant on the strong seismic reflector mentioned above. It is assumed that this reflector has been properly placed in the well, and is clearly above the stratigraphic break 3 discussed above.

Stratigraphic break 5

In Meda 1, a possible break (?5, Fig. 10) representing a sea-level fall in the middle *praesulcata* Zone was discussed by Jones & Young (1990a, p. 9). This break was correlated by McTavish (1968a) with a break at 1500 m (4920') in May River 1, and at 5555' in Blackstone 1, where he showed a major unconformity, and he interpreted this break to be present in various other wells. However there are no palaeontological data available to us supporting this interpretation. Jones & Young (1990b) noted a much thicker section in Meda 2 than Meda 1 at about this level. This could be sequence 3A of Southgate *et al.* (in press), which so far has not been identified in any other well on the Lennard Shelf.

In Blackstone 1 McTavish (1968a) shows a possible unconformity at about 5300', just below core 5, within the interval we identify as Yellow Drum Sandstone, but no palaeontological evidence for this is available to us. This may approximate to the D-C boundary, which lies within the upper part of the Yellow Drum (Druce & Radke 1979; Jones unpubl.). However we know of no evidence supporting such a break, so it is not included in Fig. 10. This may represent the same shallowing event in the middle *praesulcata* conodont Zone discussed above for Meda 1.

Stratigraphic break 6

This break is shown in Fig. 10 to occur in three wells (May Rivér, Langoora, Meda 1) in accordance with a widely held stratigraphic interpretation (e.g. McTavish 1968a; Forman & Wales 1981) of an unconformity between the Laurel and Anderson Formations. However there is no palaeontological evidence for the presence or absence of this break on the Lennard Shelf, and in the Fitzroy Trough (e.g. Yulleroo 1) there is apparent conformity between the Laurel and Anderson. More recent stratigraphic interpretations (e.g. Goldstein 1989) do not recognise this break, which may be better interpreted as a conformable lithological change from carbonates to clastics associated with transgression-regression cycles (J. Kennard, pers. comm.). In Blackstone 1 the whole of the Anderson Formation is apparently missing.

Stratigraphic break 7

A break in Meda 1 between the Anderson Formation and the 'Lower Grant Sequence' (previously 'Unnamed Formation'; Jones & Young 1990-92) has been inferred from the fact that in its type section the upper part of the Anderson Formation contains the *G. frustulentus* microflora, which together with associated conodonts (Bischoff, in Jones *et al.* 1973) implies a Visean age (*A. largus* assemblage equivalent). The overlying 'Lower Grant Sequence' contains the *S. ybertii* spore assemblage (in the wells dealt with here identified in Langoora 1, Meda 1, Blackstone 1), which implies the absence of the intervening *G. maculosa* assemblage. This break therefore covers the late Visean and early Namurian. We note that in Mimosa 1, which lies off the edge of the subsurface Famennian platform (Southgate *et al.* in press, fig. 1), both the Anderson and the Lower Grant Sequence are missing. In contrast, in some other wells in the Fitzroy Trough (e.g. Fraser River 1, Grant Range 1) the intervening *G. maculosa* assemblage occurs in an apparently complete palynomorph succession (Powis 1984). As noted above for stratigraphic break 6, the break between the Anderson and 'Lower Grant Sequence' may have been restricted to shelf areas (e.g. Lennard Shelf), although the more extensive break in Mimosa 1 is an exception, perhaps indicating tectonic activity.

Stratigraphic break 8

This break occurs below the base of the Grant Group (referred to Balme's Palynostratigraphic Unit I; see Fig. 9), and above the top of the 'Lower Grant Sequence' just discussed (with the *S. ybertii* Assemblage). The break encompasses the Westphalian-Stephanian boundary and most or all of the Stephanian, and palynologically the *birkheadensis* Zone of Powis (1984), which has not been recognised in any of our six analysed wells. However dating of the lower part of the overlying Grant in these wells is poor. Unspecified Permian spores are recorded in Langoora 1, and in Blackstone 1 the succeeding zone (the *Granulatisporites confluens* Zone of Foster & Waterhouse 1988) occurs within the Grant, but the lowest 400' interval is unfossiliferous. The best biostratigraphic evidence is in Mimosa 1, where the *G. confluens* Zone occurs 13 m above the base of the formation.

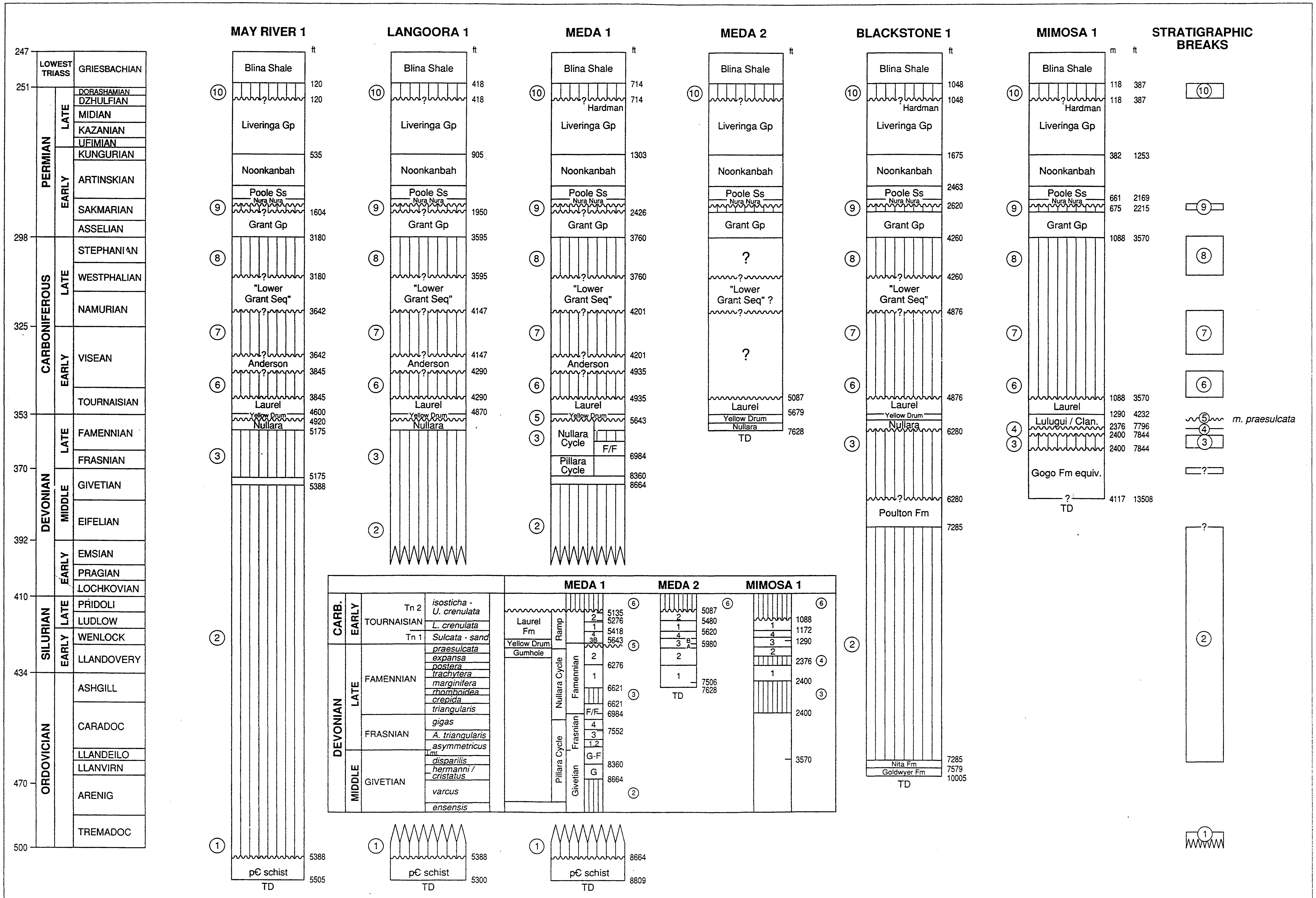
Stratigraphic break 9

Forman & Wales (1981) identified a break between the Nura Nura Member of the Poole Sandstone and the Grant Group in several wells on the Lennard Shelf, which is consistent with other evidence in outcrop of an erosional break at the base of the Nura Nura (e.g. Dickins, Towner & Crowe 1977). This hiatus lies within Unit III of Balmes scheme, equivalent to early Sterlitamakian. It occurs in the following wells (depths approximate): May River 1 (1604'), Langoora 1 (1950'), Meda 1 (2426'), Blackstone 1 (2620') and Mimosa 1 (675m).

Stratigraphic break 10

The youngest Palaeozoic stratigraphic break in wells examined by us is represented by a hiatus between the lowest part of the Blina Shale and the upper part of the Liveringa Group (Hardman Formation). The extent of this gap includes the *Protohaploxypinus microcorpus* Zone of Foster (1982), which is equivalent to the latest Permian Dorashamian (=Changhsingian) Stage. It occurs in the following wells (depths approximate): May River 1 (120'), Langoora 1 (418'), Meda 1 (714'), Blackstone 1 (1048') and Mimosa 1 (118 m).

Fig. 10. Correlation of lithostratigraphic units idenified in six key wells on the Lennard Shelf (arranged geographically from W to E). Circled numbers in the right hand column show the position of 10 stratigraphic breaks identified primarily from biostratigraphy and correlation of the Palaeozoic succession in each well, using information modified and updated from Jones & Young (1990-1992) and Jones, Foster & Young (1991). The 'unnamed formation' of previous usage is now termed the 'Lower Grant Sequence'. Inset shows detailed correlation of the Devonian and Early Carboniferous part of the sequence in Meda 1 and 2 and Mimosa 1. Numbers and letters for the Meda 1 column refer to the stratigraphic sequences identified by Jackson *et al.* (1992), and Southgate *et al.* (in press).


MAY RIVER 1
LANGOORA 1
MEDA 1
MEDA 2
BLACKSTONE 1
MIMOSA 1
STRATIGRAPHIC BREAKS
LOWEST TRIASS
GRIESBACHIAN
DORASHAMIAN
DZHULFIAN
MIDIAN
KAZANIAN
UFIMIAN
KUNGURIAN
ARTINSKIAN
SAKMARIAN
ASSELIAN
PERMIAN
LATE
EARLY
STEPHANIAN
WESTPHALIAN
NAMURIAN
VISEAN
TOURNAISIAN
CARBONIFEROUS
FAMENNIAN
FRASNIAN
GIVETIAN
EIFELIAN
EMSIAN
PRAGIAN
LOCHKOVIAN
DEVONIAN
MIDDLE
PRIDOLI
LUDLOW
WENLOCK
LLANDOVERY
SILURIAN
ASHGILL
CARADOC
LLANDEILO
LLANVIRN
ARENIG
TREMADOC
ORDOVICIAN
247
251
298
325
353
370
392
410
434
470
500
Blina Shale
Liveringa Gp
Hardman
Noonkanbah
Poole Ss
Nura Nura
Grant Gp
"Lower Grant Seq"
Anderson
Laurel
Yellow Drum
Nullara
Nullara Cycle
F/F
Pillara Cycle
pЄ schist
TD
Lulugui / Clan.
Gogo Fm equiv.
Poulton Fm
Nita Fm
Goldwyer Fm
m. praesulcata
CARB.
Tn 2
Tn 1
isosticha - U. crenulata
L. crenulata
Sulcata - sand
praesulcata
expansa
postera
trachytera
marginifera
rhomboidea
crepida
triangularis
gigas
A. triangularis
asymmetricus
Lmt.
disparilis
hermanni / cristatus
varcus
ensensis
Laurel Fm
Gumhole
Ramp
Famennian
Frasnian
Givetian
G-F
20/WA/56

APPENDIX: UPDATED BIOSTRATIGRAPHIC SUMMARIES OF SELECTED WELLS ON THE LENNARD SHELF

The following summaries are in the same format as previously provided for the same six wells by Jones & Young (1990-1992) and Jones, Foster & Young (1991). However the information and interpretations have been updated and revised for Meda 1, Meda 2, Blackstone 1, and Mimosa 1. The wells are arranged geographically from W to E, as in Figure 10. Information is based on well completion reports and various other published and unpublished sources which update the original information. In some cases palaeontological samples have been re-examined.

For each well every level from which palaeontological information has been recorded is listed, with stratigraphic unit name and age specified where this information is available. If several horizons containing fossils indicate the same age, the stratigraphic unit name and age are given beside the lowest level. Depths have been converted to the nearest metre, with the original depth in feet in parentheses. Stage names for the various geological periods conform to usage in the 'Australian Phanerozoic Timescales' series published by the Australian Geological Survey Organisation (preliminary editions, 1989-1990). Throughout, 'E', 'M', and 'L' are abbreviations for Early, Middle and Late subdivisions of units of geological time.

Type sections for two formations have been defined in the wells dealt with here: **May River Conglomerate** (2588-2599m in Meda 1), and the **Poulton Formation** (1941-2220m in Blackstone 1)

DEPTH	FORMATION	AGE

1. MAY RIVER NO. 1 WELL (from Jones & Young 1991)

1266-68 (4154-62')	**Laurel**	**Tournaisian**

Remarks: From core 1 Balme (1967) reported a microfloral assemblage of undiagnostic age, which he referred to the Lower Carboniferous because of the absence of '*Leiozonotriletes naumovae*' (now referred to *Retispora lepidophyta*; the nominate species of the latest Devonian *R. lepidophyta* Assemblage of Playford, 1976). This would probably now be referred to the Tournaisian *Grandispora spiculifera* Assemblage of Playford (1976).

1349-53 (4425-39')	**Laurel**	**Tournaisian**

Remarks: Balme (1967) suggested an Early Carboniferous age for the microfloral assemblage from core 2, based on its general composition, and the presence of *Dibolosporites distinctus* (as revised by Playford 1972, 1976), and *Dictyotriletes* cf. *fitzroyensis*' Fowler, both also in BMR No 2 well (Laurel Downs, 250-52') and Meda 1 (5055-63'; see Jones & Young 1990a). Although *D. distinctus* is a component of Visean microfloras in the Bonaparte Basin, its occurrence as part of the *Grandispora spiculifera* Assemblage in the Laurel is regarded by Playford (1976: 56) to be no younger than late Tournaisian.

1428-30 (4686-93') **Yellow Drum** **Dev.Carb.**

Remarks: *Granulatisporites frustulentus* identified by Balme (1967) from core 3 ranges from late Famennian (Fa 2d) to Visean (Kemp *et al.* 1977) so this level can only be dated within broad limits.

1510-14 (4955-68') **Nullara** **Famennian**

Remarks: Core 5 comes from within 'unit D' of Johnson & Brownhill (1967). Balme (1967) considered the microfloral assemblage from core 5 to have a marked Upper Devonian aspect, although diagnostic forms were absent. Fossil fragments, including forams, ostracods, crinoid ossicles, brachiopods, pelecypods, and fish remains, were mentioned by Johnson & Brownhill (1967) as coming from limestones within their 'unit D' (4920-5175'; subsequently assigned to the Gumhole Formation by Druce & Radke 1979). No further details on these determinations are available.

A Late Devonian age is confirmed by conodonts from core 5. *Pelekysgnathus 'nodosus'* identified by Seddon (1970) from core 5 was placed in synonymy with *P. inclinatus* by Sandberg & Dreesen (1984). These authors show this species to have a minimum age in the upper *praesulcata* Zone. Seddon (1970) also included within his species the material referred to *Pelekysgnathus* sp. by Glenister & Klapper (1966) from outcrop samples (BMR locality K289, in the Horseshoe Range). These specimens were referred by Nicoll & Druce (1979, p. 17) to their new species *P. australis*, which has a more restricted stratigraphic range, with a slightly older upper age limit (in their *Icriodus platys* Zone, equivalent to the lower *praesulcata* Zone; see Jones & Young 1990a, fig. 3). The lower limit of *P. australis* is determined by early occurrences in the Nullara Limestone ('unnamed zone in birdseye limestone' of Nicoll & Druce 1979, p. 17) in which it is associated with *Polygnathus communis collinsoni* (see Nicoll 1980). The latter species first appears in the lower *styriacus* Zone (Druce 1976; cf. Jones & Young 1990a, fig. 3, where the indicated lower limit of this species down to the *marginifera* Zone is now considered doubtful). The presence of *P. australis* in core 5 is cannot be established because of poor preservation of the available specimens, but we note the close comparison of Seddon's figured material (1970, pl. 11, figs 25, 26) with the type figures of Nicoll & Druce (1979, pl. 1).

2. LANGOORA NO. 1 WELL (from Jones, Foster & Young 1991)

37-128 (120-420') **Blina Shale** **E.Triassic**

Remarks: Gorter (unpublished) examined cuttings taken over this interval which have yielded conchostracans (reported as pelecypods by Gardner 1963), lingulid brachiopods and microvertebrate remains (fish scales and teeth, ?amphibian vertebrae, and coprolites), megaspores, and wood remains. This assemblage resembles that discussed by Jones (in Tasch & Jones 1979) for the Blina Shale in Meda 1, and by Jones & Young (1990c) for the same unit in Blackstone 1. As discussed previously (Jones & Young 1990a,c), the conchostracans require derivation from a nonmarine (lacustrine or estuarine) environment. The absence of the foram *Ammodiscus* (which is common in the upper parts of the Blina Shale in Meda 1 and Blackstone 1) suggests a reduction in marine influence, so perhaps only the lower part of the Blina Shale is represented in Langoora 1.

577-81 (1894-1907') Poole/Nura Nura L.Sakmarian-E.Artinskian

Remarks: Fowler (1963a) concluded on the basis of the presence of *Granulatisporites* cf. *trisinus, Verrucosisporites* cf. *pseudoreticulatus, Apiculatisporites cornutus* and *Punctatisporites gretensis* that core 1 is of late Sakmarian to early Artinskian age. Recent re-examination of an existing palynological slide from this core revealed a Stage 3a-3b assemblage, indicating an Early Permian age (see Appendix).

916-919 (3004-14') Grant E.Permian

Remarks: Fowler (1963a) reported sparse and poorly preserved spores in core 3, which she regarded as undoaubtedly Permian in age. The spore content was insufficient to determine whether it was Sakmarian or Artinskian. The relevant slide was not among those received for re-examination.

1225-1230 (4018-34') Lower Grant Sequence L.Carboniferous

Remarks: From core 6 Fowler (1963a) reported a poorly diversified spore assemblage dominated by the distinctive spore informally named *Apiculatisoris cf. maculosis*. A re-examination of the original slides (see appendix) now shows this taxon can be identified as *Spelaeotriletes ybertii*, a key index of the *Grandispora maculosa* and *S. ybertii* Assemblages of Kemp *et al.* (1977). Core 6 is referred to the latter assemblage. Fowler compared these spores to a similar assemblage in the upper part of the Anderson Formation in Fraser River 1 well. As both the *maculosa* and *ybertii* assemblages occur above the top of the Anderson Formation, as defined in the type section in Grant Range 1 (Powis 1984, fig. 2), we assign the *ybertii* Assemblage in core 6 of Langoora 1 to the 'unnamed formation' ('Lower Grant Sequence') previously mentioned for this assemblage in other wells (e.g. Blackstone 1, Meda 1).

The identification of Anderson Formation between 4147-4290' on lithology (see Fig. 10) is not supported by any palaeontological evidence available to us.

1369-1478 (4491-850') Laurel Tournaisian

Remarks: Fowler (1963b) suggested an Early Carboniferous age for the microfloral assemblage over this interval based on the presence of *Dibolosporites distinctus* (reported as *Apiculatisporis turriculaeformis*) from core 7 (4491-502') and core 8 (4552-560'), and *Dictyotriletes 'fitzroyensis'* (Fowler MS name) from core 9 (4845-50'), also in the Laurel Formation in BMR No. 2 well (Laurel Downs, 250-252'), Meda 1 (Jones & Young 1990a), Meda 2 (Jones & Young 1990b), and May River 1 (Jones & Young 1991). Spores reexamined from cores 7 and 8 (with *Dibolosporites distinctus* and *D. medaensis*) now suggest a Tournaisian age (see appendix), within the *Grandispora spiculifera* Assemblage of Playford (1976). The slide examined from core 9 was barren.

1526 (5006') **?Tournaisian**

Remarks: The presence of *Granulatisporites frustulensis* and *Dibolosporites medaensis* in a SWC taken at this depth indicates an Early Carboniferous (Tournaisian) age, but the spore yield is very low, and the lithology at this level according to the Well Completion Report is different from that of the SWC (see appendix by Foster in Jones *et al.* 1991). It is therefore considered likely that this flora is derived from a wash-out of a higher horizon in the well.

Druce & Radke (1979) referred the sequence of dolostone with minor siltstone in the 1484-1551 m interval to the Yellow Drum Sandstone. As the indeterminable ostracods reported by McTavish (1963) from the SWC at 1521 m are the only fossils definitely recorded from this interval, they should be re-examined.

1550-59 (5086-114') **L.Devonian**

Remarks: The palynomorphs from core 10 were recorded by Fowler (1963a) as long-ranging Late Devonian - Carboniferous forms. Recent re-examination of the original palynological slides indicates the presence of a Late Devonian assemblage containing very few spores and abundant acritarchs (see appendix). McTavish (1963) noted arenaceous foraminifera from this core which also suggested a Late Devonian age because of some similarity with the fauna described by Crespin (1961) from the Gogo and Virgin Hills Formations. Mamet & Playford (1968) assigned foraminiferal assemblages from Langoora 1, Meda 2, and two outcrop localities to three *Quasiendothyra* Zones (*Qu. bella*/*Qu.* ex gr. *communis*, *Qu. communis*/*Qu. konensis*, and *Qu.* cf. *kobeitusana-Klubovella*). These zones range in age from the late Famennian upper *Palmatolepis marginifera* Zone to the late Strunian upper *praesulcata* Zone, but the precise content of the Langoora assemblage from core 10 was not specified. A small dipnoan (lungfish) toothplate (BMR V712) from this horizon is consistent with a Late Devonian age.

3. MEDA NO. 1 WELL (modified after Jones & Young 1990a)

73-82 (240-70')
180-6 (590-610') **Blina** **E.Triassic**

Remarks: Balme (1962) recorded the Early Triassic *Lueckisporites* microflora from both these levels. Jones (in Tasch & Jones 1979: 10) recorded fish remains associated with foraminifera from 80-310' down the well, and Conchostraca, lingulid brachiopods and fish fragments in cuttings from the 310-714' interval (see Jones & Young 1990a, fig. 2). The conchostracans indicate derivation from a non-marine (lacustrine or estuarine) environment, with forams indicating marine influence in the top of the sequence. Identified conchostracan taxa (also known from the Early Triassic of the Bowen Basin) confirm the age indicated by spores.

241-250 (790-820')
372-381 (1220-50') **Liveringa** **L.Permian**

Remarks: Balme (1962) recorded a '*Tholosporites* microflora' (= *Dulhuntyispora* Assemblage of Balme 1964) from these horizons, indicating a Late Permian age. His subsequent work placed the upper 40 m or so of the Liveringa Formation in this well, and in Blackstone 1, in the informal palyno-stratigraphic Unit VIII of Kemp *et al.* (1977). Palynological evidence for fixing the limits of Unit VIII within the Late Permian was discussed by (Kemp *et al.* 1977: 189). The apparently younger *Protohaploxypinus microcorpus* Zone was included above Unit VIII in the Canning Basin succession by Gilby & Foster (1988, fig. 4). Foster & Jones (in prep.) have summarised evidence now indicating that the *Playfordia crenulata* Assemblage Zone previously recognised in eastern Australia is probably equivalent to most or all of Unit VIII. This confirms that the upper 40 m interval in Meda 1 and Blackstone 1 is a lateral equivalent of the marine Hardman Formation (Kemp *et al.* 1977: 188), which is regarded as Late Permian (Dzulfian) in age (Archbold & Dickins 1991). The major break indicated by palynology between the 186 and 241 m levels (610-790') identified by Balme (1962) was thought to represent the contact between the Blina Shale and the underlying Liveringa Group (placed within these limits at the lithological break at 714'). The new evidence now indicates that this break probably only represents the latest Permian Dorashamian Stage (= Changhsingian) Stage. The lower part of the Liveringa Group is referred by Kemp *et al.* (1977, fig. 5) to their palyno-stratigraphic unit VII, which may extend down into the late Early Permian (see also Archbold & Dickins 1991).

390 (1280')
393 (1289')
407 (1336')
409 (1344')
422 (1383')
430-436 (1410-30')
480-482 (1576-81') **Noonkanbah** **Artinskian**

Remarks: Balme (1962) recorded a *Striatites* microflora (= *Vittatina* - Assemblage of Balme 1964) from the above horizons, with a minor break between 381 and 390 m probably corresponding to the base of the Liveringa Formation. Foraminifera from the 430-436 level (core 1) also indicate Noonkanbah Formation (Crespin 1962). Brachiopods from the same core indicate a Permian age (Thomas 1962). The top of the Noonkanbah in Blackstone 1 is made equivalent to the top of palynostratigraphic unit VI of Kemp *et al.* (1977, fig. 5), but Archbold & Dickins (1991) show it possibly extending above this into the base of Unit VII.

592-598 (1943-63') **Noonkanbah** **Artinskian**
650-660 (2134-64') **Noonkanbah or Poole** **E.Artinskian**

Remarks: The upper interval yielded some scarce forams, a spiriferid brachiopod fragment (Thomas 1962), and a spore assemblage provisionally assigned to the '*Cirratriradites* microflora' (Balme 1962). Species of *Cirratriradites* dominate from the 650 m level, in this respect differing notably from assemblages higher in the section. Balme (1964: 61) noted the high abundance of such spores in the late Sakmarian-early Artinskian interval within his *Nuskoisporites* Assemblage (palynostratigraphic unit IV of Kemp *et al.* 1977), and in Meda 1 Balme (1962) assigned this microflora an early Artinskian age, and referred these levels either to the lower Noonkanbah or the Poole Sandstone.

661 (2170')
669 (2195')
671-672 (2200-06')
686-687 (2250-55') Poole E.Artinskian

Remarks: Balme (1962) again identified the '*Cirratriradites* microflora' at these levels, which he assigned to the Poole Sandstone, except for the lowest level which was very poorly preserved.

720-724 (2361-75')
747 (2450') Poole or Grant L.Sakmarian-E.Artinskian

Remarks: The '*Cirratriradites* microflora' was identified at both levels by Balme (1962). In the upper level (core 3) a foraminiferal assemblage was recorded by Crespin (1962), with a suggestion that this could be equivalent to the Nura Nura Member of the Poole Sandstone. The Nura Nura in Blackstone 1 straddles the boundary between palynostratigraphic Units III and IV of Kemp *et al.* (1977).

748 (2455')
750 (2460')
761 (2496') Grant L.Sakmarian

Remarks: A *Nuskoisporites* microflora was provisionally identified at 748 m, and this microflora is confirmed at 750, indicating Grant Formation at this level (Balme 1962). On palynological evidence a precise upper limit for the Grant was difficult to place, but he suggested that it occurred somewhere in the 687-750 m interval (2255-460'). The upper part of the *Nuskoisporites* microflora is equivalent to unit III of Kemp *et al.* (1977) which is Late Sakmarian (see Archbold & Dickins 1991).

No palaeontological evidence has been recorded from this well for identifying the lower part of the Grant (equivalent to unit II of Kemp *et al.* 1977), which in Blackstone 1 is represented by some 340 m of section (2752-3864' interval).

1233-1237 (4045-60') 'Lower Grant Sequence' Carboniferous

Remarks: Both *Ahrensisporites cristatus* and the nominate species of the *Spelaeotriletes (Anabaculites) ybertii* spore Assemblage of Kemp *et al.* (1977) have been recorded from core 6 (Playford & Powis 1979, 378, table 1). The age limits of the *ybertii* Assemblage are unclear, and could lie anywhere in the early Namurian-Westphalian interval.

140' below this core, the Anderson Formation has been identified on lithology to occur between 4201-935' (see Jones & Young 1990a, fig. 1), but we know of no palaeontological evidence supporting this.

1524-27 (5000-10') **Laurel** **E.Carboniferous**

Remarks: Jones (1962a) identified the ostracod *Cryptophyllus* from cuttings at this level, which indicates a minimum age of Early Carboniferous. The same species also occurs in core 9 (see below). Jones (1962b: 11) erected the species *Cryptophyllus diatropus* for this material, and referred specimens from other bores (BMR 2 Laurel Downs; Sisters 1, Meda 2) to the same species. In the Bonaparte Basin this species is apparently confined to Tournaisian strata (Jones 1962b, 1989); it ranges up into the Septimus Limestone (middle Tournaisian) but is replaced by another species in the Milligan Beds (Visean). This evidence therefore indicates a Tournaisian age for this level.

1541-43 (5056-62') **Laurel** **E.Carboniferous**

Remarks: Playford (1972: 312) recorded two spore species from this level (core 8) which were referred by Playford (1976) to the genus *Dibolosporites* (*D. distinctus, D. medaensis*). These forms were first recorded by Balme (1967) in May River 1. Both species belong to the *Grandispora spiculifera* Assemblage of Playford (1976), giving a Tournaisian-Visean age range for this interval.

1597-99 (5239-45') **Laurel** **M.Tournaisian**

Remarks: Glenister (1958a) recorded a large and well preserved fauna of conodonts and ornate fish remains from core 9. In a recent re-examination of the material, G. Klapper (pers. comm.) has identified *Clydagnathus darensis* and *Pseudopolygnathus primus* (the former species he considers not synonymous with *Cl. cavusformis*; cf. Nicoll & Druce 1979: 22). The same two species occur in association in Meda 2 in the 5438-45' interval. In the Bonaparte Basin Druce (1969) recorded the lowest occurrence of *Cl. darensis* in the Septimus Limestone (middle Tournaisian in age). In cuttings from this same level (5239-45') in Meda 1 Klapper has identified *Clydagnathus cavusformis* and *Pseudopolygnathus primus.* The ostracod assemblage from this level, including the same *Cryptophyllus* species as in the previous sample (Jones 1962a,b; see above), was placed by Jones (1961a,b, 1962b) in his Assemblage C, which is also middle Tournaisian (Tn2; see Jones 1989, fig. 9). Playford (1972) recorded elements of his *Grandispora spiculifera* Assemblage (Playford 1976; see above), and Thomas (1962) recorded an Early Carboniferous brachiopod assemblage including *Orbiculoidea* (also known from BMR 2 and other wells; see Thomas 1959a; Jones 1961a,b).

1735-38 (5694-703') **?Nullara** **Famennian/Tournaisian**

Remarks: Klapper (pers. comm.) records a single juvenile specimen of *Polygnathus* from Core 10, probably *P. inornatus*, but the range of this species could be as old as *expansa* Zone (see Fig. 6), so the age of this level is inconclusive.

1882-85 (6175-85') **Nullara** **M.-L.Famennian**

Remarks: Core 11 yielded a few poorly preserved conodonts and a fish plate, which initially suggested a Tournaisian rather than Late Devonian age to Glenister (1958a), but he later (1958b) processed additional material which yielded a more significant conodont fauna. This was described by Glenister & Klapper (1966), and included the genus *Pelekysgnathus* ('*P. communis*'), a species subsequently synonymised with *P. inclinatus* by Anderson (1966). Sandberg & Dreesen (1984: 161) give this species an upper range limit in the upper *praesulcata* Zone. The associated '*Polygnathus znepolensis*', recorded from this horizon by McTavish (1968a; presumably the *Pol.* cf. *P. obliquicostata* listed by Glenister & Klapper 1966 from core 11, which was referred to *P. znepolensis* by Druce 1976: 205), has an upper limit in the lower *praesulcata* Zone (Ziegler & Sandberg 1984). The same authors give its lower limit as middle *expansa* Zone (Ziegler & Sandberg 1984: 182, fig. 3), but the Canning Basin material is not conspecific (G.Klapper, pers. comm.), and is probably a new species, referred to by Klapper as *P.* aff. *znepolensis*, which apparently has a much earlier appearance in the Canning Basin, where it is known to be associated with *Palmatolepis quadrantinodosa inflexoidea* (Nicoll 1980, table 2). According to Ziegler & Sandberg (1984, fig. 2) the latter species is restricted to the lower *Palmatolepis marginifera* Zone (see Fig. 6).

Playford (1962) suggested that the D-C boundary in Meda 1 may lie at a lithological break at the 5483' level, but biostratigraphic limits for the boundary are still between the levels of core 9 and core 11. Druce & Radke (1979) considered the D-C boundary to lie within their Yellow Drum Sandstone, which they identified in Meda 1 between the 1623 and 1649 m levels (i.e. slightly above Playford's suggested boundary).

2014-017 (6606-16')

Remarks: From core 12 Glenister (1958a) recorded only the fish *Holmesella* sp., a form common in both Upper Devonian and Lower Carboniferous strata. Glenister (1958b, Glenister & Furnish 1962) recorded indeterminate conodont remains which were not age diagnostic (confirmed 1992 by G. Klapper, pers. comm.).

2038-44 (6686-706') **?Windjana Lmst./ ?Pillara** **E.Famennian**

Remarks: The conodont *Palmatolepis triangularis* is recorded from cores 13 and 14, in the latter associated with subspecies of *P. delicatula* which combination suggests an early Famennian age equivalent to the Middle to Upper *triangularis* Zone (G. Klapper, pers. comm. 1992).

2098-128 (6883-980') **?Windjana Lmst./ ?Pillara** **E.Famennian**

Remarks: Core 15 (2098 m) contains fish material including *Holmesella*, which has not been analysed, but core 17 (2126-28 m) again has the conodont *Palmatolepis triangularis*, which indicates a zonal position not below that of the earliest Famennian conodont zone, the Lower *triangularis* Zone (G. Klapper, pers. comm. 1992). *Palmatolepis triangularis* ranges from the lower *triangularis* to the lower or middle *crepida* conodont Zones (Glenister & Klapper 1966; Druce 1976), whilst the associated *Palmatolepis delicatula* from core 14 has a narrower range, from the middle *triangularis* to the lower *crepida* Zones. Thus the Frasnian-Famennian boundary must be just below core 17.

2161-64 (7089-101') **?Pillara** **?L.Frasnian**

Remarks: Two conodont taxa recorded by Glenister (1958a) from core 18 (*Hindeodella* and *?Icriodus*) have broad ranges, but G. Klapper (pers. comm. 1992) regards them as indeterminate, so the close similarity Glenister (1958a) noted to forms in the Gogo Formation cannot be substantiated. The ostracod '*Aparchites*' (now *Fellerites*) suggested a correlation with the Sadler Formation and possible equivalence to the upper part of the *saltica* brachiopod zone according to Jones (1958, 1962a). A brachiopod assemblage from this core was referred by Veevers (1962) to either the *apena* or the *saltica* Zones. It is more likely to belong to the *apena* Zone (as revised by Roberts *et al.* 1972), which from conodont evidence is late Frasnian in age. Strusz (1992) has recently shown that the upper part of the *apena* Zone extends into the early Famennian, but as core 17 belongs to the Lower *Palmatolepis triangularis* Zone, it is probable the core 18 lies within the late Frasnian part of the *apena* Zone

2195-98 (7200-10') **L.Frasnian**

Remarks: Klapper (pers. comm. 1992) reports that cuttings from this level have yielded conodonts including *Polygnathus lodinensis*, which is known from the late Frasnian (Montagne Noire Zones 11-13).

2204 (7230') **L.Frasnian**

Remarks: McTavish (1968a) shows a to1γ (ammonoid zone) age at this level, presumably from cuttings (but biostratigraphic evidence is not given), which is consistent with the *apena* Zone age mentioned above (see Young 1989).

2323-41 (7620-80') **E.Frasnian**

Remarks: From cuttings Klapper (pers. comm. 1992) has recorded a small conodont fauna including one specimen of *Mesotaxis* sp. indet. This genus is restricted to the early Frasnian.

2347 (7700') **?L.Givetian/E.Frasnian**

Remarks: McTavish (1968a) showed a to1α (?) possibly Givetian age below 7700', presumably based on material from core 21 (7718-7728'), but we have not been able to confirm this (G. Klapper, pers. comm. 1992 records indeterminate conodont fragments from cuttings at 7700-10'). The to1α ammonoid Zone ranges from the middle *varcus* conodont Zone of the middle Givetian into the earliest Frasnian lower *asymmetricus* Zone. Beneath this level there is no biostratigraphic age control in Meda 1. However Lehmann (1984) defined a new formation in the lowermost sediments intersected by this well as the May River Conglomerate (type section 2588-2699 m; but total depth is 2684 m!), which was described as a pre-Pillara clastic unit possibly equivalent to the Tandalgoo Formation. However we emphasise that the cited evidence for age, that Givetian-Frasnian spores occur in the overlying formations in Tappers Inlet 1 (Lehmann 1984: 275), cannot be reliably extrapolated to this well.

2377-80 (7800-10') **?Devonian**

Remarks: G. Klapper (pers. comm. 1992) records conodonts including the Famennian species *Alternognathus regularis* from cuttings at this level, which is assumed to represent caving from higher in the well (?May River Shale at 6150-80', or perhaps higher at 6275').

4. MEDA NO. 2 WELL (modified after Jones & Young 1990b)

1294 (4245-46') **Anderson** **Carboniferous**

Remarks: From cuttings at this level Balme (1959) reported large quantities of fragmentary wood, and rare spores belonging to the genera *Cyclogranisporites*, cf. *Lycospora*, and *Punctatisporites*. These suggested a Carboniferous age, but the assemblage was considered insufficiently diverse for reliable comparisons to be made with Meda 1.

1609-11 (5280-87') **Laurel** **M.Tournaisian**

Remarks: An ostracod assemblage from core 1 is similar to that from the top of the Laurel in BMR 2 (Laurel Downs), which indicates a middle Tournaisian age (P. J. Jones, unpublished). Glenister (1959) recorded abundant fish plates and teeth from this core, which he considered similar to those of core 9 in Meda 1. McTavish (1968b) recorded ostracods and fish from the 5286' level in this core.

1611-15 (5287-98') **Laurel** **Tournaisian**

Remarks: From core 2 Thomas (1959a) reported a brachiopod assemblage (including *Linoproductus* and *Orbiculoidea*), which is comparable to that in core 9 of Meda 1 (Jones 1961b). This suggests a horizon near the top of the Laurel Formation (mid-Tournaisian). McTavish (1968b) recorded conodonts, rare gastropods, and abundant fish from the 5288 and 5296' levels.

1615-17 (5298-304') **Laurel** **Tournaisian**

Remarks: From core 3 Balme (1959) reported an abundant spore assemblage with cf. *Lycospora* as a dominant form, associated with *Cyclogranisporites* sp., *Punctatisporites* spp., *Apiculatisporis* and a new genus. Although not very diverse, this microflora compared closely with samples from BMR Laurel Downs 2 bore (250-52' interval), which indicated an Early Carboniferous age (see Balme 1960). The 5303' level in core 3 produced the same two species of *Dibolosporites* as in cores 8 and 9 of Meda 1 (Playford 1971, 1972). These species (*D. distinctus*, *D. medaensis* of Playford 1976), first recorded by Balme (1967) in May River 1, belong to the *Grandispora spiculifera* Assemblage of Playford (1976), consistent with a Tournaisian age (see discussion in Jones & Young 1990).

From the 5299' level McTavish (1968b) recorded rare conodonts, ostracods and gastropods, and abundant fish remains.

1658-60 (5438-45') **Laurel** **M.Tournaisian**

Remarks: From core 4 Balme (1959) reported a similar but more diverse microflora than that from the 5298' level, with species of *Convolutispora*, cf. *Endosporites*, and *Retusotriletes* again indicating an Early Carboniferous age.

A conodont fauna associated with ornate fish plates and teeth, including the genus *Holmesella* were recorded by Glenister (1959) to indicate and 'Osagean (late Tournaisian-middle Mississippian)' age. The assemblage was said to be 'almost identical to that from Core 9 in Meda 1'. G. Klapper (pers. comm. 1992) records the conodonts *Pseudopolygnathus primus* Branson & Mehl and *Clydagnathus darensis* Rhodes, Austin and Druce from this core, which in local stratigraphic terms would support a middle Tournaisian age (see previous discussion for Meda 1).

1661 (5450') **Laurel** **Tournaisian**

Remarks: McTavish (1968a) recorded fish remains at this horizon, apparently to define the base of a unit within the Laurel Formation, but no further details are available. The top of the underlying unit on his section is defined by the presence of an ostracod identified as '*Cavellina* sp. 2', but this species is not known to extend into the Carboniferous, so in the absence of further information we regard this evidence as very doubtful.

1705 (5595.5')
1706 (5598')
1709 (5607') **Laurel** **M.Tournaisian**

Remarks: Both cores 5 and 6 have the spore species *Dibolosporites distinctus* of Playford (1972), which indicates a Tournaisian age, no older than the *spiculifera* Assemblage of Playford (1976). McTavish (1968b) also recorded rare conodonts, fish, ostracods, bryozoans, and abundant gastropods from the 5595.5' and 5598' levels (core 5), and conodonts, fish and gastropods from 5601' and 5605' levels (core 6). These have not been studied.

1798-1823 (5900-980') **M.Tournaisian**

Remarks: A re-examination of the original slide of microfossils from cuttings taken from this depth revealed ostracod species (belonging to the genera *Graphiadactyllis, Lichvinella*, and *Cavellina*), which are the same as those reported from core 9 in Meda 1 (Jones 1962a).

2018-21 (6620-29') **L.Famennian**

Remarks: From core 7 comes a conodont assemblage including *Bispathodus aculeatus*, and *Polygnathus communis* (Glenister & Klapper 1966). If the latter is *P. communis communis* it indicates an age in the upper *praesulcata* Zone (uppermost Devonian) or younger (Ziegler & Sandberg 1984). However if it belongs to the subspecies *P. c. collinsoni* it is probably no younger than the lower *praesulcata* Zone (see below). Interpreted in the context of adjacent wells, the latter alternative is favoured here, but this requires confirmation with re-examination of the actual specimens. McTavish (1968b) also records conodonts from core 7 (6621' level), associated with fish remains.

Forams discussed by Mamet & Playford (1968) from Meda 2, Langoora 1 and two outcrop localities were assigned to three *Quasiendothyra* zones (*Q. bella*/*Q.* ex gr. *communis* and *Q. communis*/*Q. konensis, Q.* cf. *kobeitusana-Klubovella*; late Famennian and Strunian), but the precise content of the Meda assemblage (from core 7) was not specified. Veevers (1959c) reported brachiopods which could either be of Late Devonian or Early Carboniferous age.

2021-23 (6629-37') **L.Famennian**

Remarks: One specimen of the conodont *Polygnathus* was recorded by Glenister & Klapper (1966) from core 8, but its age was indeterminate. However the brachiopod provisionally identified as *Cyrtospirifer* by Thomas (1959b) would indicate a Late Devonian age. This genus is very abundant in the Gumhole Formation (Druce & Radke 1979), but is not known from Carboniferous horizons. More precise evidence of age has been obtained from a sample processed for ostracods, which has yielded a fragmentary bairdiid, possibly *Orthobairdia ordensis*, and a juvenile *Shishaella*, reminiscent of the new species listed by Jones (1987: 288) from the Buttons Beds in the Bonaparte Basin. Both taxa have also been recorded from the Canning Basin, in 'Assemblage A' of Jones (1961a). In the Bonaparte Basin these taxa indicate an age within the range of the *Retispora lepidophyta* palynoflora (Jones 1987). This is consistent with the conodont evidence for age from cores 7 and 9, which indicate the lower *praesulcata* Zone as a maximum and minimum age respectively for these cores.

2024-29 (6639-57') **L.Famennian**

Remarks: From the 6640' level in core 9 Glenister & Klapper (1966) recorded the conodont *Apatognathus varians*, whilst McTavish (1968b) recorded abundant conodonts and common fish from this level. Nicoll (1980) referred Glenister & Klappers species to the subspecies *A. varians varians*, and also identifed *Polygnathus communis collinsoni*, and *P. webbi*. Elsewhere *P. c. collinsoni* occurs with *P. znepolensis*, which has an upper limit in the lower *praesulcata* Zone (Nicoll 1980). Veevers (1959c) again reported brachiopods which could either be of Late Devonian or Early Carboniferous age.

2031-32 (6662-67') **L.Famennian**

Remarks: From core 10 comes a conodont fauna containing *Bispathodus aculeatus* and *Apatognathus varians* (Glenister & Klapper 1966), the latter indicating a Late Devonian age, and the former a maximum age in the middle *expansa* Zone. In the light of evidence from preceding cores this horizon is considered to be probably assignable to the upper *expansa* Zone (lowermost Strunian). Thus a duration of about 0.5 m.y. can be suggested for the deposition of the section between cores 7 and 9 (see Jones & Young, 1990b, fig. 1).

2032-38 (6667-85')

Remarks: Veevers (1959c) also reported brachiopods from this horizon which could either be of Late Devonian or Early Carboniferous age.

2284-88 (7494-506') **M.Famennian**

Remarks: From core 13 Glenister (1959) recorded the conodont cf. *Hindeodella* sp., but it was too fragmentary to give a restricted age. However McTavish (1968a) recorded a middle Famennian (toIII) age (presumably based on conodonts) from this level, but no further details are available.

2288 (7509') **?Devonian**

Remarks: One conodont slide said to be from core 15 at the 7509' level contains two badly etched specimens of *Polygnathus* sp. indet. (R.S. Nicoll, pers. comm.), which provide no age information. If the given level is correct, then this sample possibly represents the evidence used by McTavish as discussed in the next section (it lies between the two dated levels previously quoted; see Jones & Young 1990b). If so, no reliability can be placed on the Givetian age.

2332 (7650') **?Givetian**

Remarks: At this level near the base of the well on McTavish's (1968a) chart he shows a pre-Frasnian age, with a reference to conodonts of the '*Polygnathus cristata* Zone' (presumably *hermanni-cristatus* Zone; middle Givetian). Apart from the comment in the previous section no further details are available on this determination (the actual depth is also uncertain, since total depth for the well is given as 7628'). Under these circumstances no reliability can be placed on the Givetian age.

5. BLACKSTONE NO. 1 WELL (modified from Jones & Young 1990c)

73-320 (240-1050') **Blina** **E.Trias**

Remarks: Gorter (unpubl.) examined cuttings taken over this interval, which have yielded fragmentary conchostracans, lingulid brachiopods, fish remains, megaspores, pyritised wood, and the foraminiferid *Ammodiscus*. This assemblage closely resembles that discussed by Jones (in Tasch & Jones 1979) for the Blina Shale in Meda 1. As discussed previously (Jones & Young 1990a), the conchostracans require derivation from a non-marine (lacustrine or estuarine) environment, with forams indicating some marine influence.

Balme (1968) identified his *Taeniaesporites* Assemblage (Balme 1964) in sidewall cores cut in the interval 178-320 m (585-1050'). This marine basal Triassic palynofloral assemblage is clearly differentiated from the underlying Permian assemblages by a marked palynofloral break (Balme 1964), although there is no evidence to judge its precise age. Balme (1990, fig. 10) illustrates this by depicting the base of the *Taeniaesporites* Assemblage above a slight hiatus at the base of the early Griesbachian.

335-485 (1099-1582') **Liveringa** **L.Permian**

Remarks: Sidewall cores from this interval produced the *Dulhuntyispora* Assemblage of Balme (1964), which was considered to encompass the whole of the Liveringa Formation except probably for its lower part (Balme 1968). Subsequently Balme (in Kemp *et al.* 1977) divided this assemblage into two informal palyno-stratigraphic units: Unit VIII in the upper 40 m of the Liveringa Formation, and Unit VII beneath (between 1350 and 1582'). The base of the latter was considered to possibly represent the base of the Liveringa Formation. The sharp palynological break between the two units may reflect a sedimentary hiatus between the Noonkanbah Formation and the Lightjack Formation of the Liveringa Group, or a break within the Noonkanbah itself. However Archbold & Dickins (1991) place the boundary between the two units somewhat higher, within the Condren Sandstone or its correlatives. The relative abundance of acritarchs in Unit VIII could indicate strata that are lateral equivalents of the Hardman Formation (Kemp *et al.* 1977: 188).

511-86 (1676-1921') **Noonkanbah** **Artinskian**

Remarks: Sidewall cores from this interval (Balme 1968) produced the *Vittatina* III unit of the *Vittatina* Assemblage of Balme (1964). This was renamed by Balme (in Kemp *et al.* 1977: 186) as his informal palynostratigraphic unit VI, defined by the high relative frequency of the trilete spore *Granulatisporites trisinus*. This unit was considered to represent the upper part of the Noonkanbah Formation, excluding its top. Archbold & Dickins (1991) place unit VI in the Noonkanbah Formation, and assign it an Artinskian age.

648-725 (2126-380') **Noonkanbah/?Poole** **Artinskian**

Remarks: The *Vittatina* II unit of the *Vittatina* Assemblage of Balme (1964) was encountered in sidewall cores from this interval (Balme 1968). Again Balme (in Kemp *et al.* 1977: 186) used this interval in Blackstone 1 to define his informal palynostratigraphic unit V, considered to represent the middle part of the Noonkanbah Formation. However on the chart of Archbold & Dickins (1991) unit V encompasses the lower part of the Noonkanbah and the upper part of the Poole Sandstone.

734-74 (2408-2540') **Poole** **E.Artinskian**

Remarks: Sidewall cores from this interval (Balme 1968) produced the *Vittatina* I unit of the *Vittatina* Assemblage of Balme (1964), renamed by Balme (in Kemp *et al.* 1977: 186) as his informal palynostratigraphic unit IV, considered to represent the lower part of the Noonkanbah, and the Poole Sandstone (excluding its lower Nura Nura Member).

812-28 (2663-715') **Grant** **Sakmarian**

Remarks: The *Nuskoisporites* III unit of the *Nuskoisporites* Assemblage of Balme (1964), encountered in sidewall cores from this interval (Balme 1968), is now referred to informal palynostratigraphic unit III of Balme (in Kemp *et al.* 1977: 186). This unit straddles the Grant/Poole boundary, encompassing the upper shalier part of the Grant Group, and the Nura

Nura Member of the Poole Sandstone, with the age of its upper part based partly on ammonoids from the Nura Nura described by Glenister & Furnish (1961). Unit III is now regarded as Sakmarian in age by Archbold & Dickins (1991). In Blackstone 1 the base of the Nura Nura Member is picked at 799 m (2620'). Diversification of the microfloral assemblage compared to those lower in the sequence was considered to reflect amelioration in climate, with the presence of spinose acritarchs indicating some marine influence (Kemp *et al.* 1977: 186). In some places there is an erosional break at the base of the Nura Nura (e.g. Dickins, Towner & Crowe 1977).

839-1178 (2752-3864') **Grant** **Asselian**

Remarks: The *Nuskoisporites* II unit of the *Nuskoisporites* Assemblage of Balme (1964) was encountered in sidewall cores from this interval (Balme 1968), and assigned a Late Carboniferous-Early Permian age. This assemblage is now the informal palynostratigraphic unit II of Balme (in Kemp *et al.* 1977: 186), which was referred to the Late Carboniferous, but subsequent revison now indicates an Asselian age (Archbold & Dickins 1991). Unit II (plus lower Unit III) corresponds to the *Granulatisporites confluens* zone of Foster & Waterhouse (1988; J.M. Dickins, pers. comm.).

1448-62 (4750-97')
1464-79 (4803-51') **'Lower Grant Sequence'** **L.Carboniferous**

Remarks: In the first core cut from this well (core 1), Balme (1968) reported a highly diverse assemblage of mainly undescribed species, for which he tentatively suggested a 'Moscovian' age (Late Carboniferous). Subsequently (in Jones *et al.* 1973) Balme referred this interval to the 'lower Grant', on the basis that it represented a correlative of the *Grandispora maculosa* Assemblage, but later (in Kemp *et al.* 1977: 186) he revised this opinion, referring this interval to the younger *Anabaculites ybertii* Assemblage (Namurian-Westphalian; Kemp *et al.* 1977, fig. 2). This assignment was later confirmed by Playford & Powis (1979), who described four species of trilete miospores (*Spelaeotriletes ybertii, Ahrensisporites cristatus, Anapiculatisporites amphus*, and *Waltzispora polita*) from core 1 (4792'). These authors also identified the *Spelaeotriletes ybertii* Assemblage at a slightly lower level in sidewall cores (4803-4851'). The age limits of this assemblage are unclear (most described taxa are long-ranging), and on available evidence we consider it could lie anywhere in the Namurian-Westphalian interval. Immediately beneath is the Laurel Formation, but this core seems not to be an Anderson equivalent. In Grant Range 1 (containing the type section for the Anderson Formation) both the *maculosa* and *ybertii* assemblages occur above the top of the Anderson (Playford & Powis 1979, table 1). Thus a major break is indicated with the whole of the Anderson Formation apparently missing from Blackstone 1. This may correspond to the break shown at the 4876' level by McTavish (1968a). The interval between the top of the Anderson and the base of the Grant in Grant Range 1 was first identifed as an 'unnamed unit' by Gorter (1980). Roberts (1985: 96) discussed this unit and its occurrence in various wells in the Canning Basin, and reached the same conclusion regarding its age as given here.

1532 (5025-27')
1532-41 (5027-55')
1541-42 (5055-60') Laurel Tournaisian

Remarks: McTavish (1968a) assigned the above three continuous cores (cores 2-4) an 'Early Osagean' age, but this is not considered reliable, and the fossil evidence on which it is based is unavailable to us. Presumably it was based on analysis of some of the abundant fossils (brachiopods, pelecypods, fish, polyzoans, crinoids, echinoids, ostracods, etc.) reported by Johnson (1968: 13) from below the 5010' level. In Meda 2 McTavish (1968a) assigned an 'Early Osagean' age to horizons known to be within the Tournaisian (presumably middle Tournaisian), so we have assumed a similar age here. Druce & Radke (1979) assigned the interval 1486-1579 m to the Laurel Formation.

The next two cores down, Cores 5 (5250-85') and 6 (5540-47'), have not yielded any fossils. Druce & Radke (1979) referred the 116 m of section above contact with the Gumhole Formation (at 1699 m) to the Yellow Drum Sandstone.

1714-27 (5622-67') ?Gumhole/Nullara L.Famennian

Remarks: Johnson (1968:14) reported a diverse assemblage including ostracods and conodonts from core 7, and McTavish (1968a) identified *Quasiendothyra communis* and *Umbellina* from this core, which he assigned a ?toVI age. In core 7 of Meda 2 these taxa have indicated a Late Famennian age (see Jones & Young 1990b: 2). Druce & Radke (1979) regard this level in Blackstone 1 as Gumhole Formation (cf. Forman & Wales 1981, who include it in the Nullara; see Fig. 1).

1804-18 (5920-65')
1818-21 (5965-75') ?Gumhole/Nullara L.Famennian

Remarks: From core 8 Johnson (1968: 15) recorded a palynofloral assemblage including the index species '*Leiozonotriletes naumovae*' (= *Retispora lepidophyta*), which gives a Late Famennian age (Playford 1976). McTavish (1968a) also records the conodont *Polygnathus znepolensis*, which has an upper limit in the lower *praesulcata* Zone (see Jones & Young 1990a, fig. 3). This conodont-spore association thus fixes the age of this interval to middle *expansa* - lower *praesulcata*. Cores 8 and 9 lie within the Gumhole Formation as identified by Druce & Radke (1979).

1888-94 (6193-215')
1894-99 (6215-30') Nullara L.Famennian

Remarks: From these two cores (cores 10, 11) McTavish (1968a) recorded *Umbellina* (a long-ranging taxon), but no other fossil evidence of age. Previously Jones & Young (1990c) suggested that these cores may lie somewhere within the *expansa* Zone, perhaps in its upper part. However In WAPET internal report no. 1756, McTavish (1968b) mentions fish remains of Devonian age from core 11 (6219-21' interval), which he considered similar to those from the Thangoo Calcarenite (type section 1022-1116 m in Roebuck Bay 1). These are not mentioned in the WCR and have not been examined, but the Thangoo Calcarenite specimen is regarded by Turner *et al.* (1981) to be probably an actinopterygian scale referable to *Ligulalepis*, a form known from the Early Devonian of eastern Australia (Schultze 1968, Turner 1991) and Late Silurian-Early Devonian of South China (Wang 1989, 1992). This material needs to be examined to clarify its age significance.

1975-84 (6480-510') **Poulton** **?Givetian**

Remarks: Core 12 is within the type section of the Poulton Formation as defined between 1941 and 2220 m by Playford *et al.* (1975). Fish fragments are recorded (WAPET WCR, p. 22) from two levels within this core: 6486.5' (possible) and 6502' (abundant). These have not been studied. McTavish (1968a) also records a ?Givetian microflora, but no details are available to us. Presumably this microflora is of Givetian/Frasnian age. If correct, a large break is indicated between cores 11 and 12 as shown on the section in McTavish (1968a). In core 13 some finer fish fragments than in the previous core are recorded from 6710.5' level in the WAPET WCR (p. 23).

Further down the section, but still within the type section of the Poulton Formation, Lehmann (1984) used seismic evidence to identify an unconformity at 6895', which he used to separate units he interpreted as the 'Mellinjerie Formation' above, from the 'Worral Formation' below. This interpretation is not supported by palaeontological evidence (see comments on Carribuddy Group above). Lehmann included cores 15 and 16, previously placed at the Ordovician-Devonian boundary, within the 'lower carbonate member' of his 'Worral Formation', and picked its base at 7337' (2236 m). However, In WMC Acacia 1, presumed equivalents of the lower Worral have been dated on conodonts as Early Silurian (middle Llandovery) (Nicoll & Jones 1982), which implies that the 'lower carbonate member' on the Barbwire Terrace should be correlated with the top of the Carribuddy Group, as in Figs. 2 and 3. In Fig. 10 we follow McTavish's (1968a) original interpretation of this well, with the Poulton/Nita boundary placed at 7285' (in the top of core 16).

2220-29 (7285-7312')
2289-91 (7510-17') **?Nita** **E.Ordovician**

Remarks: Conodont evidence establishes an Ordovician age for cores 16 (Nicoll, in prep.) and core 17 (Watson pers. comm. 1990). Ordovician conodonts (e.g. *Drepanodus*) come from unspecified horizons within the 7284-312' interval of core 16 (Nicoll, in prep.). Watson (pers. comm. 1990) records a small conodont fauna from core 17 which includes *Protopanderodus nogamii*. This species ranges across the boundary between the two assemblages identified by Watson (1988) in WMC Santalum 1A on the Broome Platform. He correlated the base of the upper assemblage with the base of the *E. suecicus* Zone, and the lower assemblage with the upper part of the *?E. variabilis* Zone, both within the Llanvirn series of the British sequence (see Fig. 4B). McTavish & Legg (1976) reported *Eoplacognathus foliaceus* from their zone OCJ in Blackstone 1, but did not specify the horizon, so its occurrence in core 17 cannot be confirmed. Watson (1988) noted this reported occurrence of *E. foliaceus* as the highest North Atlantic Ordovician zonal species known from the Canning Basin, but in his material only one fragmentary specimen was tentatively referred to this species. This was associated with the conodont *Eoplacognathus suecicus*, defining the underlying zone in the North Atlantic zonal scheme (Fig. 4), so a precise younger age limit for the Nita Formation in the Canning Basin is uncertain.

Nicoll. *et al.* (in press) note new conodont evidence apparently at variance with the graptolite-trilobite evidence for the age determined by Legg (1976). They suggests the 2221-2600 m interval is better referred to the Gap Creek Formation, which is considerably older than the Nita (Fig. 3). New palaeontological information is required to resolve the apparent discrepancy between the conodont and trilobite-graptolite age determinations (see also below, and Jones & Young 1990c).

2368-77 (7770-800'; core 18)
2455-63 (8055-80'; core 19) ?Goldwyer E.Llanvirn

Remarks: Johnson (1968: 17) noted the presence of palynomorphs and conodonts in cores 18 and 19, which he assigned to his 'Unit B' of Middle Ordovician age. Subsequently McTavish & Legg (1976 :464) assigned the 2310-3050 m interval in Blackstone 1 to the Goldwyer Formation, based on the palaeontological evidence presented by Legg (1976, 1978). From cores 18 and 19 Legg (1978, fig. 2) reported his Fauna 6, considered to be Late Darriwilian (upper Da3-Da4) in age. He noted (p. 332) that the graptolite *Didymograptus stabilis* was associated with the conodont *E. foliaceus*, which suggests occurrence of the latter in core 19 (the youngest occurrence of *D. stabilis*; Legg 1976). However this is within the Goldwyer, and thus contradicts the earlier comment of McTavish & Legg (1976), as discussed above. Nicoll *et al.* (in press) consider that the 2606-3050 m interval is more likely correlated with the Emanuel Formation, which is three conodont zones older than assumed age of the Goldwyer (Fig. 3). Watson (pers. comm. 1990) recorded the conodonts *Drepanoistodus* sp. from core 18 and *D. forceps?* from core 19. The upper limit of *D. forceps* approximates to the top of his lower assemblage (Watson 1988, fig. 4), which suggests an age in the upper part of the *E. variabilis* Zone (Fig. 4). This corresponds to the Da2 age given by Legg (1976, 1978) based on graptolites (see Webby & Nicoll 1989). Legg (1978, fig. 7) showed his faunas 4-6 ranging from Da2 to Da4 of the Victorian graptolite sequence, but all these faunas are more probably of Da2-early Da3 age or older. As noted above, the apparent discrepancy between the conodont and trilobite-graptolite age determinations cannot be resolved without access to the original and/or new faunal data.

Palynomorphs from these cores were mentioned by Johnson (1968), but no details were given. Foster (pers. comm.) advises of an abundant palynomorph assemblage of *Micrhystridium* in core 19, which he correlates with core 7 of Willara 1.

2582-85 (8470-80'; core 20)
2585-682 (8780-98'; core 21)
2740-43 (8990-9000'; core 22)
2833-38 (9293-310'; core 23) ?Goldwyer E.Llanvirn

Remarks: Graptolites from cores 20-23 (identified by J.G. Tomlinson) were said by Johnson (1968: 17) to indicate an age of 'very late Lower Ordovician to early Middle Ordovician'. Legg (1976) showed the youngest definite occurrence of the graptolite *Amplexograptus confertus* in core 20. According to Vandenberg (in Webby & Nicoll 1989, fig. 2) this species ranges from the top of Da2 to the top of Da3. Legg (1976) showed his fauna 6 occurring in cores 20-23, and he defined the base of this assemblage zone by the first appearance of *Didymograptus artus*. According to Vandenberg (in Webby & Nicoll 1989) this is equivalent to the original '*D. bifidus* Zone' of the British sequence (i.e. lower Llanvirn).

There is no further information on palynomorphs from cores 20 and 21 mentioned by Johnson (1968). As noted above Nicoll *et al.* (in press) suggest that the 2606-3050 m interval is more likely correlated with the Emanuel Formation.

2912-15 (9555-565'; core 24)
3008-11 (9870-80'; core 25)
3046-50 (9995-10005'; core 26) **?Goldwyer** **E.Llanvirn**

Remarks: Cores 24-26 are the lowest cores at the bottom of the well. Johnson (1968: 17) used the graptolite *Amplexograptus* sp. (identified by J.G. Tomlinson) from cores 25 and 26 to indicate correlation with the Goldwyer Formation. Legg (1978) assigned assemblages from cores 24-26 to his Fauna 5, the base of which was defined by the first appearance of *Diplograptus allesi* and *Amplexograptus confertus*. The former indicates a Da2 age because in the British sequence it is restricted to the '*D. bifidus* Zone' (Legg 1978: 331). The latter (as *Pseudamplexograptus confertus*) first appears in the top of Da2 in the Victorian sequence (Webby & Nicoll 1989, fig. 2), but it may have an earlier first appearance in the Canning Basin, suggesting that the bottom of Blackstone 1 is still of Llanvirnian age (Fig. 4). However Nicoll *et al.* (in press) would correlate the whole of this interval with the Emanuel Formation. There is no new information on palynomorphs from core 24 mentioned by Johnson (1968).

6. MIMOSA 1 WELL (modified from Jones & Young 1992)

105m **Blina Shale** **E.Triassic (Griesbachian)**

Remarks: Dolby *et al.* (1973) reported a palynoflora in a side wall core taken at this depth, which contains several species known to straddle the Permian/Triassic boundary (e.g. *Nevesisporites fossulatus, Playfordiaspora crenulata, Densoisporites playfordii*). This contains a rich acritarch assemblage with strong affinities to those found in the Kockatea Shale, Perth Basin, and therefore, it probably belongs to the Early Triassic (Griesbachian) *Kraeuselisporites saeptatus* Assemblage Zone (of Dolby & Balme, 1976).

105-110m **Blina Shale** **E.Triassic (Griesbachian)**

Remarks: Gorter (unpublished) examined cuttings at these depths which yielded fragmentary conchostracans, ribbed 'palaeoniscoid' fish scales, and a trilete megaspore.

120
150
180m Liveringa Group (Hardman) L.Permian (Dzhulfian)

Remarks: Dolby *et al.* (1973) noted that the acritarch assemblages from cuttings taken from these depths are a mixture of Triassic Blina Shale varieties and Late Permian types. The proportion of Permian miospores increases with depth between 120m and 180m, and the presence of Triassic species was thought to be due, in part, to caving. The spore/pollen assemblage was reported to be similar to those previously recorded (Balme, in Kemp *et al.*, 1977) from well samples taken from the upper part of the Sue Coal Measures in the southern Perth Basin. This assemblage would now be placed in the *Playfordiaspora crenulata* Zone (Foster, 1982), the penultimate palynofloral zone of the Permian of Australia. The palynofloral taxa listed by Dolby is also indicative of Unit VIII of Balme (in Kemp *et al.*, 1977). Palynological evidence for fixing the limits of Unit VIII within the Late Permian was discussed by Kemp *et al.* (1977: 189), and Foster & Jones (in prep.) have summarised evidence now indicating that the *Playfordiaspora crenulata* Assemblage Zone, previously recognised in eastern Australia, is probably equivalent to most or all of Unit VIII.

In the original well completion report Osborne & O'Shaughnessy (1973) interpreted this horizon as undifferentiated Liveringa Group. On the new evidence just discussed it is probalbe that these levels represent the Hardman Formation, which is Dzhulfian in age. The Permian/Triassic hiatus is between 110 and 120 m (taken as 118 m in Fig. 10), and now is thought to represent only the latest Permian stage (Dorashamian = Changhsingian; see Archbold & Dickins 1991).

201
300m Liveringa (?Lightjack Fm) Permian (?Kungurian-Kazanian)

Remarks: A side wall core from 201 m depth produced the *Dulhuntyispora* Assemblage of Balme (1964, 1968), and from species listed, would correspond to Unit VII of Balme (in Kemp *et al.*, 1977). Archbold & Dickins (1991) showed Unit VII palynofloras occuring in the Liveringa Group, of latest Early Permian (Kungurian) to Late Permian in age.

Cuttings from 300 m, not mentioned in the original well completion report, have provided a Lower Stage 5 palynoflora (Foster & Jones, in prep.), which supports the age for Unit VII given above.

406m Noonkanbah E.Permian (Artinskian)

Remarks: Dolby *et al.* (1973) reported a side wall core from this depth which produced the *Vittatina* III unit of the *Vittatina* Assemblage of Balme (1964, 1968). This unit was renamed by Balme (in Kemp *et al.*, 1977: 186) as palynostratigraphic unit VI, being defined by the high relative frequency of the trilete spore *Granulatisporites trisinus*. This unit was considered to represent the upper part of the Noonkanbah Formation, excluding its top. Archbold & Dickins (1991) place Unit VI in the Noonkanbah Formation, and assign it an Artinskian age, as did Dolby *et al.* (1973). *Bascanisporites undosus*, listed by Dolby *et al.* (1973) in this assemblage, may indicate downhole contamination or could be misidentified (Foster & Jones, in prep.).

541m

Remarks: A side wall core from this level produced a palynoflora determined by Dolby *et al.* (1973) to represent the *Vittatina* I unit of the *Vittatina* Assemblage of Balme (1964, 1968), renamed by Balme (in Kemp *et al.*, 1977: 186) as his palynostratigraphic unit IV.

732
982
1075
1085m **Grant Group** **E.Permian (Asselian)**

Remarks: The upper three side wall cores produced a palynoflora determined by Dolby *et al.* (1973) to represent the *Nuskoisporites* II unit of the *Nuskoisporites* Assemblage of Balme (1964), now the informal palynostratigraphic Unit II of Balme (in Kemp *et al.* 1977: 186). This was referred to the Late Carboniferous, but subsequent revison now indicates an Asselian-Sakmarian age (Archbold 1982; Archbold & Dickins, 1991). Unit II corresponds in part to the *Granulatisporites confluens* Zone of Foster & Waterhouse (1988).

The side wall core from 1085 m was judged by Dolby *et al.* (1973) to be unreliable in view of the lithology (light-grey, fine grained sandstone), and of indeterminate age, as it contained a mixture (unlisted) of Early Carboniferous spores, and Early and Late Permian spores and pollen. We note that Osborne & O'Shaughnessy (1973) included this level within the Grant Group, above a major break at 1088 m, separating the Grant from the Laurel Formation below.

1125m
1145m
1155m
1170m **Laurel Formation** **Tournaisian (Tn2)**

Remarks: Dolby *et al.* (1973) reported a Tournaisian spore assemblage with minor acritarchs from SWC's at 1125 and 1145 m, assessed as no older than lower Tournaisian (Tn1bß). The assemblage includes *Dibolosporites distinctus* and *D. medaensis* (reported under their previous generic name *Umbonatisporites*), and is now referred to the *Grandispora spiculifera* Zone of Playford (1976).

Cuttings from 1125 and 1155 m contain conodonts identified by McTavish in Dolby *et al.* (1973) as *Spathognathodus tridentatus* and *Clydagnathus cavusiformis*, which he considered to indicate the *Spathognathodus tridentatus* Zone of Druce (1969). This zone, originally established for the lower 35 m of the Septimus Limestone in the Bonaparte Basin, was considered to indicate a middle Tournaisian (Tn2c) age (e.g. Jones *et al.* 1973). The concept of this zone is no longer reliable because the nominate species was placed by Ziegler *et al.* (1974) in synonymy with *Bispathodus aculeatus aculeatus*, a proposal accepted by Nicoll & Druce (1979). *Bispathodus aculeatus aculeatus* has a wider range (Sandberg *et al.* 1978; Ziegler & Sandberg 1984), from the Late Devonian (middle *expansa* Zone) probably to the lower *Siphonodella crenulata* Zone (middle Tournaisian). G. Klapper (pers. comm. 1992) records the conodonts *Clydagnathus cavusformis* and *Bispathodus aculeatus* from cuttings at 1125 m, indicating a Tournaisian age.

McTavish noted a rich associated fauna of ostracods, fish remains (teeth and plates), and microscopic gastropods, of which only the ostracods have been restudied. These confirm a middle Tournaisian age. A slide containing ostracods from cuttings taken at 1125 m includes internal moulds (steinkerns) of *Cavellina* cf. *taidonensis, Graphiadactyllis* sp.nov., and *Cryptophyllus diatropus*. Cuttings from 1170 m (not mentioned in the original report) have yielded ferruginous steinkerns of ostracods identified (by P.J.Jones) as paraparchitids possibly belonging to *Chamishaella subinornata* Bushmina, 1986 and *Shishaella electa* Tschigova, 1977. The ostracod species from both horizons are characteristic of the upper (Tn2) part of the Laurel Formation. From the 1170 m cuttings G. Klapper (pers. comm. 1992) has identified two conodont genera (species indeterminate).

1200m Luluigui Formation L.Famennian/Tournaisian (Tn2)

Remarks: McTavish in Dolby *et al.* (1973) suggested a slightly older age (Tn1b-Tn2) for conodonts from cuttings at this level, presumably based on the absence of '*Spathognathodus tridentatus*', although *Spathognathodus* sp., *Clydagnathus cavusiformis*, and a similar microfauna to the 1125 m level was listed. As noted above the *Spathognathodus tridentatus* Zone of Druce (1969) is no longer reliable, and the other listed species are long ranging and first appear in the latest Famennian. Conodonts present are only indeterminate fragments (G. Klapper, pers. comm. 1992).

1230m Luluigui Formation Famennian/Tournaisian

Remarks: Fossiliferous cuttings from this depth not mentioned by Osborne & O'Shaughnessy (1973) have yielded a small ostracod fauna typical of the Laurel Formation (Foster & Jones, in prep.).

1245m
1260m
1275m Luluigui Formation Famennian/Tournaisian

Remarks: Dolby *et al.* (1973) reported palynomorph assemblages from cuttings at these levels similar to those from the SWC's at 1125 and 1145 m, but with some Permian caving. The species '*Zonotriletes*' *explanatus* was cited as characteristic of the early Tournaisian, although he noted that this form first appears in the late Famennian (doVI) in Europe. It is now referred to *Hymenozonotriletes explanatus*, and first appears in the Canning Basin in the *Grandispora spiculifera* Assemblage (Playford 1976).

1290m Laurel/Lulugui Formations Dev./Carb. boundary

Remarks: Cuttings taken from this depth yielded both a very poor and sparse spore assemblage with *Dictyotriletes* sp. and *Punctatisporites* sp. indicating an Early Carboniferous age, and a conodont fauna with rare ostracods and fish remains indicating a late Famennian (doVI) age (significant species listed include *Spathognathodus stabilis* and *S.* cf. *werneri*). The spore assemblage could be due to caving, and on the conodont evidence we regard this horizon as latest Devonian, but possibly straddling the D/C boundary.

1294
1305m **Lulugui Formation** **late Famennian**

Remarks: A SWC from the upper horizon provided only two spore specimens, one being identified in Dolby *et al.* (1973) as *Spelaeotriletes lepidophytus* (Kedo), now the nominate species of the *Retispora lepidophyta* Zone of Playford (1976). Cuttings from the lower horizon yielded spore species also belonging to the *Retispora lepidophyta* Zone.

1320m **Lulugui Formation** **late Famennian**

Remarks: This horizon, not mentioned in the original well completion report, contains abundant ostracods, mainly steinkerns. Taxa identified belong to the genera *Cavellina, Knoxiella, Shishaella electa,* and one specimen of *Tulenia* sp. (previously reported as *Coeloenellina* cf. *fabiformis* in Jones, 1968) all typical of the latest Devonian ('Strunian') in the Canning Basin.

1391
1425
1480.5
1500
1560
1620
1716
1798
1876
1890
1950
2070
2201.5
2238
2319
2370
2372m **Lulugui/Clanmeyer** **L.Famennian**

Remarks: SWC's from 1391, 1480.5, 1560, 1716, 1798, 1876, 2070, 2201.5, 2238, 2319, 2370 and 2372 m levels contain palynomorph assemblages including *Retispora lepidophyta* (Foster & Jones, in prep.). These include the assemblages from some of these horizons originally listed by Dolby *et al.* (1973) which are all now referable to the *Retispora lepidophyta* Zone of Playford (1976). At 1500 m cuttings yielded a conodont assemblage with bryozoans, crinoids, fish remains and ostracods, not age diagnostic within the Famennian. The 1890 and 1950 m level contain ostracods, not mentioned by Osborne & O'Shaughnessy (1973), which are consistent with the late Famennian age. Cuttings from 1425, 1500, and 1620 m levels have yielded indeterminate conodont fragments or elements (G. Klapper, pers. comm. 1992).

2385 m **M.Famennian**

Remarks: As noted by Jones & Young (1992), Mimosa 1 was drilled to evaluate the reservoir potential below a suspected unconformity marked by a deep seismic reflector at 2743 m, which after drilling was assumed to lie at 2376 m, beneath the lowest identified level of *R. lepidophyta* at 2372 m, and above a supposed late Frasnian conodont fauna at 2400 m. On the palaeontological evidence a hiatus was inferred by Osborne & O'Shaughnessy (1973), which represented the whole of the Famennian older than the *lepidophyta* Zone. New evidence is provided by abundant ostracods retrieved from 2385 m, and not recorded by Osborne & O'Shaughnessy (1973), which indicate a mid Famennian age, even though they are beneath the supposed unconformity at 2376 m. The fauna consists mainly of poorly preserved kloedenellaceans, and some bairdiaceans. However, two specimens of entomozoaceans are sufficiently preserved to be determined (by P.J.Jones) as *Richterina (Richterina) eocostata* Wang, 1983. This species is the nominate species of the *eocostata* Zone, which is present in the middle Famennian of South China (Groos-Uffenorde & Wang, 1989). In terms of the conodont zonation, the *eocostata* Zone ranges from the Uppermost *marginifera* Zone to the Lower *postera* Zone (Fig. 7).

2400
2426-34 m **?Frasnian/Famennian**

Remarks: From the 2400 m level McTavish (in Dolby *et al.* 1973) identified the conodonts *Icriodus alternatus, ?Palmatolepis subrecta, Polygnathus decorosus*, and *Belodella* sp. from cuttings, which he regarded as Late Devonian (late Frasnian - probably doγ) in age. Re-examination of the original slide (by R.S. Nicoll) did not confirm these determinations (Foster & Jones in prep.), but (G. Klapper, pers. comm. 1992) has identified *Palmatolepis* and *Ancyrodella* (both species indeterminate), which nevertheless indicate a Frasnian age.

Dolby *et al.* (1973) also reported on three samples taken from core 1 (2426, 31, 34 m) yielding rich spore assemblages, but extremely poorly preserved, which they determined as pre- doVI in age (in present day terms, older than the *Retispora lepidophyta* Zone). The material from the 2426 m level has been reexamined, but is indeterminate (Foster & Jones, in prep.).

2451 m **Frasnian**

Remarks: A 'core slice' taken at 2451 m yielded a rich palynoflora listed by Dolby *et al.* (1973), which on the presence of *Archaeoperisaccus* sp. was determined as Frasnian rather than an early Famennian in age. This form is not known to occur in post-Frasnian strata in Australia (B. Balme, pers.comm.), and on the basis of late Givetian ostracods from 3570 m (see below), this level is interpreted as Frasnian in age (Foster & Jones, in prep.).

2631
2745
2760 m **?Frasnian**

Remarks: These three fossilisiferous horizons are attributed to downhole contamination. *Retispora lepidophyta*, which would indicate a late Famennian age, is represented by a few crushed specimens supposedly from a SWC at 2631 m, and in cuttings from 2745 m, but neither is considered reliable (Foster & Jones, in prep.). Cuttings from the 2760 m level contain a late

Famennian or younger ostracod, which is also attributed to downhole contamination (caliper logs confirm the strong likelihood of contamination).

3570m **M.Devonian (?late Givetian)**

Remarks: A single entomozoacean ostracod determined from cuttings taken at this depth indicates the *torleyi* Zone, of late Givetian-earliest Frasnian age in Germany and South China (Groos-Uffenorde & Wang, 1989). In terms of the conodont zonation, this zone ranges from within the Upper *hermanni-cristatus* Zone to within the Lower *asymmetricus* Zone (Fig. 7).

3600
3660
3955
4108- 4117 m **?Givetian**

Remarks: Cuttings from 3600 and 3660 m contain small numbers of ostracods apparently indicating younger ages (Foster & Jones, in prep.), and therefore considered due to contamination. Indeterminate Devonian spores were obtained from a SWC at 3955 m (Foster & Jones, in prep.).

A palynomorph assemblage from core 3 (4112.4-113.2 m level) was listed by Dolby *et al.* (1973) to contain *Archaeoperisaccus* sp. and *Ancyrospora* sp., and assessed as 'possibly mid-Frasnian' in age. Re-examination confirms the presence of *Ancyrospora* (relatively common) and absence of *Geminospora lemurata*, but '*Archaeoperisaccus*' could not be found (Foster & Jones, in prep.). A Givetian age is not inconsistent with ranges shown on the Devonian chart of Young (1989) and is required by the new ostracod evidence from 3570 m listed above.

A sample of calcareous clasts taken from core 3 (4108-4117m) was reported to contain various corals and stromatoporoids suggestive of the Pillara Limestone or its equivalents, but the inference that the clasts may be significantly older than the surrounding sandstone at this level is no longer supported by the biostratigraphic evidence.

REFERENCES

ANDERSON, W.I. 1966. Upper Devonian conodonts and the Devonian-Mississippian boundary in north-central Iowa. *Journal of Paleontology*, 40, 395-415.

ARCHBOLD, N.W. 1982. Correlation of Early Permian Gondwana faunas. *Journal of the Geological Society of Australia* 29, 267- 76.

ARCHBOLD N.W. 1988. Studies on Western Australian Permian brachiopods 8. The Late Permian brachiopod fauna of the Kirkby Range Member, Canning Basin. *Proceedings of the Royal Society of Victoria*, 100, 21-32.

ARCHBOLD, N.W., & DICKINS, J.M. 1991. Australian Phanerozoic Timescales 6. Permian. Biostratigraphic chart and explanatory notes. *Bureau of Mineral Resources, Australia, Record* 1989/36.

ARCHBOLD, N.W. & THOMAS, G.A. 1984. Permian Elythidae (Brachiopoda) from Western Australia. *Alcheringa*, 8, 311-326.

ARCHBOLD, N.W. & THOMAS, G.A. 1985a. Permian Spiriferellinae (Brachiopoda) from Western Australia. *Alcheringa*, 9, 35-48.

ARCHBOLD, N.W. & THOMAS, G.A. 1985b. New genera of Western Australian Permian Spiriferidae (Brachiopoda). *Alcheringa*, 9, 269-292.

ARCHBOLD, N.W. & THOMAS, G.A. 1986. *Neospirifer* and *Trigonotreta* (Spiriferida, Brachiopoda) from the Permian of Western Australia. *Alcheringa*, 10, 125-161.

ARCHBOLD, N.W. & THOMAS, G.A. 1987. *Fusispirifer* (Spiriferidae, Brachiopoda) from the Permian of Australia and Afghanistan. *Alcheringa*, 11, 175-203.

AUSTIN, R.L., ORCHARD, M.J. & STEWART, I.J. 1985. Conodonts of the Devonian system from Great Britain. pp. 93-166, In HIGGINS, A.C. & AUSTIN, R.L. Eds., *A stratigraphical index of conodonts*. British Micropalaeontological Society, Ellis Horwood Ltd, Chichester.

BALME, B.E. 1959. Palynological report no. GP 41. Samples submitted by West Australian Petroleum Pty. Limited. Meda No. 2 Well. p. 1, Appendix A, *In* Meda No. 2 Well, Geological Completion Report. West Australian Petroleum Pty Limited. *Bureau of Mineral Resources, Australia, File* 62/1022.

BALME, B.E. 1960. Notes on some Carboniferous microfloras from Western Australia. *Compte Rendu 4ieme Congres International de Stratigraphie er de Geologie du Carbonifere*, Heerlen, 1958, 1, 25-31.

BALME, B.E., 1962. Palynological examination of samples from Meda No. 1 - Permian Section. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 7, 23-24.

BALME, B.E. 1964. The palynological record of Australian pre-Tertiary floras. In CRANWELL, L.M. (Ed.) 49-80 *Ancient Pacific Floras*. University of Hawaii Press, Honolulu.

BALME, B.E. 1967. Palynological report No. 268: May River No. 1. pp.17-20, In *Western Australian Petroleum Pty. Limited, Well Completion Report, May River No. 1, Bureau of Mineral Resources, File* 67/4252 (unpublished)

BALME, B.E. 1968. Palynology summary. Blackstone No. 1 well. pp. 21-29, In JOHNSON, N.E.A. 1968. Blackstone No. 1. Well Completion Report. *West Australian Petroleum Pty. Limited* (unpublished).

BALME, B.E. 1988. Miospores from Late Devonian (early Frasnian) strata, Carnarvon Basin, Western Australia. *Palaeontographica* B209, 109-166.

BALME, B.E. 1990. Australian Phanerozoic Timescales 7. Triassic. *Bureau of Mineral Resources, Australia, Record* 1989/37.

BECKER, R.T., HOUSE, M.R., KIRCHGASSER, W.T. & PLAYFORD, P.E. 1991. Sedimentary and faunal changes across the Frasnian/Famennian boundary in the Canning Basin of Western Australia. *Historical Biology*, 5, 183-196.

BECKER, R.T., HOUSE, M.R. & KIRCHGASSER, W.T. 1992. Devonian goniatite biostratigraphy and timing of facies movements in the Frasnian of the Canning Basin, Western Australia. In Hailwood, E.A. and Kidd, P.R. (Eds) 'High Resolution of Marine Sequences'. *Geological Society of London, Special Publication* (in press).

BISCHOFF, G. 1968. Yulleroo No. 1 well completion report (Gewerkschaft Elwerath Inc.). *Bureau of Mineral Resources, Australia,* File 67/4249 (unpublished).

BLATCHFORD, T. 1927. The geology of portions of the Kimberley Division, with special references to the Fitzroy Basin, and the possibilities of the occurrences of mineral oil. *Geological Survey of Western Australia*, Bulletin 93, 1-56.

BRIGGS, D.E.G. & ROLFE, W.D.I. 1983. New Concavicarida (new order: ?Crustacea) from the Upper Devonian of Gogo, Western Australia, and the palaeoecology and affinities of the group. *Special Papers in Palaeontology*, 30, 249-276.

BROWN, I.A. 1964. An Ordovician cystoid (Pelmatozoa, Echinodermata) from Western Australia. *Journal and Proceedings of the Royal Society of Western Australia*, 47, 3-7.

BRUNNSCHWEILER R.O., 1954. Mesozoic stratigraphy and history of the Canning Desert and Fitzroy Valley, Western Australia. *Journal of the Geological Society of Australia*, 1, 35-54.

BRUNNSCHWEILER R.O., 1957. The geology of Dampier Peninsula, Western Australia. *Bureau Mineral Resources, Australia. Report* 13, 1-19

BRUNNSCHWEILER R.O. 1960. Marine fossils from the Upper Jurassic and the Lower Cretaceous of Dampier Peninsula, Western Australia. *Bureau Mineral Resources, Australia. Bulletin* 59, 1-46.

BUGGISCH, W., RABIEN, A., & HÜBHNER, G., 1978. Biostratrigraphische Parallelisierung und Faziesvergleich von oberdevonischen Becken und Schwellen-Profilen E. Dillenburg. *Geologisches Jahrbuch Hessen*, 106, 53-115, 6 pls. Wiesbaden.

BUGGISCH, W., RABIEN, A., & HÜBHNER, G., 1986. Stratigraphie und Fazies von Oberdevon/Unterkarbon-Profilen im Steinbruch "Beuerbach" bei Oberscheld. *Geologisches Jahrbuch Hessen*, 114, 5-60, 1 pl. Wiesbaden.

BUSHMINA, L.S., 1986. Nizhnekamennougol'nye predstaviteli semeistva Paraparchitiadae iuga zapadnoi Sibiri. (Lower Carboniferous representatives of the family Paraparchitidae from southwestern Siberia). *In* A.V. KANYGIN (ed.) Microfauna and biostratigraphy of the Phanerozoic of Siberia and adjacent regions. *Akademiya Nauk SSSR, Sibirskoye Otdeleniye, Institut Geoloigii i Geofiziki, Trudy*, 651, 111-135, pls. 25-30.

CASEY, J.N. & WELLS A.T., 1964. The geology of the north-east Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia. Report* 49, 1-61.

COCKBAIN, A.E. 1984. Stromatoporoids from the Devonian reef complexes, Canning Basin, Western Australia. *Geological Survey of Western Australia*, Bulletin 129, 1-105.

COCKBAIN, A.E. & PLAYFORD, P.E. 1988. The Devonian of Western Australia: A review. *In* McMILLAN, N.J., EMBRY, A.F. & GLASS, D.J. (Eds), 'Devonian of the World' *Canadian Society of Petroleum Geologists, Calgary, vol. 1*, 743-754.

COLBATH, G.K. 1990. Devonian (Givetian-Frasnian) organic-walled phytoplankton from the Limestone Billy Hills reef complex, Canning Basin, Western Australia. *Palaeontographica* B217, 87-145.

COLEMAN P.J., 1957. Permian Productacea of Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 40, 1-147.

COLLINS, D.H. 1959. *Canadian nautiloids from the Prices Creek area, Fitzroy Basin, Western Australia.* B.Sc. thesis, University of Western Australia (unpublished).

COMBAZ, A. & PENIGUEL, G. 1972. Etude palynostratigraphie de l'Ordovicien dans quelques sondages du Bassin de Canning (Australie Occidentale). *Bulletin Centre Recherche Pau SNPA*, 6, 121-167.

COSGRIFF, J.W., 1965. A new genus of Temnospondyli from the Triassic of Western Australia. *Journal and Proceedings of the Royal Society of Western Australia*, 48, 65-90.

CREEVEY K.J., 1971. Recent information and prospects in the Kidson Sub-basin. *APEA Journal* 11(1), 53-58.

CRESPIN, I. 1961. Upper Devonian foraminifera from Western Australia. *Palaeontology* 3(4), 397-409.

CRESPIN, I. 1962. Foraminifera in cores Nos. 1, 2, & 3 from Meda No. 1. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 7, 25-26.

CROCKFORD, J. 1957. Permian Bryozoa from the Fitzroy Basin, Western Australia. *Bureau Mineral Resources, Australia. Bulletin* 34, 1-91.

DELEPINE, G. 1935. Upper Devonian goniatites from Mt. Pierre, Kimberley District, Western Australia. *Quarterly Journal of the Geological Society of London,* 91, 208-15.

DENNIS, K.D. & MILES, R.S. 1979a. A second eubrachythoracid arthrodire from Gogo, Western Australia. *Zoological Journal of the Linnean Society*, 67, 1-29.

DENNIS, K.D. & MILES, R.S. 1979b. Eubrachythoracid arthrodires with tubular rostral plates from Gogo, Western Australia. *Zoological Journal of the Linnean Society*, 67, 297-328.

DICKINS J.M., 1963. Permian pelecypods and gastropods from Western Australia. *Bureau Mineral Resources, Australia. Bulletin* 63, 1-150.

DICKINS, J.M., TOWNER, R. & CROWE, P. 1977. A Permian cold-water marine fauna in the Grant Formation, Canning Basin, Western Australia. *Journal of the Palaeontological Society of India*, 20, 275-78.

DOLBY, J.H., & BALME, B.E., 1976. Triassic palynology of the Carnarvon Basin, Western Australia. *Review of Palaeobotany and Palynology* 22, 105-168.

DOLBY, G., McTAVISH, R.A., & QUILTY, P.G., 1973. Mimosa No. 1 Palaeontological Report, Appendix No. 1, *In*, OSBORNE, D.G., & SHAUGHNESSY, P.R., 1973. *WAPET Mimosa No. 1. Well Completion Report* (unpublished).

DRUCE, E. 1969. Upper Palaeozoic conodonts from the Bonaparte Gulf Basin, northwestern Australia. *Bureau of Mineral Resources, Australia, Bulletin* 98, 1-242.

DRUCE E.C., 1976. Conodont biostratigraphy of the Upper Devonian reef complexes of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 158, 1-303.

DRUCE E.C., & RADKE B.M. 1979. The geology of the Fairfield Group, Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 200, 1-62.

ETHERIDGE, R. 1897. An *Actinoceras* from north-west Australia. *Records of the Australian Museum* 3, 7-9.

ETHERIDGE, R. 1918. Observations on Carboniferous and other fossils. *Proceedings of the South Australian Branch of the Royal Geographical Society of Australia* 18, 250-62.

FLETCHER, H.O. 1943. The genus *Conocardium* from Australian Palaeozoic rocks. *Records of the Australian Museum,* 21, 231-42.

FOORD, A.H. 1890. Notes on the palaeontology of Western Australia. *Geological Magazine* 3,7, 97-106, 146-155.

FORMAN, D.J. & WALES, D.W. (compilers), 1981. Geological evolution of the Canning Basin, Western Australia. *Bureau of Mineral Resources,* Geology and Geophysics, *Bulletin* 210, 1-91.

FOSTER, C.B., 1982. Spore-pollen assemblages of the Bowen Basin, Queensland (Australia): their relationship to the Permian/Triassic boundary. *Review of Palaeobotany and Palynology* 36, 165-183.

FOSTER, C.B. & WATERHOUSE, J.B. 1988. The *Granulatisporites confluens* Oppel-zone and Early Permian marine faunas from the Grant Formation on the Barbwire Terrace, Canning Basin, Western Australia. *Australian Journal of Earth Sciences*, 35, 135-157.

FOSTER, C.B. & WILLIAMS, G.E. 1991. Late Ordovician-Early Silurian age for the Mallowa Salt of the Carribuddy Group, Canning Basin, Western Australia, based on occurrences of *Tetrahedraletes medinensis* Strother & Traverse 1979. *Australian Journal of Earth Sciences*, 38, 223-228.

FOSTER, C.B. & JONES, P.J. in prep. Re-examination of palaeontological samples from Mimosa 1 Well, Canning Basin, Western Australia. *AGSO Professional Opinion.*

FOWLER, E.M. 1963a. Palynological report. Langoora No. 1 well. pp. 16-19, *In* GARDNER, W.E. 1963. *WAPET Langoora No. 1. Well Completion Report* (unpublished).

FOWLER, E.M. 1963b. Palynological report. Samples submitted by West Australian Petroleum Pty. Ltd. Langoora No. 1 well. pp. 19a,b, *In* GARDNER, W.E. 1963. *WAPET Langoora No. 1. Well Completion Report* (unpublished).

GARDINER, B.G., 1984. The relationships of the palaeoniscid fishes, a review based on new specimens of *Mimia* and *Moythomasia* from the Upper Devonian of Western Australia. *British Museum (Natural History) Bulletin (Geology)*, 37, 173-427.

GARDINER, B.G. & MILES, R.S., 1975. Devonian fishes of the Gogo formation, Western Australia. *Colloques internationaux du Centre national de la Recherche scientifique*, 218, 73-79.

GARDNER, W.E. 1963. *WAPET Langoora No. 1. Well Completion Report* (unpublished).

GILBY, A.R. & FOSTER, C.B. 1988. Early Permian palynology of the Arckaringa Basin, South Australia. *Palaeontographica*, B209, 167- 191.

GLENISTER, B.F. 1958a. Conodonts & nautiloids from Meda No. 1. Report No. 22. pp. 33-35, In Meda No. 1 Well, Geological Completion Report. West Australian Petroleum Pty Limited. *Bureau of Mineral Resources, Australia, File* 62/1022.

GLENISTER, B.F. 1958b. Additional conodonts from Meda No. 1. Report No. 25. pp. 36-37, In Meda No. 1 Well, Geological Completion Report. West Australian Petroleum Pty Limited. *Bureau of Mineral Resources, Australia, File* 62/1022.

GLENISTER, B.F. 1958c. Upper Devonian ammonoids from the *Manticoceras* zone, Fitzroy Basin, Western Australia. *Journal of Paleontology* 32, 58-96.

GLENISTER, B.F. 1959. Conodonts from Meda Number 2. Report No. 29. pp. 5-7, appendix A, In Meda No. 2 Well, Geological Completion Report. *West Australian Petroleum Pty Limited* (unpublished)

GLENISTER, B.F. 1960. Carboniferous conodonts and ammonoids from Western Australia. *Compte Rendu 4ieme Congres International de Stratigraphie er de Geologie du Carbonifere*, Heerlen, 1958, 1, 213-217.

GLENISTER, B.F., & CRESPIN, I. 1959. Upper Devonian microfaunas from the Fitzroy Basin, Western Australia. *Australian Journal of Science*, 21, 222-223.

GLENISTER, B.F. & FURNISH, W.M. 1961. The Permian ammonoids of Australia. *Journal of Paleontology*, 35, 673-736.

GLENISTER, B.F. & FURNISH, W.M. 1962. Conodonts from Meda No. 1. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 7, 27-30.

GLENISTER, B.F., & GLENISTER, A.T., 1958. Discovery of subsurface Ordovician strata, Broome area, Western Australia. *Australian Journal of Science*, 20, 183-184.

GLENISTER, B.F., & KLAPPER, G. 1966. Upper Devonian conodonts from the Canning Basin, Western Australia. *Journal of Paleontology*, 40(4), 777-842.

GOLDSTEIN, B.A., 1989. Waxings and wanings in stratigraphy, play concepts and prospectivity in the Canning Basin. *Australian Petroleum Exploration Association Journal* 29, 466-508.

GORTER, J.D. 1980. Petroleum potential of the Permo-Carboniferous of the Northern Canning Basin, Western Australia. *Esso exploration Report* (unpublished)

GORTER, J.D., 1992. Ordovician petroleum in Australia in relation to eustasy. *In*. Webby, B.D. & Laurie, J.R. (eds.), *Global Perspectives on Ordovician Geology*, 433-443. Balkema, Rotterdam.

GORTER, J.D. & NICOLL, R.S., 1978. Reptilian fossils from Windjana Gorge, Western Australia. *Journal and Proceedings of the Royal Society of Western Australia, 60, 97-104.*

GREY, K. 1991. A mid-Givetian miospore age for the onset of reef development on the Lennard Shelf, Canning Basin, Western Australia. *Review of Palaeobotany and Palynology*, 68, 37-48.

GREY, K. 1992. Miospore assemblages from the Devonian reef complexes, Canning Basin, Western Australia. *Geological Survey of Western Australia, Bulletin* 140, 1-139.

GROOS-UFFENORDE, H., & WANG, S-Q., 1989. The entomozoacean succession of South China and Germany (Ostracoda, Devonian). *Courier Forschungsinstitut Senckenberg*, 110, 61-79.

GROSS, W., 1971. Unter devonische Thelodontier- und Acanthodier-Schuppen aus Westaustralien. *Palaontologischen Zeitschrift*, 45, 97-106.

GUPPY, D.G. & OPIK, A.A. 1950. Discovery of Ordovician rocks, Kimberley Division, Western Australia. *Australian Journal of Science*, 12, 205.

GUPPY, D.G., LINDNER, A.W., RATTIGAN, J.H. & CASEY, J.N., 1958. The geology of the Fitzroy Basin, Western Australia. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin 36*, 116 p.

HARDMAN, E.T., 1884. Report on the geology of the Kimberley District, Western Australia. *Western Australia Parlimentary Paper* 31.

HARDMAN, E.T., 1885. Report on the geology of the Kimberley District, Western Australia. *Western Australia Parlimentary Paper* 34.

HILL, D. 1936. Upper Devonian corals from Western Australia. *Journal and Proceedings of the Royal Society of Western Australia*, 22, 25-29.

HILL, D. 1939. Western Australian Devonian corals in the Wade collection. *Journal and Proceedings of the Royal Society of Western Australia*, 25, 141-151.

HILL, D. 1954. Coral faunas from the Silurian of New South Wales and the Devonian of Western Australia. *Bureau of Mineral Resources,* Geology and Geophysics, *Bulletin* 23, 1-51.

HILL D., & JELL J.S., 1970. Devonian corals from the Canning Basin, Western Australia. *Geological Survey of Western Australia. Bulletin* 121.

HOSKING, L.F.V. 1932. Western Australian Orthotetinae. *Journal and Proceedings of the Royal Society of Western Australia*, 18, 43-53.

HOSKING, L.F.V. 1933. Distribution of Devonian rocks in the Kimberley Division; and description of a recent collection of Devonian fossils from the Kimberley Division. *Journal and Proceedings of the Royal Society of Western Australia*, 19, 67-76.

HOWELL, B.F. 1952. Four new Devonian sponges from Western Australia. *Bulletin of the Wagner Institute of Science,* 27 (1).

HOWELL, B.F. 1956. A new Devonian *Sphaerospongia* from Western Australia. *Bulletin of the Wagner Institute of Science,* 31 (1).

HOWELL, B.F. 1957. A new Devonian sponge, *Striatospongia cylindrica* from Western Australia. *Bulletin of the Wagner Institute of Science,* 32 (1).

JACKSON, M.J., L.J. DIEKMAN, J.M. KENNARD, P.N. SOUTHGATE, P.E. O'BRIEN, & SEXTON, M.J. 1992. Sequence stratigraphy of the Devonian-Carboniferous of the Canning Basin and its use in the identification of basin floor fans and other petroleum plays: *Australian Petroleum Exploration Association Journal*, 32, 214-230.

JOHNSON, N.E.A. 1968. Blackstone No. 1. Well Completion Report. *West Australian Petroleum Pty. Limited* (unpublished).

JOHNSON, N.E.A. & BROWNHILL, M.H. 1967. May River No. 1. Well Completion Report. *West Australian Petroleum Pty. Limited.*

JONES, M.J. & TRUSWELL, E.M. 1992. Late Carboniferous and Early Permian palynostratigraphy of the Joe Joe Group, southern Galilee Basin, Queensland, and implications for Gondwanan stratigraphy. *BMR Journal of Australian Geology & Geophysics*, 13, 143-185.

JONES, P.J. 1958. Preliminary notes on micropalaeontological examination of sample from core 18, 7089-7101 feet from Meda No. 1 Bore. p. 40, *In* Meda No. 1 Well, Geological Completion Report. West Australian Petroleum Pty Limited. *Bureau of Mineral Resources, Australia File* 62/1022.

JONES, P.J., 1959. Preliminary report on Ostracoda from Bore BMR No. 2, Laurel Downs, Fitzroy Basin, Western Australia. *Bureau of Mineral Resources, Australia, Report* 38, 37--52, 2 figs.

JONES, P.J., 1961a. Ostracod assemblages near the Upper Devonian- Lower Carboniferous boundary in the Fitzroy and Bonparte Gulf Basins. In VEEVERS, J.J., & WELLS, A.T., 1961--The geology of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 60, 277-281.

JONES, P.J., 1961b. Preliminary notes on palaeontological examination of Barlee No. 1, core 2, 2308-2325 feet. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 16, 31-32.

JONES, P.J., 1962a. Micropalaeontological examination of the Lower Carboniferous--Upper Devonian sequence of Meda No. 1. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 7, 31-32.

JONES, P.J., 1962b. The ostracod genus *Cryptophyllus* in the Upper Devonian and Carboniferous of Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 62(3), 1-37, 3 pls.

JONES, P.J. 1968. Upper Devonian Ostracoda and Eridostraca from the Bonaparte Gulf Basin, northwestern Australia *Bureau of Mineral Resources, Australia, Bulletin*, 99, 1-93.

JONES, P.J. 1987. *Rhytiobeyrichia*, a new beyrichiacean ostracod from the late Devonian of Western Australia. *BMR Journal of Australian Geology & Geophysics*, 10, 287-300.

JONES, P.J. 1989. Lower Carboniferous Ostracoda (Beyrichiicopida and Kirkbyocopa) from the Bonaparte Basin, northwestern Australia. *Bureau of Mineral Resources, Australia, Bulletin* 228, 1-70.

JONES, P.J. 1991. Australian Phanerozoic Time Scales 5. Carboniferous. Bistratigraphic charts and explanatory notes. *Bureau of Mineral Resources, Australia, Record* 1989/35.

JONES, P.J., CAMPBELL, K.S.W., & ROBERTS, J., 1973. Correlation chart for the Carboniferous System of Australia. *Bureau of Mineral Resources, Australia, Bulletin* 156A, 1-40.

JONES, P.J., FOSTER, C.B. & YOUNG, G.C. 1991. Biostratigraphic summary of Langoora No. 1 well, Canning Basin, Western Australia. *BMR Professional Opinion*, 1991/4.

JONES, P.J. & YOUNG, G.C. 1990a. Biostratigraphic summary of Meda No. 1 well, Canning Basin, Western Australia. *BMR Professional Opinion*, 1990/2.

JONES, P.J. & YOUNG, G.C. 1990b. Biostratigraphic summary of Meda No. 2 well, Canning Basin, Western Australia. *BMR Professional Opinion*, 1990/3.

JONES, P.J. & YOUNG, G.C. 1990c. Biostratigraphic summary of Blackstone No. 1 well, Canning Basin, Western Australia. *BMR Professional Opinion*, 1990/4.

JONES, P.J. & YOUNG, G.C. 1991. Biostratigraphic summary of May River No. 1 well, Canning Basin, Western Australia. *BMR Professional Opinion*, 1991/1.

JONES, P.J. & YOUNG, G.C. 1992. Biostratigraphic summary of Mimosa 1 well, Canning Basin, Western Australia. *BMR Professional Opinion*, 1992/2.

KEMP, E.M., BALME, B.E., HELBY, R.J., KYLE, R.A., PLAYFORD, G., & PRICE, P.L. 1977. Carboniferous and Permian palynostratigraphy in Australia and Antarctica: a review. *BMR Journal of Australian Geology & Geophysics*, 2(3), 177-208.

KENNARD, J.M., P.N. SOUTHGATE, M.J. JACKSON, P.E. O'BRIEN, N. CHRISTIE-BLICK, A.E. HOLMES, & SARG, J.F. 1992. A new sequence perspective on the Devonian reef complex and the Frasnian-Famennian boundary, Canning Basin, Australia. *Geology* 20, 1135-1138

KOOP, W.J., 1966. Recent contributions to Palaeozoic geology in the South Canning Basin, Western Australia. *APEA Journal 1966*, 106-109.

LAURIE J.R., 1987. A re-assessment of the brachiopod genus *Spanodonta* Prendergast from the Lower Ordovician of Western Australia. *Alcheringa* 11, 44-49.

LEGG, D.P., 1976. Ordovician trilobites and graptolites from the Canning Basin, Western Australia. *Geologica et Palaeontologica* 10, 1-58.

LEGG, D.P., 1978. Ordovician biostratigraphy of the Canning Basin, Western Australia. *Alcheringa* 2, 321-334.

LEHMANN, P.R., 1984. The Stratigraphy, Palaeogeography and Petroleum Potential of the Lower to lower Upper Devonian Sequence in the Canning Basin. *In* Purcell, P.G., (Ed.), *The Canning Basin, W.A.*: Proceedings of Geological Society of Australia/Petroleum Exploration Society Australia Symposium, Perth, 1984.

LINDSTROM, M., McTAVISH, R.A. & ZIEGLER, W. 1972. Feinstrukturelle Untersuchungen an Conodonten. 2. Einige Prioniodontidae aus dem Ordovizium Australiens. *Geologica et Palaeontologica*, 6, 33-43.

LONG, J.A., 1985. A new osteolepid fish from the Upper Devonian Gogo Formation, Western Australia. *Records of the Western Australian Museum* 12(3), 361-377.

LONG J.A., 1987a. A new dinichthyid fish (Placodermi: Arthrodira) from the Upper Devonian of Western Australia, with a discussion of dinichthyid interrelationships. *Records of the Western Australian Museum* 13(4), 515-540.

LONG J.A., 1987b. Upper Devonian conodonts associated with a large placoderm fish skull from the Canning Basin, Western Australia. *Records of the Western Australian Museum* 13(4), 501-513.

LONG, J.A., 1988. Late Devonian fishes from Gogo, Western Australia. *National Geographic Research*, 4, 436-450.

LONG, J.A., 1990. *Dinosaurs of Australia, and other animals of the Mesozoic Era.* Reed Books, Balgowlah, 1-87.

MAMET, B. & PLAYFORD, P.E. 1968. Sur la presence de Quasiendothyrinae (foraminiferes) en Australie occidentale (Canning Basin). *Comptes Rendus Sommaire des Seances de la Societe Geologique de France*, 1968, fascicule 7, 229.

McTAVISH, R.A., 1961. *Conodonts from the Prices Creek Group (Ordovician) of northwestern Australia.* (M.Sc. Thesis, University of Western Australia, unpublished).

McTAVISH, R.A. 1963. Micropalaeontological report. Langoora No 1 Well, Canning Basin, W.A. *In* GARDNER, W.E. 1963. *WAPET Langoora No. 1. Well Completion Report* (unpublished).

McTAVISH, R.A. 1968a. Correlation of the Lower Carboniferous-Devonian. May River No. 1, Meda Nos. 1 and 2, Blackstone No. 1, Frome Rocks No. 2, and Yulleroo No. 1. *Correlation Chart C- 11,787, from West Australian Petroleum Pty Ltd*, Unpublished Report.

McTAVISH, R.A. 1968b. The Devonian-Lower Carboniferous microfauna of Meda No. 2. *West Australian Petroleum Pty Ltd*, Unpublished Report No. 1756.

McTAVISH, R.A., 1971. Microstructure and taxonomy of *Prioniodus* - a case history. *Symposium on Conodont Taxonomy, Marburg/Lahn 1971*. Abstracts of Lectures, 22.

McTAVISH, R.A., 1973. Prioniodontacean conodonts from the Emanuel Formation (Lower Ordovician) of Western Australia. *Geologica et Palaeontologica 7*, 27-58.

McTAVISH, R.A. & LEGG, D.P., 1976. The Ordovician of the Canning Basin, Western Australia. *In* Bassett, M.G. (ed.), *The Ordovician System: Proceedings of a Palaeontological Association symposium*, 447-478. University of Wales Press and National Museum of Wales, Cardiff.

McWHAE, J.R., PLAYFORD, P.E., LINDNER, A.W., GLENISTER, B.F. & BALME, B.E. 1958. The stratigraphy of Western Australia. *Journal of the Geological Society of Australia*, 4, 1-161.

MIDDLETON, M.F. 1990. Canning Basin. *In* The Geology of Western Australia. *Geological Survey of Western Australia, Memoir* 3, 425-457.

MILES, R.S., 1971. The Holonematidae (placoderm fishes), a review based on new specimens of *Holonema* from the Upper Devonian of Western Australia. *Philosophical Transactions of the Royal Society of London (B)*, 263, 101-234.

MILES, R.S., & DENNIS, K., 1979. A primitive eubrachythoracid arthrodire from Gogo, Western Australia. *Zoological Journal of the Linnean Society*, 66, 31-62.

MILES, R.S. & YOUNG, G.C., 1977. Placoderm interrelationships reconsidered in the light of new ptyctodontids from Gogo, Western Australia. *In* S.M. Andrews, R.S. Miles & A.D. Walker (Eds), *Problems in Vertebrate Evolution. Linnean Society Symposium Series*, 4, 123-198. Academic Press, London.

NAZAROV, B.B., COCKBAIN, A.E. & PLAYFORD, P.E. 1982. Upper Devonian Radiolaria from the Gogo Formation, Canning Basin, Western Australia. *Alcheringa* 6, 161-174.

NICOLL, R.S., 1980. The multielement genus *Apatognathus* from the Late Devonian of the Canning Basin, Western Australia. *Alcheringa* 4, 133-152.

NICOLL, R.S. in prep. Ordovician conodont distribution in selected petroleum exploration wells, Canning Basin, Western Australia.

NICOLL, R.S., & DRUCE, E.C., 1979. Conodonts from the Fairfield Group, Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 190, 1-134.

NICOLL, R.S. & JONES, P.J. 1982. Conodont and ostracod faunas from W.M.C. Acacia No. 1, Canning Basin, Western Australia. *BMR Professional Opinion*, GEOL 82.011.

NICOLL, R.S., NIELSEN, A.T., LAURIE, J.R. & SHERGOLD, J.H., 1992. Preliminary correlation of Payntonian (Latest Cambrian) to earliest Arenig (Early Ordovician) sealevel events in Australia and Scandinavia. *In.* Webby, B.D. & Laurie, J.R. (eds.), *Global Perspectives on Ordovician Geology,* 381-394. Balkema, Rotterdam, 381-394.

NICOLL, R.S., OWEN, M., SHERGOLD, J.H., LAURIE, J.R. & GORTER, J.D., 1988. Ordovician event stratigraphy and the development of a Larapintine Seaway, central Australia. *Bureau of Mineral Resources,* Australia, *Record 1988/42, 72-77.*

NICOLL, R.S. & YOUNG, G.C. 1987. Age of microfossils from Gingerah Hill No. 1, Canning Basin, Western Australia. *Bureau of Mineral Resources,* Australia, *Professional Opinion 1987/12.*

NICOLL, R.S., LAURIE, J.R. & ROCHE, M.T. in press. Revised stratigraphy of the Ordovician (late Tremadoc - Arenig) Prices Creek Group and Devonian Poulton Formation, Lennard Shelf, Canning Basin, Western Australia. *BMR Journal of Australian Geology & Geophysics*, 13 (4).

OSBORNE, D.G., & O'SHAUGHNESSY, P.R., 1973. WAPET Mimosa No. 1. *Well Completion Report* (unpublished).

PETERSEN, M.S. 1975. Upper Devonian (Famennian) ammonoids from the Canning Basin, Western Australia. *Journal of Paleontology Vol. 49 Supplement. Paleontological Society Memoir*, 8, 1-55.

PLAYFORD, G. 1971. Lower Carboniferous spores from the Bonaparte Gulf Basin, Western Australia and Northern Territory. *Bureau Mineral Resources, Australia, Bulletin* 115, 1-69.

PLAYFORD, G. 1972. Trilete spores of *Umbonatisporites* in the Lower Carboniferous of northwestern Australia. *Neues Jahrbuch fur Geologie und Palaontologie. Abhandlungen*, 141, 301-315.

PLAYFORD, G. 1976. Plant microfossils from the Upper Devonian and Lower Carboniferous of the Canning Basin, Western Australia. *Palaeontographica B*, 158, 1-71.

PLAYFORD, G. & MARTIN F., 1984. Ordovician acritarchs from the Canning Basin, Western Australia. *Alcheringa*, 8, 187-223.

PLAYFORD, G. & POWIS, G.D. 1979. Taxonomy and distribution of some trilete spores in Carboniferous strata in the Canning Basin, Western Australia. *Pollen et Spores*, 21, 371-94.

PLAYFORD, P.E. 1962. Carboniferous-Devonian contact in Meda No. 1, the Sisters No. 1, and B.M.R. No. 2 (Laurel Downs). *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 7, 35-36.

PLAYFORD, P.E., 1980. Devonian "Great Barrier Reef" of the Canning Basin, Western Australia. *American Association of Petroleum Geologists Bulletin*, 64, 814-840.

PLAYFORD, P., COPE, R.N., COCKBAIN, A.E., LOWE, G.H. & LOWRY, D.C., 1975. Canning Basin. *In* The Geology of Western Australia. *Geological Survey of Western Australia, Memoir 2*, 319-368

PLAYFORD, P.E. & LOWRY, D.C., 1966. Devonian reef complexes of the Canning Basin, Western Australia. *Geological Survey Western Australia, Bulletin* 118, 150pp.

POWIS, G.D., 1984. Palynostratigraphy of the Late Carboniferous sequence, Canning Basin, W.A. In PURCELL, P.G. (Editor) 1984, *The Canning Basin, W.A.: Proceedings of the Geological Society of Australia/Petroleum Exploration Society of Australia Symposium, Perth*, 429-438.

PRENDERGAST, K.L., 1935. Some Western Australian Upper Palaeozoic fossils. *Journal and Proceedings of the Royal Society of Western Australia*, 21, 9-35.

PURCELL, P.G., 1984 (Editor). *The Canning Basin, W.A.: Proceedings of the Geological Society of Australia/Petroleum Exploration Society of Australia Symposium, Perth*, 1984, 582 p.

RIPPER, E.A. 1937. A note on the occurrence of *Amphipora ramosa* (Phillips) in Western Australia. *Journal and Proceedings of the Royal Society of Western Australia*. 23, 37-41.

ROBERTS, J., 1985. Australia, 9-145. *In* MARTINEZ DIAZ, C. (Editor)--The Carboniferous of the world: 2. Australia, Indian subcontinent, South Africa, South America and North Africa. *International Union of Geological Sciences Publication* 20, 1-447.

ROBERTS, J., JONES, P.J., JELL, J.S. JENKINS, T.B.H., MARSDEN, M.A.H., MCKELLAR, R.G., MCKELVEY, B.C., & SEDDON, G. 1972. Correlation of the Upper Devonian rocks of Australia. *Journal of the Geological Society of Australia*, 18, 467-490.

ROSS, J.R.P., 1961. Ordovician, Silurian and Devonian Bryozoa of Australia. *Bulletin of the Bureau of Mineral Resources, Australia*, Bulletin 50, 1-172.

SANDBERG, C.A., & DREESEN, R. 1984. Late Devonian icriodontid biofacies models and alternate shallow-water conodont zonation. *Geological Society of America, Special Paper* 196, 143-178.

SANDBERG, C.A., ZIEGLER, W. LEUTERITZ, K. & BRILL, S.M. 1978. Phylogeny, speciation, and zonation of *Siphonodella* (Conodonta, Upper Devonian and Lower Carboniferous). *Newsletters on Stratigraphy*, 7, 102-120.

SCHULTZE, H.-P. 1968. Palaeoniscoidea-schuppen aus dem Unterdevon Australiens und Kanadas und aus dem Mitteldevon Spitzbergens. *Bulletin of the British Museum (Natural History) (Geology)*, 16, 343-368.

SEDDON G., 1970. Frasnian conodonts from the Sadler Ridge-Bugle Gap area, Canning Basin, Western Australia. *Journal of the Geological Society of Australia*, 16, 723-753.

SHAW, R.D., TYLER, I.M., GRIFFIN, T.J. & WEBB, A., 1992. New K-Ar constraints on the onset of subsidence in the Canning Basin, Western Australia. *BMR Journal of Australian Geology and Geophysics 13*, 31-35.

SHAW, R.D., SEXTON, M.J. & ZEILINGER, I. in prep. Tectonic framework of the Canning Basin. *AGSO Record.*

SKWARKO, S.K., 1967. Mesozoic Mollusca from Australia and New Guinea. *Bureau of Mineral Resources, Australia. Bulletin* 75, 1-98.

SKWARKO, S.K., 1974. Some Ordovician graptolites from the Canning Basin, Western Australia. 2. Graptolites from the Goldwyer No.1 well. *Bureau of Mineral Resources, Australia. Bulletin* 150, 43-54.

SOUTHGATE, P.N. KENNARD, J.M., JACKSON, M.J., O'BRIEN, P.E. & SEXTON, M.J. in press. Reciprocal lowstand clastic and highstand carbonate sedimentation, subsurface Devonian Reef Complex, Canning Basin, Western Australia. *AAPG Memoirs.*

STRUSZ, D.L. 1992. A review of the Devonian brachiopod record in the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Record* 1992/48.

TASCH P., & JONES P.J., 1979. Carboniferous and Triassic Conchostraca from the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 185, 3-20.

TEICHERT, C., 1939. Nautiloid cephalopods from the Devonian of Western Australia. *Journal of the Royal Society of Western Australia*, 25, 103-121.

TEICHERT, C., 1940. Actinosiphonate cephalopods (Cyrtoceroida) from the Devonian of Australia. *Journal of the Royal Society of Western Australia*, 26, 59-75.

TEICHERT, C., 1941. Upper Devonian goniatite succession of Western Australia. *American Journal of Science*, 239, 148-153.

TEICHERT, C., 1943. The Devonian of Western Australia - a preliminary review. *American Journal of Science*, 241(2), 69-94, 167-184.

TEICHERT, C., 1947. Stratigraphy of Western Australia. *Journal and Proceedings of the Royal Society of New South Wales*, 80, 81-142.

TEICHERT, C., 1949. Observations on stratigraphy and palaeontology of Devonian, western portion of Kimberley Division, Western Australia. *Bureau of Mineral Resources, Australia Report*, 2, 1-55.

TEICHERT, C. & GLENISTER, B.F., 1952. Fossil nautiloid faunas from Australia. *Journal of Paleontology*, 26, 730-752.

TEICHERT, C. & GLENISTER, B.F., 1954. Early Ordovician cephalopod fauna from northwestern Australia. *Bulletin of American Paleontology* 35, 1-130.

THOMAS, D.E., 1960. The zonal distribution of Australian graptolites. *Journals and Proceedings of the Royal Society of New South Wales*, 94, 1-58.

THOMAS, G.A. 1957. Lower Carboniferous deposits in the Fitzroy Basin, Western Australia. *Australian Journal of Science*, 9, 160-161.

THOMAS, G.A. 1958. The Permian Orthotetacea of Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 39, 1-159.

THOMAS, G.A. 1959a. No. 2 core, Meda No. 2 bore, 5287-5298 feet. p. 2, appendix A, In Meda No. 2 Well, Geological Completion Report. *West Australian Petroleum Pty Limited* (unpublished)

THOMAS, G.A. 1959b. Core 8, Meda No. 2 bore, 6629'-6637'. p. 3, appendix A, In Meda No. 2 Well, Geological Completion Report. *West Australian Petroleum Pty Limited* (unpublished)

THOMAS, G.A. 1959c. The Lower Carboniferous Laurel Formation of the Fitzroy basin. *Bureau of Mineral Resources Report, Australia,* 38, 31-36.

THOMAS, G.A. 1962. Preliminary identifications of macrofossils from Meda No. 1. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 7, 33.

THOMAS, G.A., 1971. Carboniferous and Early Permian brachiopods from Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 56, 1-215.

TOMLINSON, J.G. 1961. Preliminary report on Lower Palaeozoic fossils of Samphire Marsh No. 1. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 5, 29-36.

TOWNER R.R., & GIBSON D.L., 1980. Geology of the Late Carboniferous and younger rocks of the onshore western Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia. Record* 80/30.

TOWNER, R.R. & GIBSON, D.L., 1983. Geology of the onshore Canning Basin, Western Australia. *Bureau of Mineral Resources, Geology and Geophysics, Bulletin* 215, 1-51.

TSCHIGOVA, V.A. 1977. *Stratigrafiya I Correlyatsiya Neftegaz-onosnykh Otlozhenii Devona I Karbona Evropeiskoi Chasti SSR I Zarububezhnykh Stran.* (Stratigraphy and correlation of the oil and gas deposits of the Devonian and Carboniferous of the European part of the USSR and neighbouring regions). Moskva, *Nedra*, 1-194, pls. 1-47.

TURNER, S. 1991. Palaeozoic vertebrate microfossils in Australasia. *In* Rich, P., Monaghan, J.M., et al. (eds) *Vertebrate Palaeontology of Australasia*, 429-464, Monash University, Melbourne.

TURNER, S., JONES, P.J., & DRAPER, J.J., 1981. Early Devonian thelodonts (Agnatha) from the Toko Syncline, western Queensland, and a review of other Australian discoveries. *BMR Journal of Australian Geology & Geophysics*, 6, 51-69.

VEEVERS, J.J. 1959a. Devonian brachiopods from the Fitzroy Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 45, 1-173.

VEEVERS, J.J. 1959b. Devonian and Carboniferous brachiopods from northwestern Australia. *Bureau of Mineral Resources, Australia, Bulletin* 55, 1-34.

VEEVERS, J.J. 1959c. Fossils from WAPET Meda No. 2. p. 4, appendix A, In Meda No. 2 Well, Geological Completion Report. *West Australian Petroleum Pty Limited* (unpublished)

VEEVERS, J.J. 1962. Report on fossils from Meda No. 1, core 18. *Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Publication* 7, 34.

VEEVERS, J.J. & WELLS, A.T., 1961. The geology of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Bulletin* 60, 1-323.

WANG, S.-Q. 1983. Late Devonian pelagic ostracod sequences in Luofu region of Guangxi. *Bulletin of the Nanjing Institute of Geology and Paleontology, Academia Sinica*, 6, 159-172.

WANG, N.Z., 1989. Discovery of Late Silurian microfossils of Agnatha and fishes from Yunnan, China. *Acta Palaeontologica Sinica*, 28, 192-206.

WANG, N.Z., 1992. Microremains of agnathans and fishes from Lower Devonian of central Guangxi with correlation of lower Devonian between central Guangxi and eastern Yunnan, south China. *Acta Palaeontologica Sinica*, 31, 280-303.

WATSON, S.T., 1988. Ordovician conodonts from the Canning Basin (W. Australia). *Palaeontographica* A203, 91-147.

WEBSTER, G.D. & JELL, P.A. 1992. Permian echinoderms from Western Australia. *Memoirs of the Queensland Museum*, 32, 311-73.

WEBBY, B.D. & NICOLL, R.S. 1989. Australian Phanerozoic Timescales 2. Ordovician. *Bureau of Mineral Resources Australia, Record* 1989/32.

WELLS A.T., 1980. Evaporites in Australia. *Bureau Mineral Resources, Australia, Bulletin* 198, 1-104.

WHITE M.E., & YEATES A.N., 1976. Plant fossils from the northeastern part of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia, Record* 76/18.

YEATES A.N., CROWE R.W.A., TOWNER R.R., WYBORN L.A.I., & PASSMORE V.L., 1975. Notes on the geology of the Gregory sub-basin and adjacent areas of the Canning Basin, Western Australia. *Bureau of Mineral Resources, Australia. Record* 75/77.

YEATES, A.N., GIBSON, D.L., TOWNER, R.R. & CROWE, R.W.A., 1984. Regional geology of the onshore Canning Basin, W.A. (keynote paper). In PURCELL, P.G. (Editor) 1984, *The Canning Basin, W.A.: Proceedings of the Geological Society of Australia/Petroleum Exploration Society of Australia Symposium, Perth,* 23-55.

YOUNG, G.C., 1984. Reconstruction of the jaws and braincase in the Devonian placoderm fish *Bothriolepis. Palaeontology* 27, 625- 661.

YOUNG, G.C., 1987. Devonian fish remains from Billiluna, eastern Canning Basin, Western Australia. *BMR Journal of Aust. Geol. & Geophys., 10(2), 179-192.*

YOUNG, G.C. 1989. Australian Phanerozoic Timescales 4. Devonian. Biostratigraphic chart and explanatory notes. *Bureau of Mineral Resources, Australia, Record* 1989/34.

YOUNG, G.C., BARWICK, R.E., & CAMPBELL, K.S.W., 1989. Pelvic girdles of lungfishes (Dipnoi). pp.59-75, In R. W. Le Maitre (ed.) *Pathways in Geology. Essays in honour of Edwin Sherbon Hills.* Blackwells Scientific Publications (Australia), ix + 463 pp.

YOUNG, G.C., TURNER, S. & JONES, P.J. in prep. Ordovician and Devonian microvertebrates, and age control within the Carribuddy Group, Canning Basin, Western Australia.

ZIEGLER, W. 1962. Taxionomie und Phylogenie Oberdevonischer Conodonten und ihre stratigraphische Bedeutung. *bh. Hess. Landesamt. Bodenforsch.*, 38, 1-166.

ZIEGLER, W. & SANDBERG, C.A. 1984. *Palmatolepis*-based revision of upper part of standard Late Devonian conodont zonation. *Geological Society of America, Special Paper* 196, 179-194.

ZIEGLER, W. & SANDBERG, C.A. 1990. The Late Devonian standard conodont zonation. *Courier Forschungsinstitut Senckenberg*, 121, 1-115.

ZIEGLER, W., SANDBERG, C.A., & AUSTIN, R.L., 1974. Revision of *Bispathodus* group (Conodonta) in the Upper Devonian and Lower Carboniferous. *Geologica et Paleontologica* 8, 97-112.