Early Cambrian acritarchs, trilobites and archaeocyaths from Yalkalpo 2, eastern Arrowie Basin, South Australia

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January 2001

Report Book 2001/00002

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EARLY CAMBRIAN ACRITARCHS, TRILOBITES AND ARCHAEOCYATHS FROM YALKALPO 2, EASTERN ARROWIE BASIN, SOUTH AUSTRALIA

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Early Cambrian sediments in the Arrowie Basin, South Australia, were deposited on a continental platform and have been divided into five unconformity bounded depositional sequences and subsequences from basal Cambrian to early Toyonian. The Cambrian sediments are well exposed in the western part of the basin, but are under Mesozoic to Quaternary cover in the east. A nearly complete Cambrian succession was intersected and fully cored in Yalkalpo 2, and the sediments contain abundant trilobites, small skeletal fossils, archaeocyaths, and organic-walled microfossils. Four trilobite zones are recognised in cores, ranging from late Atdabanian (*Abadiella huoi* Zone) to Toyonian (*Pararaia janeae* Zone). Two archaeocyathan zones (beds) also occur with the trilobites. Three acritarch assemblages are present, dominated by *Skiagia*. Continuous occurrences of acritarch *Skiagia, Ceratophyton* and *Corollasphaeridium* provide valuable evidence of evolutionary development and are thus useful for biostratigraphic zonation in South Australian Cambrian sequences.

New acritarch species or combinations in Yalkalpo 2 include *Baltisphaeridium bimacerium* sp. nov., *Ceratophyton circufuntum* sp. nov., *Ceratophyton dumufuntum* sp. nov., *Ceratophyton spinuconum* sp. nov., *Corollasphaeridium aliquolumum* sp. nov., *Corollasphaeridium opimolumum* sp. nov., *Veryhachium* (*Veryhachium*) *trisentium* sp. nov. and *Vulcanisphaera pseudofaveolata* (Fridrichosone, 1971) comb. A modified diagnosis of *Skiagia* is given.

INTRODUCTION

Early Cambrian (≡ ∈ 1) sequences in the Arrowie and Stansbury Basins were deposited on a rifted continental platform bounded to the west by the Gawler Province, and to the east, in the Arrowie Basin, by the Curnamona Craton (Fig. 1). The sequences overlie a thick Neoproterozoic rift complex (~850–545 Ma) of the Adelaide Geosyncline (Preiss, 1987; Jago and Moore, 1990). Mid-Neoproterozoic (~700 Ma) continental breakup was followed by renewed rifting, reflecting the latest Neoproterozoic – Early Cambrian continental separation that formed the western margin of Laurentia (Powell et al., 1994). The Early Cambrian sequences were mainly formed on either a rifted platform of a pericratonic basin (e.g. Arrowie Basin) or a passive margin (e.g. Stansbury Basin) of the western palaeo-Pacific Ocean. Similar structural settings and sedimentary sequences in South Australia led Wopfner (1972) to suggest that the Arrowie and Stansbury Basins were interconnected during the Early Cambrian even though currently they are ~150 km apart. The Neoproterozoic and Cambrian sediments in the study region were deformed by the Cambro-Ordovician Delamerian Orogeny.

Cambrian sediments in the Arrowie Basin consist of carbonate and siliciclastics up to 4.2 km thick, which can be mapped from platform to slope–trough facies (Dalgarno, 1964; Wopfner, 1970; Forbes, 1972; Coats, 1973; Gravestock, 1995). The basin can be divided into two parts. In the west, the sediments are well exposed in the Flinders Ranges and on the Stuart Shelf, and contain all type sections in the Cambrian Hawker Group. To the east, the Cambrian sequences underlie Mesozoic and Cainozoic sediments; two synclines, Yalkalpo and Moorowie, are separated by the Palaeoproterozoic and early Mesoproterozoic Benagerie Ridge. Both synclines have been drilled as part of petroleum and mineral exploration programs. This has resulted in several kilometres of core, most of which is yet to be studied systematically.

This paper summarises a joint study of sequence stratigraphy and biostratigraphic investigation, including archaeocyaths, trilobites, acritarchs and small skeletal fossils in Yalkalpo 2, by a team supervised by the late David Gravestock who was responsible for the lithological log (Fig. 4) and identification of the archaeocyaths in the drillhole. David Gravestock made a major

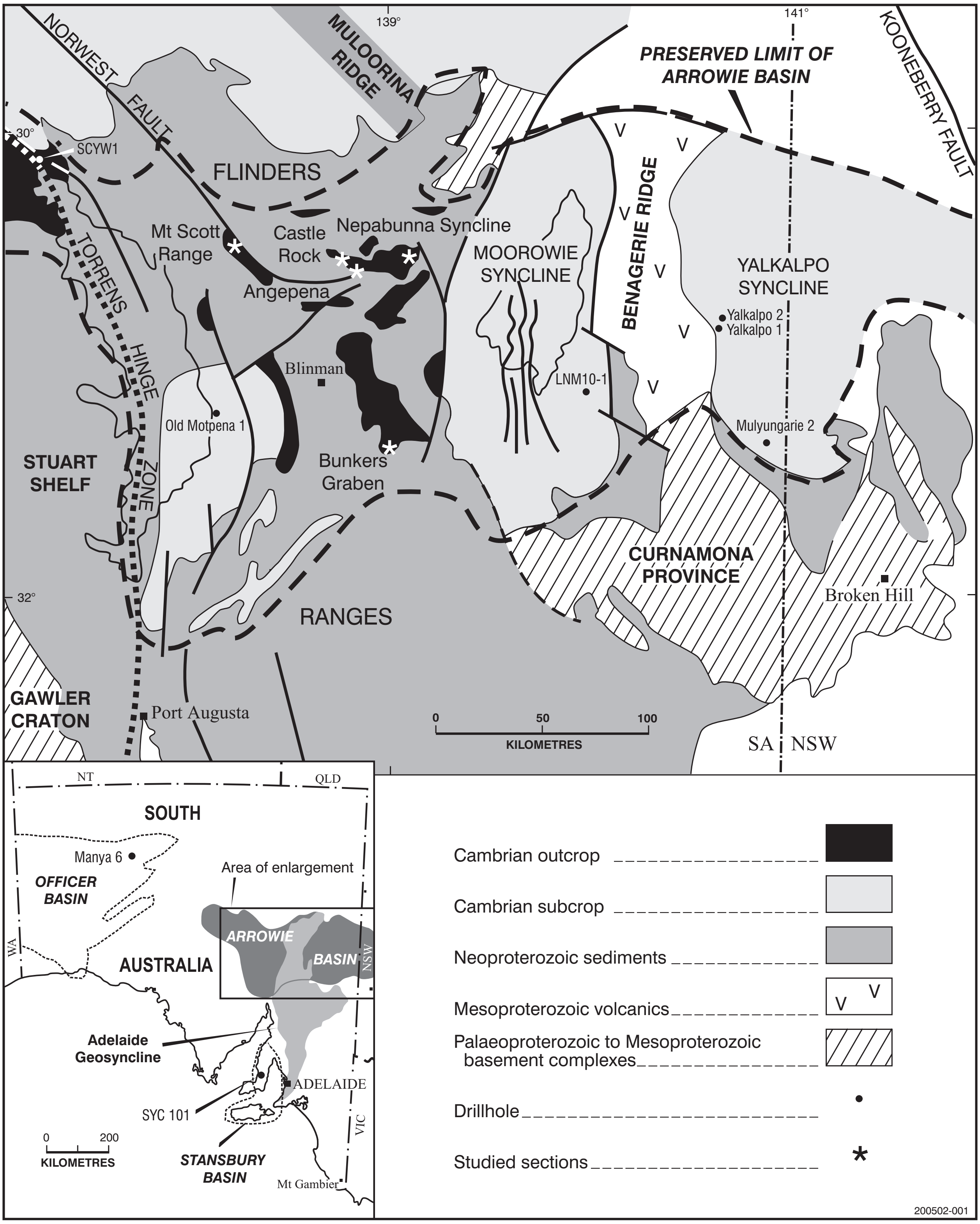


Fig. 1 *Location maps showing major basins and drillholes in this study.*

contribution to the understanding of the Cambrian of South Australia prior to his untimely death in December 1999. This paper is dedicated to his memory.

STRATIGRAPHIC SETTING

Early Cambrian sediments crop out widely in the Flinders Ranges (Fig. 1), but the lowest unit, the Uratanna Formation, is limited to the Mt Scott Range, Beltana and Angepena–Nepabunna regions. It is considered to have been deposited in isolated troughs, channels or grabens and half grabens within the Ediacara-fauna-bearing Rawnsley Quartzite during a major latest Neoproterozoic–Early Cambrian sea-level fall, although in the Angepena region it crops out continuously for more than 80 km (Coats, 1973). The formation was recognised by Daily (1972, 1973) and contains the trace fossils *Phycodes*, *Treptichnus*, *Rusophycus* and *Sabellidites*, which Mount (1993) correlated with the basal Cambrian stratotype section in Newfoundland, Canada. At the Castle Rock section, the Uratanna Formation contains a deltaic succession and consists of lowstand wedge and submarine channel deposits, which pass up into prodelta–mid-shelf laminated siltstone, and then up into highstand delta front and shoreface siltstone and sandstone. The formation is disconformably overlain by transgressive sandstone of the Parachilna Formation. Where the Uratanna Formation is absent, the Parachilna Formation rests unconformably on the Neoproterozoic succession. The unconformity at the base of the Parachilna can be mapped across the basin; it has been interpreted as a result of tectonic shift from the latest Neoproterozoic uplift phase (e.g. Petermann Ranges Orogeny) to the renewed Cambrian rift or subsidence trend (Zang, in prep.).

The Parachilna Formation is up to 570 m thick in the Nepabunna Trough (cf. Mann, 1981). It comprises a transgressive succession from the lower shallow-water sandstone to the relatively deep marine siltstone in the upper part. The siltstone contains the widespread trace fossils *Diplocraterion parallelum* and *Plagiogmus arcuatus* plus small skeletal fossils, including the gastropod *Bemella* sp. The formation is considered to have been deposited in a shelf–platform setting in the basin and is conformably overlain by the Woodendinna Dolomite.

On the platform–shelf part of the Arrowie Basin, the Woodendinna Dolomite is unconformably overlain by the Ajax Limestone (Mt Scott Range) or equivalent Wilkawillina Limestone (Bunkers Graben), which contains the earliest known occurrences of archaeocyaths and trilobites in Australia (Bengtson et al., 1990). In the eastern Arrowie Basin, the dolomite intertongues with the Wirrapowie Limestone. The Wilkawillina and Ajax Limestones can be divided into three units by recognisable regional unconformities (Gravestock, 1984; Clarke, 1990c; Zang, in prep.), ranging from Atdabanian to late Botoman (Fig. 2). Some of their equivalents in the more basinal part of the Arrowie Basin include the Mernmerna Formation, Bunkers Sandstone, Oraparinna Shale, Moorowie Formation, Narina Greywacke, Nepabunna Siltstone, and the Midwerta Shale (Clarke, 1990a,b; Gravestock, 1995). The Botoman sediments underlie the deltaic ‘red beds’ of the Billy Creek Formation (Moore, 1990), which contains a tuff layer dated at 522.8±1.8 Ma (Gravestock and Shergold, 2000). Sediments in Yalkalpo 2 are fully cored from the Tommotian Parachilna Formation to the Toyonian Billy Creek Formation. This core provides an opportunity to link acritarch, archaeocyathid and trilobite biostratigraphy because acritarchs are much better preserved in core than outcrop due to their destruction by oxidation in the latter.

In terms of sequence stratigraphy, Gravestock (1995) and Gravestock and Shergold (2000) recognised four of what were termed sequence sets (or supersequences; ∈1.0, ∈1, ∈2 and ∈3) within the Cambrian successions of the Arrowie and Stansbury Basins (Fig. 2). The ∈1 sequence set is divided into four sequences: Uratanna (≡∈1.0), ∈1.1, ∈1.2 and ∈1.3. The recognition of a local and regional unconformity between the Woodendinna Dolomite and lower Wilikawillina Limestone in the Bunkers Graben (Arrowie Basin), and dolomite and limestone units of the Kulpara Formation in the Ardrossan Quarry (Stansbury Basin), further separates the sequence into two subsequences, e.g. ∈1.1A and ∈1.1B (Figs 2, 3).

REVIEW OF BIOSTRATIGRAPHY

Daily (1956) was the first to establish an informal series of 10 Early Cambrian faunal assemblages based on the Cambrian trilobite faunas of the Stansbury and Arrowie Basins. For many years these were the basis of Early Cambrian correlations between Australia and other parts of the world.

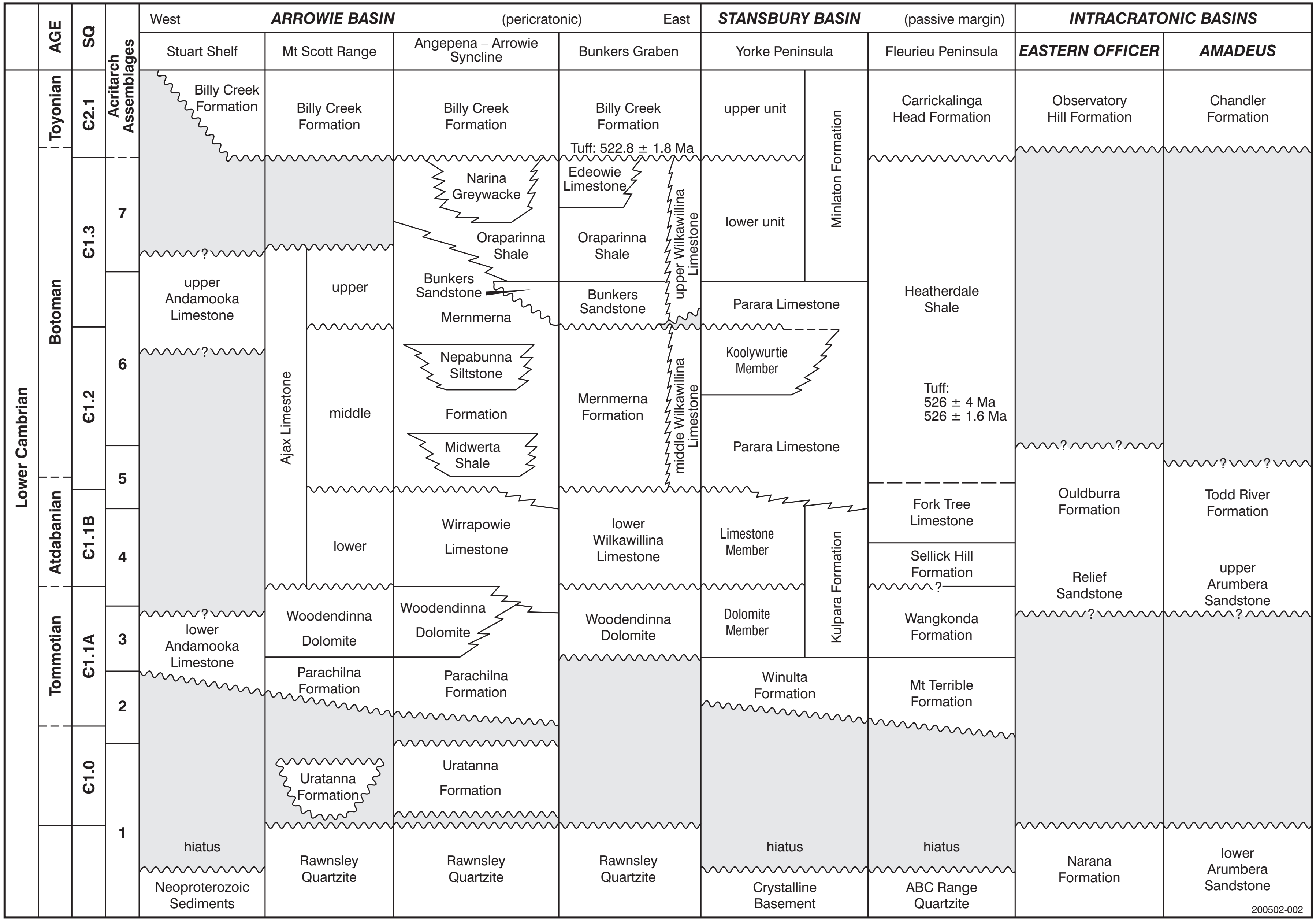


Fig. 2 Lower Cambrian in Stratigraphy in South Australia (modified from Gravestock, 1995).

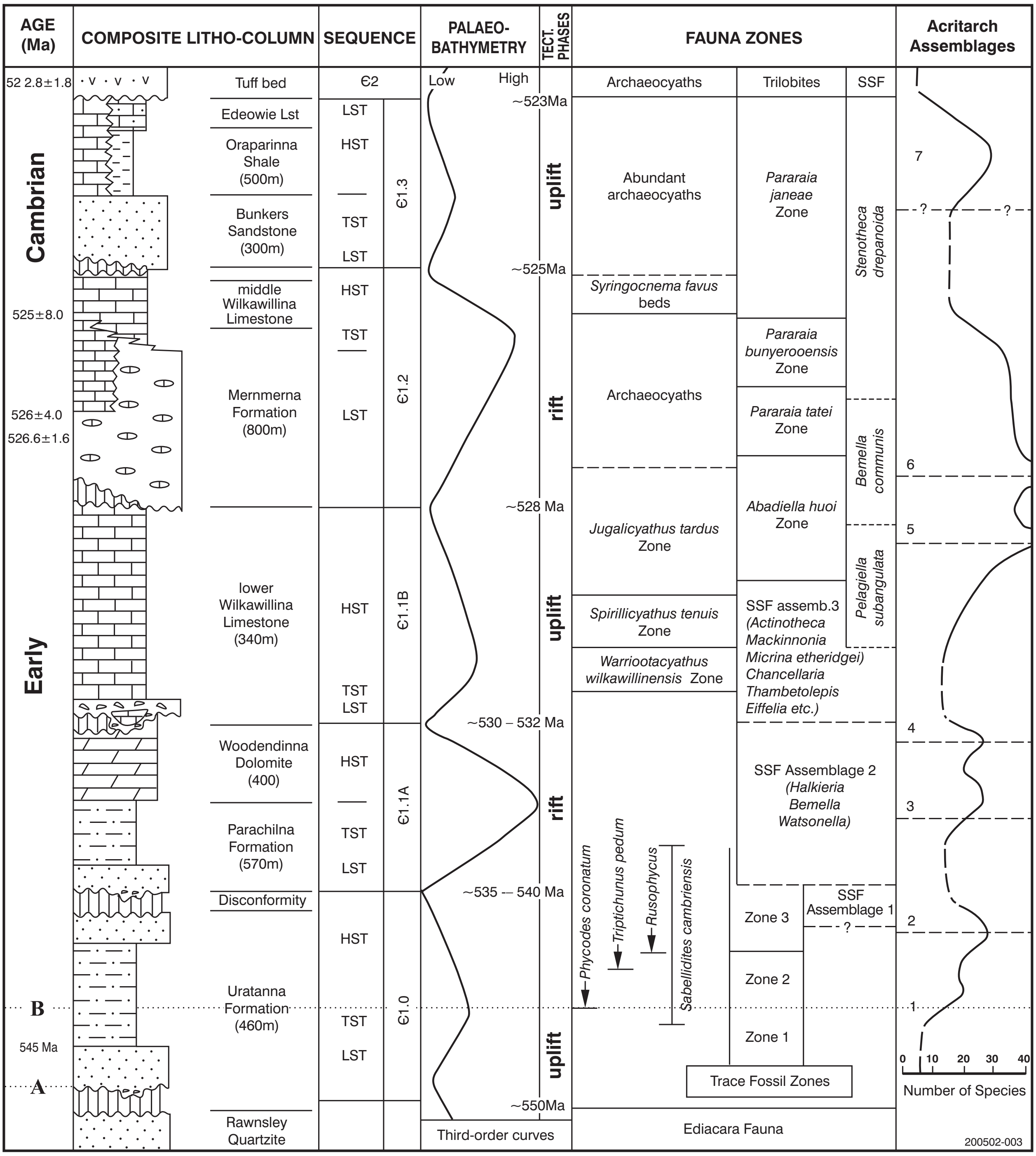


Fig. 3 *Composite of the Lower Cambrian sequences, palaeobathymetry and biozones in South Australia. Palaeobathymetry is estimated from the coastal onlap positions. Dashed part of curve in right-hand column indicate no acritarch sample collection. Thickness of lithological units is close to maximum. Isotopic data: 522.8±1.8 Ma and 526.6±1.6 Ma (Gravestock and Shergold, 2000), 526±4 Ma (Cooper et al., 1992), 525±8.0 Ma (Zhou and Whitford, 1994) and the others (Bowring et al., 1993; Brasier et al., 1994). Biozones: archaeocyaths (Gravestock, 1984; Zhuravlev and Gravestock, 1994; Shergold, 1997) trilobites (Bengston et al., 1990), trace fossils (Mount, 1993), SSF (small skeletal fossil) occurances (Daily, 1972, 1976a; Bengtson et al., 1990; Yates, 1994; Parkhaev, 2000), and acritarchs (Zang, in preparation).*

Early Cambrian faunal zones in South Australia are relatively well established. Detailed studies during the last decade have enabled the establishment of three trace fossil zones in the Uratanna Formation (Mount, 1993), three archaeocyath zones in the lower Wilkawillina Limestone, two informal zones or 'beds' in younger strata (Gravestock, 1984; Zhuravlev and Gravestock, 1994), and four trilobite biozones ranging from late Atdabanian to Botoman (Jell in Bengtson et al., 1990), which provide a reliable basis to study the sequence stratigraphy and acritarch zonation.

Early Cambrian small skeletal fossils (SSF) have been frequently reported in South Australia and used for biostratigraphic correlation, but few have been systematically described (Daily, 1973, 1976a, 1990; Bengtson et al., 1990; Zhuravlev and Gravestock, 1994). Three informal SSF assemblages can be grouped in the pre-trilobite strata. The lowest SSF assemblage is based on 'a fragment of a curved carbonised fossil' from the upper Uratanna Formation, 18.3 m below the disconformity between the Uratanna and Parachilna Formations in the Mt Scott Range (Daily, 1973). Some skeletal fossils have been found recently in the Uratanna Formation at Castle Rock. The stratigraphic significance of this lowest SSF assemblage cannot be assessed until more specimens are known. SSF assemblage 2 is represented by the first occurrence of *Watsonella*, *Bemella* and *Halkieria* in South Australia; of these, the gastropod *Bemella* sp. occurs both in the Parachilna Formation and Mt Terrible Formation (Daily, 1972, 1976a). SSF assemblage 2 is commonly associated with the widespread trace fossils *Diplocraterion* and *Plagiogmus* in the Arrowie and Stansbury Basins. In the Mt Terrible Formation on Fleurieu Peninsula, this assemblage also contains hyoliths (cf. *Turcutheca*), chancelloriides, helcionellides and other fossils including sabellidites, cf. *Sachites* sp. and *Saarina*, of which the *Watsonella*–*Sabellidites* assemblage in the formation has been suggested to indicate an early Tommotian (or Lontova Horizon) age (Daily, 1972, 1976a,b; Zhuravlev, 1995). In the overlying Wangkonda Formation, Daily (1976a) reported some hyoliths, and Bengtson et al. (1990) also reported a SSF fauna, including the appearance of *Halkieria* sp. The Mt Terrible and Wangkonda Formations were suggested to be a Tommotian equivalent (Bengtson et al., 1990).

SSF assemblage 3 is widely distributed in Australia and represented by the appearance of *Actinotheca*, *Mackinnonia corrugata*, *Dailyatia* and *Micrina etheridgei*. In the Mt Scott Range, Bengtson et al. (1990, Fig. 6) described more than 50 forms predating the trilobite *Abadiella huoi*; similar assemblages were also found in limestone of the upper Kulpara Formation on Yorke Peninsula (e.g. Horse Gully section, Bengtson et al., 1990; Zhuravlev and Gravestock, 1994), Sellick Hill Formation on Fleurieu Peninsula (Bengtson et al., 1990) and Todd River Dolomite in the Amadeus Basin (Laurie, 1986). The assemblage in the Mt. Scott Range section is correlated with three archaeocyath biozones, but can occur pre-dating the archaeocyaths in South Australia, probably indicating an early to middle Atdabanian age. Generally, SSF assemblage 3 has some similarity to the third Chinese SSF zone (Bengtson et al., 1990). Detailed study in this publication (Alexander et al., in prep.) will enable precise zonation and correlation.

Parkhaev (2000) recognised four molluscan biozones in the Cambrian limestone of South Australia, ranging from the middle Atdabanian to late Toyonian. The *Pelagiella subangulata* biozone intergrades with the SSF assemblage 3, but some species occur below the biozone, including *Eiffelia*, *Chancelloria* and *Thambetolepis* in SYC 101 (N.V. Esakova, Palaeontological Institute of Russia, pers. comm., 1995). The relationship between the SSF and other biozones is illustrated on Figure 3.

Early Cambrian acritarch biostratigraphy is relatively new in South Australia (Zang et al., 1998). However, Early Cambrian acritarchs have received considerable attention during the last three decades and have played an important role in Early Cambrian biostratigraphy on the East European Platform (Volkova et al., 1979; Moczydlowska, 1991). Detailed palaeontological studies show a dramatic increase in the abundance and diversity of the spinose acritarchs in the Early Cambrian succession in Europe (Volkova, 1968, 1969; Jankauskas, 1975; Downie, 1982; Knoll and Swett, 1987; Eklund, 1990; Hagenfeldt, 1989; Vidal and Nystuen, 1990; Vidal and Peel, 1993), Siberia (Vidal et al., 1995), China (Zang, 1992) and United States (Wood and Clendening, 1982), which led to the recognition of acritarch zonation for regional and intercontinental correlation (Volkova et al., 1979; Moczydlowska and Vidal, 1986; Moczydlowska, 1991).

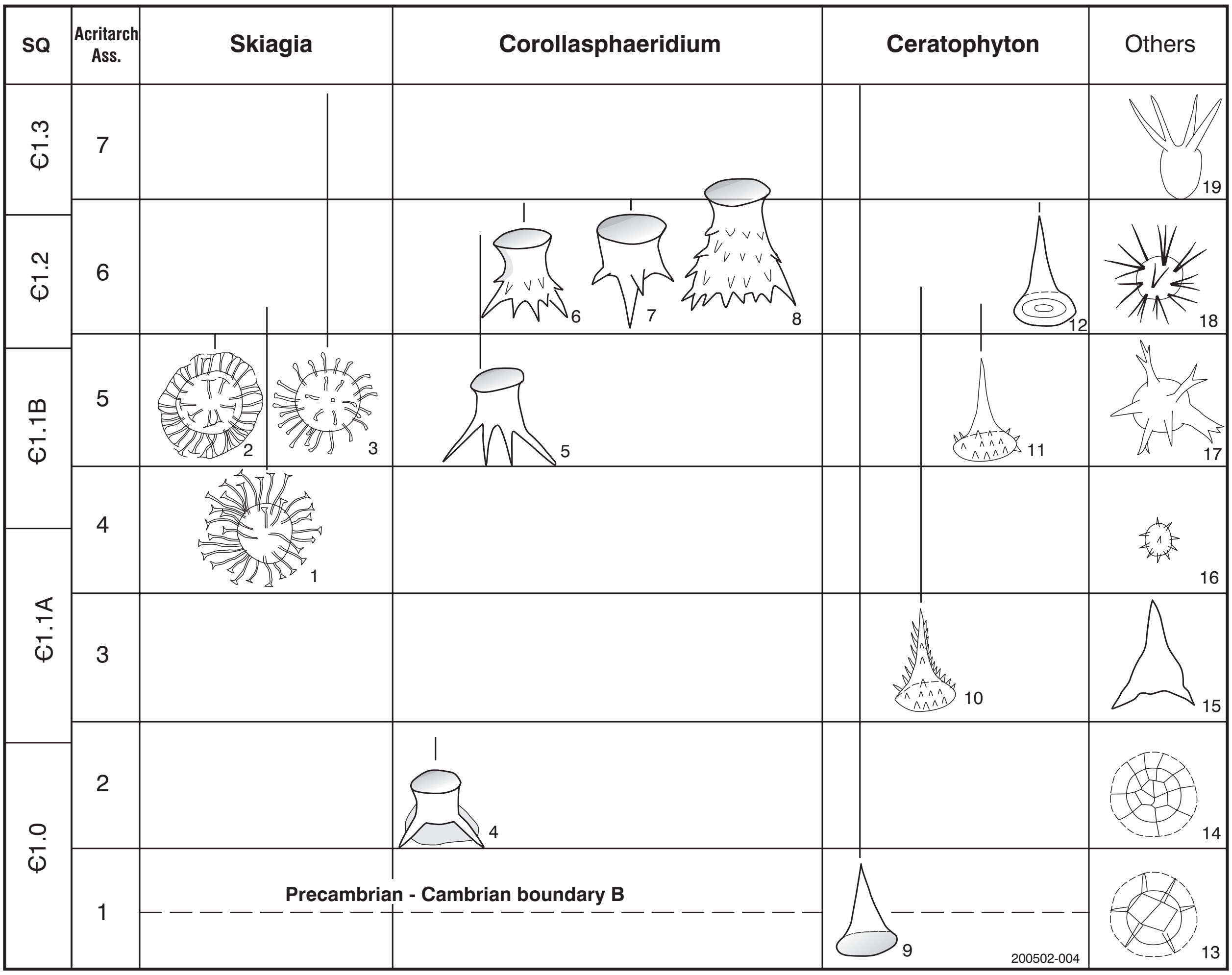


Fig. 4 *Sketches of the selected acritarch groups, showing assemblages and stratigraphic distribution. Number donates: 1. Skiagia ornata; 2. Skiagia scottica; 3. Skiaggia ciliosa; 4. Corollasphaeridium sp. indet. A; 5. Corollasphaeridium aliquolumum; 6. Corollasphaeridium opimolumum; 7. Corollasphaeridium sp. indet. B; 8 Corollasphaeridium sp. cf. C. opimolumum; 9. Ceratophyton vernicosum; 10. Ceratophyton spinuconum; 11. Ceratophyton dumufuntum; 12. Ceratophyton circufuntum; 13. Fimbriaglomerella gothlandica; 14. Fimbriaglomerella minuta; 15. Veryachium trisentium; 16. Micrhystridium sp.; 17. Multiplicisphaeridium dendroideum; 18. Vulcanisphaera pseudofaveolata; and 19. Hemibaltisphaeridium sp.*

In Australia, Early Cambrian acritarchs are poorly studied, but a few have been reported from the Heatherdale Shale of the Stansbury Basin (Foster *et al.*, 1985) and Chandler Formation of the Amadeus Basin (Zang and Walter, 1992). They are mainly simple, long-ranging species. This study reports a group of abundant morphologically complex acritarchs from Yalkalpo 2 in the Arrowie Basin, and indicates the possibility of an acritarch-based biostratigraphic correlation beyond the basinal scale. Seven acritarch assemblages are recognised in the lower part of the South Australian Early Cambrian succession (Fig. 3; Zang, in prep.).

FAUNAS AND ACRITARCHS IN YALKALPO 2

Yalkalpo 2 was drilled in 1976 to a depth of 799 m. It bottomed in a sandstone of the Parachilna Formation (Fig. 4; Youngs, 1977). The Early Cambrian succession was fully cored and contains macrofossils (mainly trilobites and inarticulate brachiopods) and microfossils. This is significant because well-preserved acritarchs are difficult to find in outcrop due to oxidation. The lowest sandstone passes transitionally into the Woodendinna Dolomite, and a sharp contact (depth 786.4 m) is present between the dolomite and overlying limestone of the lower Wilkawillina Limestone. The limestone is fossiliferous, and interbedded siltstone contains *Skiagia*-dominated assemblages. The Mernmerna Formation (769.3–628.7 m) contains mainly nodular limestone; the overlying Moorowie Formation is dominated by silty and oolitic limestone. The Billy Creek Formation in Yalkalpo 2 (523.8–258 m) comprises mainly red-brown and green-grey shales. Numerous tuff layers are present in the Billy Creek and Moorowie Formations. Generally the Cambrian sediments in the drillhole are considered to have been deposited in marine settings, including sandy foreshore–estuarine, middle and inner shelf or ramp to deltaic environments.

The currently recognised Early Cambrian sequence stratigraphy of South Australia is shown on Figure 3. Five unconformity bounded sequences can be recognised in Yalkalpo 2:

- ∈1.1A includes Parachilna Formation and Woodendinna Dolomite (799–786.4 m)
- ∈1.1B the lower Wilkawillina Limestone (786.4–769.3 m)
- ∈1.2 the Mernmerna Formation (769.3–628.7 m)
- ∈1.3 the Moorowie Formation (628.7–523.8 m)
- ∈2.1 the Billy Creek Formation (523.8–258 m).

All sequence boundaries can be traced across the basin.

TRILOBITES

The distribution of trilobites, brachiopods and other macrofossils in Yalkalpo 2 is shown on Figure 5. The lowest known trilobites occur within the lower Wilkawillina Limestone at depths of 783.67–785.65 m. Helcionellids and pelagiellids also occur at this level. The trilobites comprise a partial cranidium and four free cheeks. These specimens probably belong to *Abadiella huoi* (Plate 1A–C), the nominate species of the lowest trilobite zone erected for the Early Cambrian successions of the Flinders Ranges by Jell (*in* Bengtson et al., 1990). Shergold (1997) suggested that the *Abadiella huoi* Zone correlates with the top part of the *Abadiella* Zone plus the *Eoredlichia–Wutingaspis* Zone of South China. It should be noted that *A. huoi* extends up into the base of the overlying *Paraia tatei* Zone.

Two fragmentary trilobites are known between depths of 718.0 and 715.40 m within the Mernmerna Formation. One of these is an indeterminate free cheek; the other is a partial cranidium which appears to belong in *Pararaia* (Plate 1F). In view of the difference of over 65 m between the top specimen of *A. huoi* and the cranidium assigned to *Pararaia* sp. (Plate 1F), it is possible that this latter specimen belongs in the *P. tatei* Zone. It should be noted that in nearby Yalkalpo 1, an excellent cranidium of *P. tatei* (Plate 1E) occurs in the Mernmerna Formation at a depth of 218.12 m.

Several trilobite specimens which can be referred to *Pararaia* were found in Yalkalpo 2 between 694.42 and 636.83 m (in the upper half of the Mernmerna Formation). All are either immature or of a fragmentary nature which makes an exact species assignation difficult. The specimens occurring between 694.42 and 675.95 m (Plate 1G, H, K) may belong in *P. bunyerooensis* (Plate 1R) but this is far from certain. Three specimens of *Pararaia* are known from 636.83 m. These may belong in *P. janeae* but, given the fragmentary nature of the specimens, this is a very

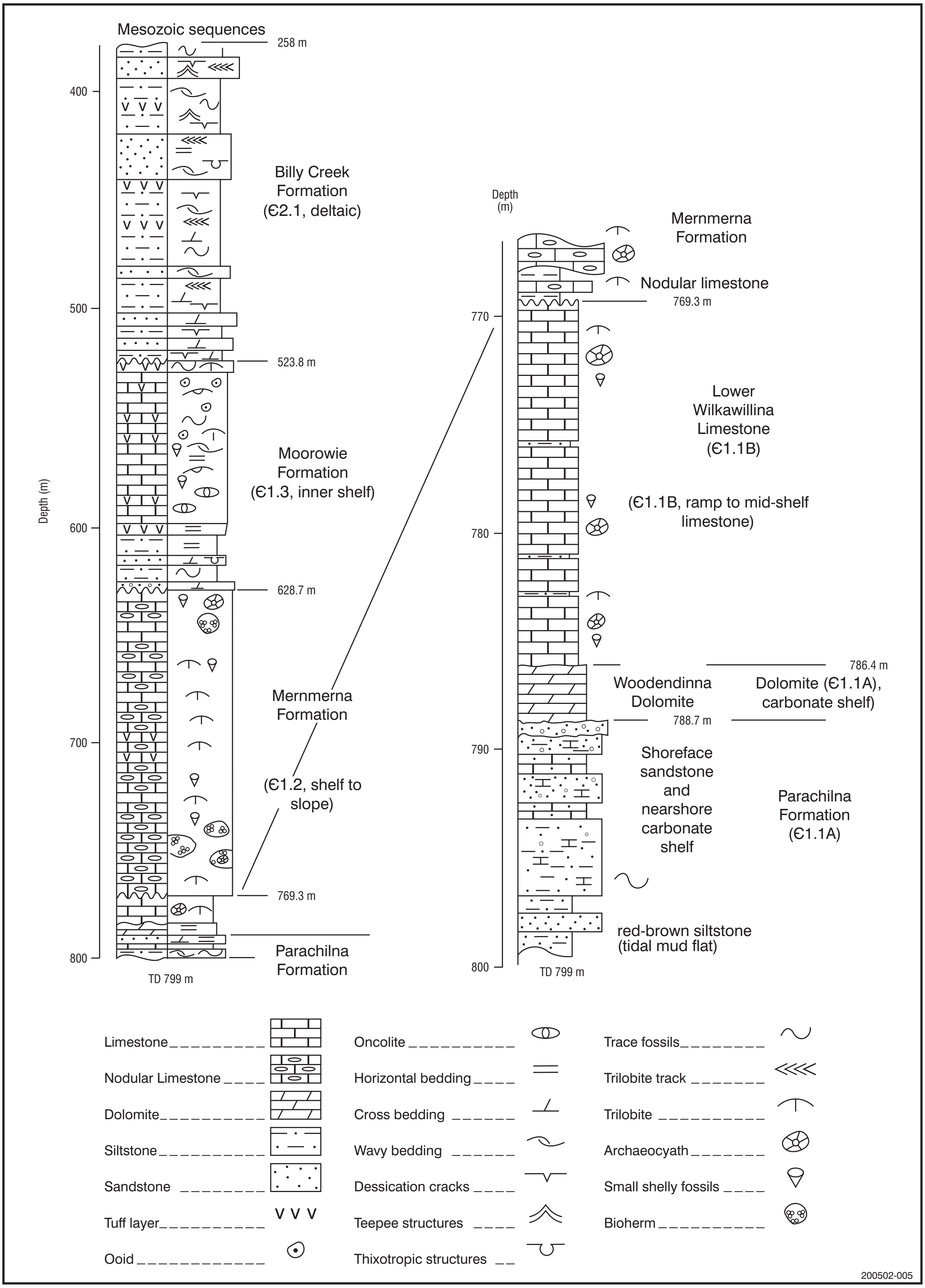


Fig. 5 Lithological log of Yalkalpo 2 (combined from Gravestock's, unpublished data).

tentative identification. It is tentatively suggested that the trilobites which occur in the 694.42–636.83 m interval belong to the *P. bunyerooensis* and *P. janeae* Zones.

Fragments of Redlichiid (Plate 1N, P) occur at 575.30 and 561.50 m (bottom part of Moorowie Formation) and an unassigned free cheek was found at 558.20 m. A granulose fragment of a large trilobite (Plate 1S) which occurs at 537.80 m almost certainly belongs in the Conocoryphidae. Conocoryphids have been previously reported in South Australia from the Heatherdale Shale on Fleurieu Peninsula (Jago et al., 1984; Jenkins and Hasenohr, 1989) and in the Flinders Ranges by Jell et al. (1992) from the transition of the Mernmerna Formation and Oraparinna Shale. The Flinders Ranges localities are within the *P. janeae* Zone of Bengtson et al. (1990). Allowing for the fact that conocoryphids are facies controlled (offshore faunas) and the very fragmentary nature of the specimen, it is reasonable to suggest that the conocoryphid found here is within the *P. janeae* Zone.

The highest identifiable trilobites found in Yalkalpo 2 are emuellids, and all are within the Billy Creek Formation. There is a very poorly preserved emuellid at 444.18 m, including two characteristic thoracic segments at 418.46 m (Plate 1 m) and an almost complete example of *Emuella polymera* at 409.88 m (Plate 1L). The emuellids were first described by Pocock (1970) who erected two genera, *Emuella* and *Balcoracania*. Pocock described three species from Kangaroo Island, i.e. *E. polymera*, *E. dalgarnoi* and *Balcoracania dailyi* and a fourth species, *B. flindersi* from the lower part of the Billy Creek Formation in the Flinders Ranges. Jell in Bengtson et al. (1990, p.15) suggested that *B. dailyi* and *B. flindersi* are synonyms. The present authors support this view. Indeed the Emuellidae are in need of revision. This is currently being done as part of a study of emuellids from a new locality on Kangaroo Island (J.B. Jago, personal collection). Palmer and Rowell (1995) have recently reported emuellids from Antarctica.

Bengtson et al. (1990) extended the *P. janeae* Zone in the Flinders Ranges into the basal Billy Creek Formation in order to encompass *B. flindersi.* Presumably this was done on the basis of the occurrence of *Hsuaspis bilobata*, which occurs in the basal part of the *P. janeae* Zone in the Flinders Ranges, along with other trilobites including the conocoryphid, *Atops rupertensis* (Jell et al., 1992), and also on Kangaroo Island in association with the emuellids described by Pocock (1970) as *E. polymera* and *B. dailyi.*

Hence it is suggested that within Yalkalpo 2 the *P. janeae* Zone extends from a depth of ~635 m to at least 409.88 m.

Above 409.88 m there are only one or two fragmentary body fossils including a possible hyolithid at 372.30 m and some possible trilobite fragments at 319.20 m. Trace fossils are present at some levels. No attempt to differentiate the different types of trace fossils is made herein, although what appears to be *Planolites* occurs at 382.98 m (Plate 1Q). The trace fossils are relatively common from 321.15 to 298.85 m.

In nearby LNM10 1, the core contains a well-preserved specimen of the emuellid trilobite *B. flindersi* at 54.7 m (D.I. Gravestock, MESA, pers. comm., 1997) in the Billy Creek Formation. A tuff layer (191.7–189.3 m) at the base of the Billy Creek Formation yields a pooled U–Pb zircon age of 522.8±1.8 Ma (Gravestock and Shergold, 2000). The tuff layer overlies the Edeowie Limestone (197.2–191.7 m) and lower Moorowie Formation. Acritarchs in LNM10 1 are poorly preserved.

ARCHAEOCYATHS

Limestone in Yalkalpo 2 contains abundant archaeocyaths; at least two levels can be identified. The lower Wilkawillina Limestone at ~785.8 m contains *Anaptyctocyathus* (≡*Erugaticyathus*) *oppositus*, *Veronicacyathus radiatus* and *Cambrocyathus* (≡*Loculicyathus*) *alternus*; the Mernmerna Formation at ~751.3 m contains *Anaptyctocyathus* (≡*Erugaticyathus*) *oppositus*, ?*A. mawsoni* and *Metaldetes ferulae* (Gravestock, unpublished data). The faunas are regarded as Daily's Faunal Assemblage 2 (Daily *in* Youngs, 1977) or *Jugalicyathus tardus* Zone (Zhuravlev and Gravestock, 1994; Gravestock, 1997, unpublished data and pers. comm.). Abundant SSF including *Micrina etheridgei* and *Dailyatia* also occur in this level.

The limestone at ~635 m (Mernmerna Formation) contains archaeocyaths *Archaeopharetra* sp. and other species; the trilobite *Pararaia* ?*janeae* (Plate 1R) is present 2 m below this level. The level is considered to correlate with *Syringocnema favus* beds (Zhuravlev and Gravestock, 1994) on Yorke Peninsula.

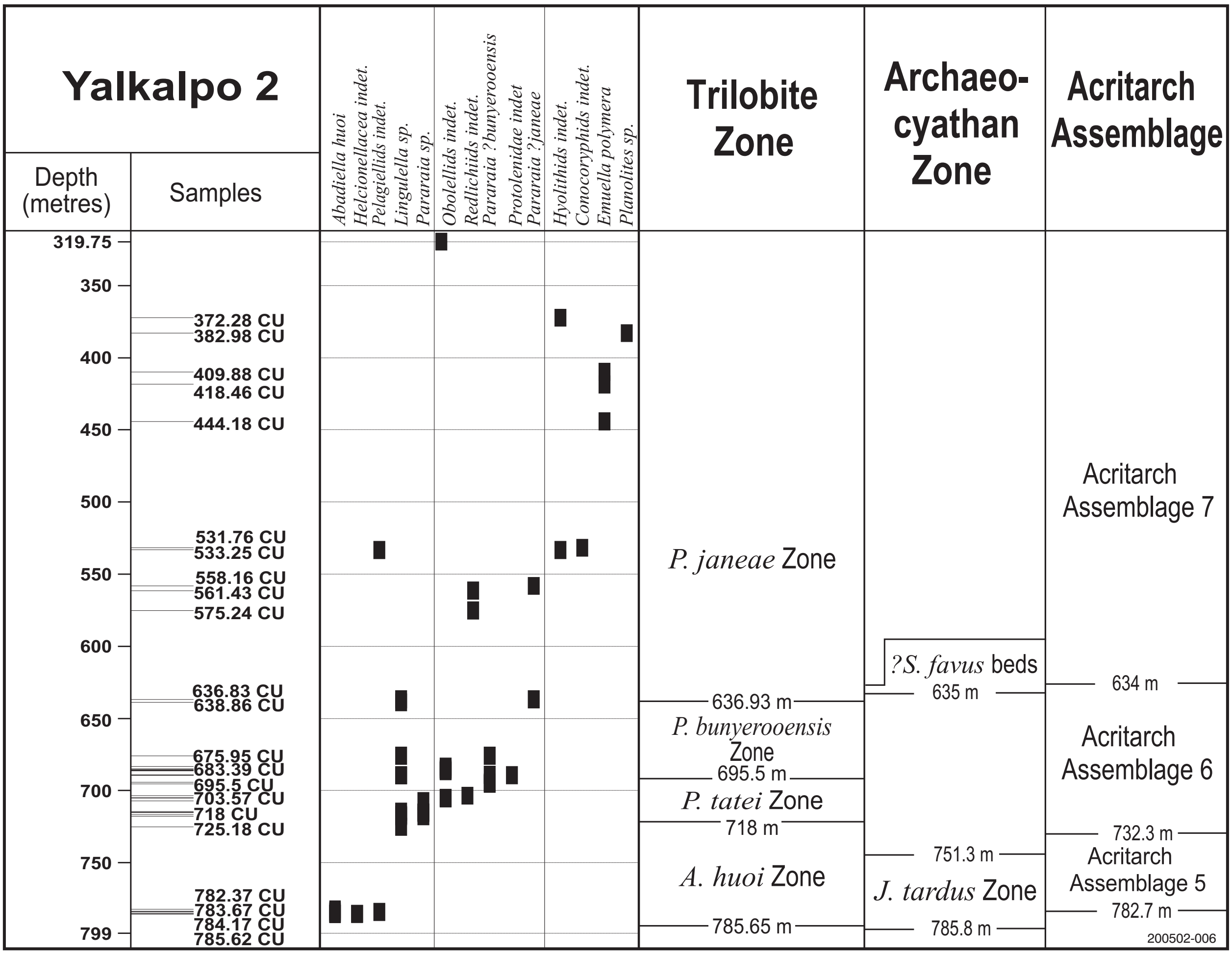


Fig. 6 *Distribution of fauna fossils and biozones in Yalkalpo 2.*

SMALL SHELLY FOSSILS

Abundant SSF were reported in the lower Wilkawillina Limestone and Mernmerna Formation by Daily (*in* Youngs, 1977). The lowest fossil depth is 786.9 m, lower than archaeocyathan depth (785.8 m). Some SSF are also found in the Mernmerna Formation (Alexander et al., in press).

ACRITARCHS

Acritarchs are abundant in siltstone layers in Yalkalpo 2, in which three assemblages can be distinguished. Seven assemblages have been recognised recently from the lowest Cambrian to Toyonian (Fig. 4; Zang, in prep.). Assemblages 1 and 2 are present in the Uratanna Formation and cross the Precambrian–Cambrian transition. Assemblage 3 is widely distributed and collected from transgressive siltstone in the upper Parachilna Formation. Assemblage 4 is present in dolomite of the Kulpara Formation (= Woodendinna Dolomite). Yalkalpo 2 acritarchs consist of assemblages 5–7, ranging from later Atdabanian to Toyonian.

Assemblage 5 occurs in the lower Wilkawillina Limestone (Fig. 7) in Yalkalpo 2 (782.7–732.3 m). The assemblage is dominated by *Skiagia*, including *S. ciliosa*, *S. scottica* and *S. pura*; other distinct species in this assemblage include *Comasphaeridium strigosum*, *Multiplicisphaeridium dendroideum*, *Polygonium implicatum*, *Polygonium varium* and *Pterospermella vitalis*; new species contain *Baltisphaeridium bimacerium*, *Corollasphaeridium aliquolumum*, *Mutabilisphaera batucrista* and *Ceratophyton dumufuntum*. This assemblage probably has a world-wide distribution (Volkova et al., 1979; Downie, 1982; Wood and Clendening, 1982; Moczydlowska, 1991; Zang, 1992).

Assemblage 5 also occurs in the lower Ouldburra Formation in the eastern Officer Basin where two drillholes (Fig. 1) were sampled for Early Cambrian acritarchs. The *Ceratophyton dumufuntum*-dominated assemblage occurs in the lower part of the formation in Manya 6 and the species is particularly abundant in sample 5642RS222 (depth 1568.9 m); well-preserved *Abadiella* trilobites were also found in the interval between 697.7 and 970.13 m in the well, indicating a late Atdabanian age (Jago et al., 1994).

The assemblage was also found in sample 6428RS119 (258.7 m, SYC 101), in which dark grey siltstone contains abundant *Skiagia ciliosa* specimens. The samples immediately above contain many new spinose species which are ascribed to Assemblage 6.

Assemblage 6 is found in the Parara Limestone (Stansbury Basin) and Mernmerna Formation (Arrowie Basin) and probably correlates with the trilobite *Pararaia tatei* and *P. bunyerooensis* Zones. Most of the species in this assemblage are inherited from assemblage 5, but the *Skiagia* group declined, although *S. ciliosa* dominates several samples, and is particularly common in Minlaton 1 and Yalkalpo 2. In SYC 101, the assemblage first appears at 232.6–232.1 m (63 m above the base of the Parara Limestone) in a 0.5 m tuffaceous siltstone bed. The siltstone contains many new forms, including the species *Annulusia centapertia*, *Ceratophyton circufuntum*, *Corollasphaeridium opimolumum*, *Cymatiosphaera taenia*, *Sertulasphaera orbisentia* and some unnamed specimens; some distinct spinose acritarchs such as *Vulcanisphaera pseudofaveolata* are also found. The assemblage continues to occur in a 70 m interval in SYC 101, but spinose acritarch forms decline, particularly *Skiagia* specimens. Assemblage 6 is also found in the nodular limestone (Mernmerna Formation) in Yalkalpo 2 (732.3–671.6 m), which is indicated by the dominance of *S. ciliosa* and occurrence of *Cymatiosphaera taenia.*

Assemblage 7 contains a few spinose species, such as cf. *Liepaina plana*, *Baltisphaeridium bimacerium*, *Skiagia ciliosa* and *Vulcanisphaera pseudofaveolata*. The assemblage in Yalkalpo 2 (635.3–520.9 m) is poorly defined and contains mainly spherical acritarchs with a few spinose fragments. A single specimen of ?*Hemibaltisphaeridium* sp. is present at 634 m in Yalkalpo 2 and is regarded as an exception. The equivalent assemblages are present in nearby LNM 10–1 (197.2–191.7 m) and Mt Frome DDM 1 drillholes. DDM 1 intersected thick archaeocyathan reef limestone of the Moorowie Formation (0–295 m) and grey siltstone of the Oraparinna Shale (295–349.8 m) which contains *Liepaina*, *Goniosphaeridium*, *Micrhystridium*, *Tasmanites*, *Dictyotidium* and *Leiosphaeridia*. A similar assemblage also occurs in grey-green siltstone (352.5–357.8 m) in Minlaton 1, Stansbury Basin. Assemblage 7 needs further detailed study.

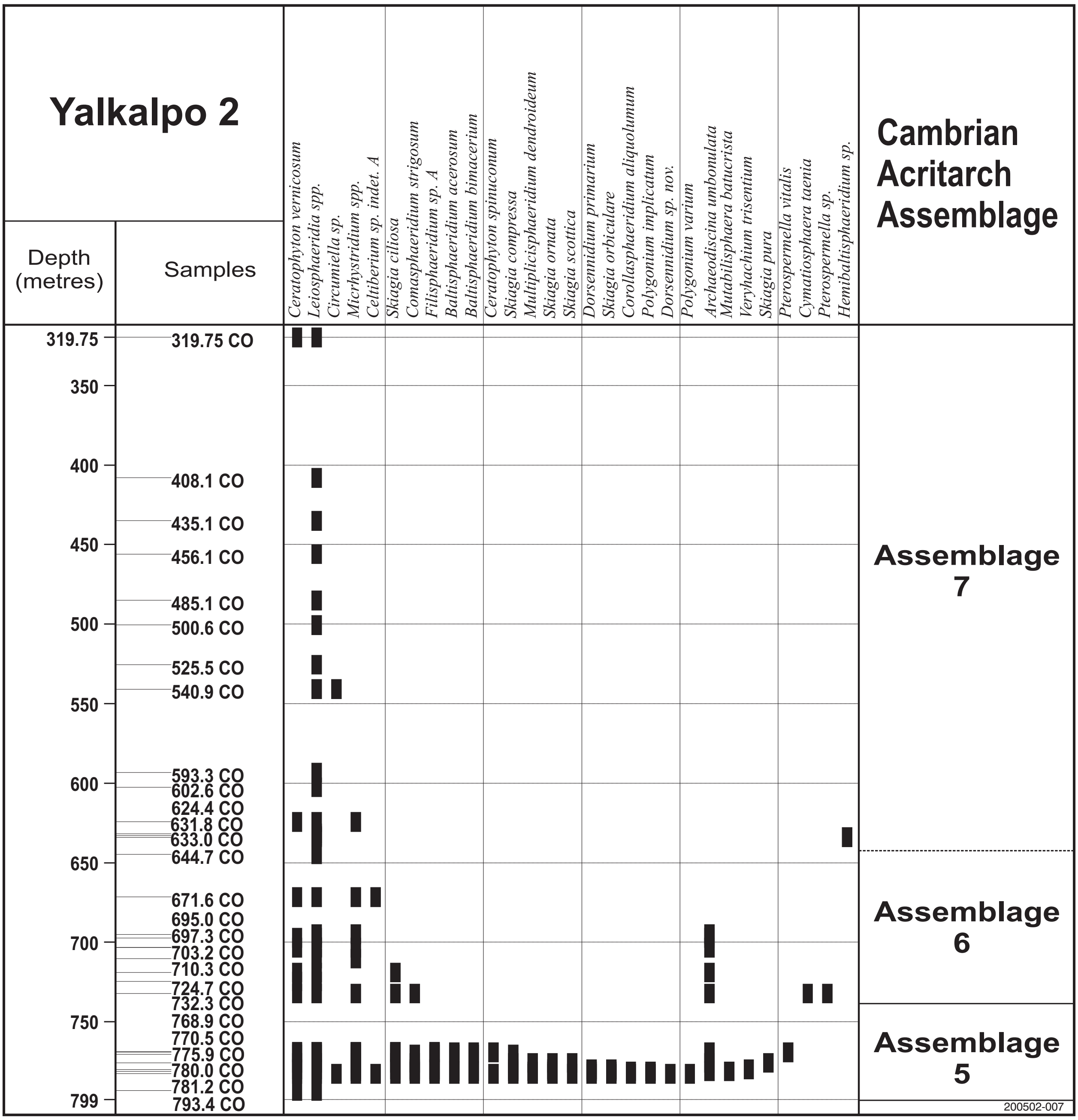


Fig. 7 Acritarch distribution and assemblages in Yalkalpo 2.

DISCUSSION

The occurrence of trilobites, archaeocyatha and acritarchs in Yalkalpo 2 currently provides the best opportunity in Australia to understand the relationship between trilobite, archaeocyathan and acritarch biostratigraphy (Fig. 6). In core, the archaeocyathan *Jugalicyathus tardus* Zone is slightly lower than the trilobite *Abadiella huoi* Zone, whereas the *Syringocnema favus* beds occur slightly higher than *Pararaia janeae* Zone trilobites. Acritarch assemblage 5 occurs later than, and ranges entirely within, the *A. huoi* Zone; acritarch assemblage 7 is later than both the *P. janeae* Zone and the *S. favus* beds. Because of the lack of fossils in the basal part of the lower Wilkawillina Limestone and Woodendinna Dolomite in the drillhole, the lower boundary of the *A. huoi* and *J. tardus* Zones cannot be determined by this study. However, the results are very similar to the study of outcrops on Yorke Peninsula and in the Flinders Ranges (Zhuravlev and Gravestock, 1994). The Parachilna Formation contains only leiosphaerid acritarchs and possible trace fossils which do not provide stratigraphic information.

Global correlation of Early Cambrian trilobite and archaeocyathan zones is in a state of flux (Palmer, 1998). The *A. huoi* and *P. tatei* Zones were considered to be Atdabanian, with the lowest *A. huoi* Zone being equivalent to the Chinese *Parabadiella* Zone (Bengtson et al., 1990), whereas Zhuravlev and Gravestock (1994) considered the Atdabanian and Botoman boundary should be within the *A. huoi* Zone, in which scheme the boundary is roughly at the level of the Flinders Unconformity, a distinct sequence boundary between the ∈1.1B and ∈1.2 sequences. This correlation places the *P. tatei* and *P. bunyerooensis* Zones in the Botoman Stage. The *P. janeae* Zone is considered to range from late Botoman to early Toyonian Stage.

The *Skiagia*-dominated acritarch assemblages in Yalkalpo 2 are reported for the first time occurring in Australian Early Cambrian sediments and can be used for correlation with similar acritarchs on the East European Platform. Volkova et al. (1979) divided the Early Cambrian into five 'Horizons' and Moczydlowska (1991) established four acritarch biozones from the Early Cambrian successions in southeastern Poland: the lowest *Asteridium–Comasphaeridium* Zone appears from the upper part of the Rovno to Lontova Horizons and correlates with the *Platysolenites antiquissimus* Zone; the second (*Skiagia ornata–Fimbriaglomerella* Zone), third (*S. ciliosa – Heliosphaeridium* Zone) and fourth (*Volkovia – Liepaina* Zone) were collected from the Talsy, Vergale and Rausve Horizons, respectively (Moczydlowska, 1991, p.25, Fig. 10). Acritarch assemblage 5 in Yalkalpo 2 is probably correlated with the *S. ciliosa – Heliosphaeridium* Zone and assemblage 7 may be correlated with the *Volkovia – Liepaina* Zone.

Early Cambrian sedimentary rocks on the South China Platform also contain well-preserved acritarchs. At the Meishucun section and nearby Maotianshan drillhole (Zang, 1992), the small skeletal fossil-bearing dolomite (upper Dengying Formation) and black to dark grey shale (lower Qiongzhusi Formation) contain poorly preserved acritarchs. It is not until the second trilobite *Eoredlichia–Wutingaspis* Zone that abundant *Skiagia* specimens occur; this is considered to correlate with the Vergale Horizon (Zang, 1992). This Chinese assemblage is probably correlated with acritarch assemblage 5 which occurs with the trilobite *Abadiella huoi* Zone in South Australia. This contradicts the suggestion that the *Abadiella huoi* Zone correlates with the Chinese first trilobite *Parabediella* Zone (Bengtson et al., 1990), but supports the suggestion of Zhang Wen-tang (NIPG, China, pers. comm., 1992) that the *Abadiella huoi* Zone at least should be partly correlated with the *Eoredlichia–Wutingaspis* Zone because of the similarities between *A.* and *Wutingaspis*.

CONCLUSION

Early Cambrian sediments in Yalkalpo 2 range from the Tommotian to Toyonian stages and can be divided into 5 unconformity bounded sequences. The sediments contain abundant archaeocyaths, trilobites, small skeletal fossils and acritarchs. Four trilobite zones, two archaeocyath zones (beds) and three acritarch assemblages are recognised in core, and detailed study of biozones and their distribution provide vital information for inter-zonal correlation beyond basinal scale. The integrated approach of biostratigraphy and sequence stratigraphy will provide a more precise correlation chart for the Early Cambrian sediments in South Australia.

SYSTEMATIC PALAEONTOLOGY OF ACRITARCHS

Early Cambrian acritarchs are reported worldwide (Volkova, 1969; Downie, 1982; Wood and Clendening, 1982; Knoll and Swett, 1987; Vidal and Nystuen, 1990; Zang, 1992; Vidal and Peel, 1993), and are particularly well documented by Volkova et al. (1979), Hagenfeldt (1989) and Moczydlowska (1991), in which the taxonomy is relatively consistent. The species in this study are described in alphabetical order, and all species will be documented by Zang (in prep.). England Finder co-ordinates are read for all illustrated specimens. All samples are reposited in the core library, Department of Primary Industries and Resources SA, Adelaide, Australia. Appendix 1 provides a full sample list of Cambrian acritarchs in the collection.

GENUS BALTISPHAERIDIUM EISENACK, 1958 RESTRICT. STAPLIN, JANSONIUS AND POCOCK, 1965

Type species. *Baltisphaeridium longispinosum* (Eisenack, 1931) Eisenack, 1958.

Diagnosis (revised). Vesicle originally spherical; vesicle wall double layered, but commonly preserved as single; process wall differentiated from that of the vesicle and always single layered; process conical to long-conical, slender, hollow, often homomorphic, unbranched to simply branched, closed at tip(s) and narrow at base; process number a few to abundant at margin, evenly distributed, well spaced and no contact at bases among neighbouring processes; process hollow and opens freely into the interior body cavity, but no communication with outer layer; when preserved as single-walled vesicle, outer layer strangled the junction of the process and vesicle, a thickened 'plug' structure may be present; rarely a circular opening structure observed.

Discussion. The revised diagnosis is combined from original descriptions and later emendations (Eisenack, 1958; Staplin et al., 1965; Eiserhardt, 1989) and emphasises: 1. differentiation between the vesicle (double layered) and process wall (single layered); 2. long-conical, slender, hollow process; 3. narrow process base and no connection with neighbouring bases; and 4. process hollow open freely with the interior body cavity, but sealed from the outer layer(s). The 'plug' structure is regarded as a preservational phenomenon due to the outer layer(s) strangling the junction between the narrow process base and interior body, but could be present in original microorganism in different reproductive stages. The present diagnosis enables the genus to be differentiated from *Gorgonisphaerdium*, *Filisphaeridium* and *Comasphaeridium* in its hollow processes; from *Solisphaeridium* and *Trachyhystrichosphaera* in its double-layered vesicle wall and 'plug' structure; from *Dorsennidium* in its homomorphic processes; from *Polygonium* for its spherical vesicle and narrow process base; from *Cymatiosphaera* and *Cymatiosphroides* in its lacking outer surrounding membrane or wall; and from *Multiplicisphaeridium* in its commonly unbranched processes.

Baltisphaeridium has been discussed at length by various authors. Staplin et al. (1965) emended the genus by the structural differentiation between the process and vesicle wall and the absence of communication between processes and the vesicle cavity. The 'plug' structure was interpreted as indicative of the presence of races since the presence or absence of the structure can be observed on same specimens (Eisenack, 1959), but Staplin et al. (1965) suggested this feature to be a result of the stage of maturity in individuals. This study demonstrates that the 'plug' structure is a preservational feature between the double-layered wall and narrow process base. The existence of a double-layered wall was speculated by Eiserhardt (1989) and now is found to be preserved in carbonate, rather than in siliciclastic facies.

BALTISPHAERIDIUM BIMACERIUM SP. NOV.

Plate 3A–B

Etymology. Bi-, Latin, two, double; maceria, Latin, wall enclosure.

Holotype. Plate 3A, slide 7036RS137–3, England Finder coordinates: D56/4, Yalkalpo 2, depth 782.7 m, lower Wilkawillina Limestone, sequence ∈1.1B sequence, acritarch assemblage 5 (Vergale Horizon), trilobite *Abadiella huoi* Zone (Atdabanian Stage), Arrowie Basin.

Description. Vesicle circular to subcircular, originally spherical; wall smooth to finely granular, commonly folded, double layered, interior layer more robust and thicker (~0.5–0.8 μm), and outer layer membrane like, translucent and thin (~0.2 μm); process long-conical, slender, hollow, homomorphic, unbranched, sharp or slightly blunt at tip and narrow or slightly widened at base; process fairly abundant, evenly distributed, well spaced among neighbouring processes (2–5 µm); process hollow open freely into the interior body cavity, but no communication with the cavity between the interior and outer layers; vesicle often preserved as single walled, outer layer sticks to the interior and strangled the junction of the process and interior body, a thickened 'plug' structure occasionally visible; sometimes medium splitting structure observed.

Dimensions. Vesicles are 25–60 µm in diameter (40 specimens), process length 4–15 µm and number seen at outline 25–60.

Remarks. The new species is characterised by its double-layered wall structure and process hollow opening freely into the interior body cavity. Of 40 measured specimens, only 14 show a double-layered wall. All 14 were collected from two thin carbonaceous shale samples in limestone (Yalkalpo 2, depth 782.7 and 781.2 m, ~5 mm thick), whereas the specimens from thick shale beds commonly display single-layered walls. Rapid carbonate cementation and dehydration may be the result of this particular preservational environment. It is interesting that several specimens show one side of the vesicle with double layering and the other single; processes cross the outer layer onto the interior layer, where communication between the process hollow and vesicle cavity is present, whereas on the other side at the junction where the outer layer, interior layer and process merged, a thickened ring around the process base shows a type of 'plug' structure. However, this study does not exclude the possibility of the existence of the original plug structures in some baltisphaerid species.

Occurrence. Yalkalpo 2, depth 782.7, 781.2, 770.5 and 769.2 m, lower Wilkawillina Limestone, acritarch assemblage 5, Arrowie Basin. SYC 101, depth 232.3 and 232.2 m, Parara Limestone, assemblage 6, Stansbury Basin. Minlaton 1, depth 357 m, lower Minlaton Formation, assemblage 7, Stansbury Basin.

GENUS CERATOPHYTON KIRJANOV, 1979

Type species. Ceratophyton vernicosum Kirjanov, 1979.

Diagnosis (revised and expanded). Vesicle single cone shaped or horn like, consisting of an expanded basal part and a prominent process; base wide open and process closed at tip; with or without minor spines; minor spines hollow and open freely into the cone cavity.

Original diagnosis. Structures of horn-like shape, hollow, fairly large (up to 1.1 mm long), made of organic substance resistant to strong oxidising agents. The outer surface of the wall smooth or scabrate, showing in some cases a fibre normal structure (Kirjanov *in* Volkova et al., 1979, English translation, 1983, p.43).

Discussion. The revised diagnosis emphasises cone-shaped form containing a base and a prominent process and expands to include some minor spines. The specimens in this study are commonly small (<200 µm in length), but in C. *vernicosum* the type specimens can be 1.1 mm (Kirjanov *in* Volkova, 1979). Single cone could be a part of a large micro- or macroorganism.

Four species in this study can be distinguished:
1. *Ceratophyton vernicosum*: single cone without ornamentations.
2. *C. circufuntum*: single cone with a ringed base.
3. *C. dumufuntum*: single cone with short, conical spines only on the basal part.
4. *C. spinuconum*: single cone with spines on both base and prominent process.

CERATOPHYTON CIRCUFUNTUM SP. NOV.

Plate 4I

Etymology. Circus, Latin, ring, circle; funtus, Latin, bottom, base.

Holotype. Plate 4I, slide 6428RS118–1, England Finder coordinates: G62/1, SYC 101, depth 232.2 m, Parara Limestone, ∈1.2 sequence, Stansbury Basin.

Description. Specimen cone-shaped, consisting a expanded base and a prominent process; wall moderately thin (~0.5 µm thick), finely granular, sometimes folded; cone base wide open, interior surface ornamented with circular rings; 4–6 rings (holotype: 5) evenly spaced; ringed base angularly connected with the prominent process; process tapering toward a closed tip, tip pointed or slightly blunt.

Dimensions. Cones are 80–130 µm high (nine specimens; holotype: 130 µm) and basal opens 50–65 µm wide (holotype: 60 µm).

Remarks. The present specimens are distinguished by the ringed basal part.

Occurrence. SYC 101, depth 232.2 and 232.3 m, Parara Limestone, acritarch assemblage 6, Stansbury Basin.

CERATOPHYTON DUMUFUNTUM SP. NOV.

Plate 4J

Etymology. Dumus, Latin, bramble, thorn-bush; fundus, Latin, bottom, base.

Holotype. Plate 4J, slide 5642RS222, England Finder coordinates L46/1, Manya 6, depth 1568.9 m, lower Ouldburra Formation, ∈1.1B sequence, acritarch assemblage 5, eastern Officer Basin.

Description. Specimen cone shaped, consisting of an expanded basal part and a long prominent process; wall thin to moderately thick (0.2–0.5 µm), smooth to finely granular, often with fine folds; cone base wide open, margin usually broken, surface ornamented with short, hollow conical spines; spinose hollow communicating with the basal cavity; prominent process smoothly drawn from the base, tapering to sharp, closed tip.

Dimensions. Cones are 80–150 µm high (15 specimens; holotype: 85 µm), bases 40–62 µm wide (holotype: 43 µm) and conical spines 1.5–4 µm long.

Remarks. The species is characterised by its base ornamented with short conical spines. The bases of some specimens show irregular forms.

Occurrence. Manya 6, depth 1568.9 m, lower Ouldburra Formation, acritarch assemblage 5, Officer Basin; SYC 101, depth 232.2 and 232.3 m, Parara Limestone, acritarch assemblage 6, Stansbury Basin.

CERATOPHYTON SPINUCONUM SP. NOV.

Plate 4G–H

Etymology. Spina, Latin, thorn; conus, Latin, cone.

Holotype. Plate 4G, slide 6337RS285–1, England Finder coordinates O41/1, SCYW 1, depth 205.05 m, basal Andamooka Limestone, ∈1.1A sequence, acritarch assemblage 3, Arrowie Basin.

Description. Specimen spinose cone like, containing a base and a prominent process; wall relatively thick (0.5 –0.8 µm), smooth to finely granular, often folded; base wide open, tapering smoothly to the prominent process; process closed at tip; cone ornamented with long, slender, hollow conical spines; spines evenly distributed, occupying from base to prominent process shaft; spinose hollow open freely into the cone cavity.

Dimensions. Cones are 32–110 µm long (15 specimens; holotype 90 µm), bases 30–40 µm wide (holotype: 40 µm), conical spines 5–10 µm long and 20–40 seen on the cone.

Remarks. The present specimens show some varieties and can be identified by slender conical spines distributed both on base and cone shaft.

Occurrence. SCYW 1, depth 205.05 m, basal Andamooka Limestone, acritarch assemblage 3, Stuart Shelf or Arrowie Basin; Old Motpena 1, depth 479.7 and 480 m, Parachilna Formation, assemblage 3, Arrowie Basin; and Yalkalpo 2, depth 782.7 m (lower Wilkawillina Limestone), 769.2 m (Mernmerna Formation), assemblages 5 and 6, Arrowie Basin.

GENUS COROLLASPHAERIDIUM MARTIN, 1982 EMEND. YIN, 1986

Type species. Corollasphaeridium wilcoxianum Martin, 1982 emend. Martin, 1992.

Discussion. The genus contains a group of cylindrical vesicles with one apex (proximal) wide open and the other (distal) closed and ornamented with processes. The type species was collected from the uppermost Cambrian to lowest Ordovician in China and Canada, and is regarded as an index fossil to mark the Cambrian–Ordovician boundary (Martin, 1992, 1993). At least four forms can be recognised in this study.

COROLLASPHAERIDIUM ALIQUOLUMUM SP. NOV.

Plate 4A–C

Etymology. Aliquot, Latin, several, few, some; luma, Latin, thorn.

Holotype. Plate 4A, slide 6428RS118–1, England Finder coordinates T53, SYC 101, depth 232.2 m, Parara Limestone, ∈1.2 sequence, acritarch assemblage 6, Stansbury Basin.

Description. Vesicle irregular square to oblong in lateral view, circular in vertical view, originally cylindrical; wall thick (~0.5–0.8 µm), finely granular to granular, folded or split; proximal apex wide open, no operculum observed, the margin of the opening rounded and thickened; distal apex bearing 4–6 processes; process elongate-conical to thin blade shaped, slender, hollow, evenly distributed, unbranched, widened at base and sharp at tip; process hollow open freely into the cylindrical cavity; processes commonly homomorphic, but can be variable in sizes, usually longer at the apical extremity.

Dimensions. Cylindrical vesicles are 19–42 µm wide and 16–34 µm long (21 specimens, holotype: 29 µm wide and 24 µm long), process length 8–31 µm (holotype 8–25 µm) and number 4–6 seen at the distal apex.

Remarks. The new species is distinguished by its cylindrical vesicle with 4–6 long processes on distal apex.

Occurrence. Yalkalpo 2, depth 782.7 and 781.2 m, lower Wilkawillina Limestone, acritarch assemblage 5, Arrowie Basin. SYC 101, depth 232.3 and 232.2 m, Parara Limestone, assemblage 6, Stansbury Basin.

COROLLASPHAERIDIUM OPIMOLUMUM SP. NOV.

Plate 4D–E
Etymology. Opimus, Latin, abundant; Luma, Latin, thorn.

Holotype. Plate 4D, slide 6428RS160, England Finder coordinates P50/3, SYC 101, depth 232.3 m, Parara Limestone, ∈1.2 sequence, acritarch assemblage 6, Stansbury Basin.

Description. Vesicle irregularly oblong in lateral view, circular in vertical view, originally cylindrical; wall moderately thick (~0.5 µm), smooth to finely granular, often folded; proximal apex wide open, no operculum observed, opening margin thickened; distal apex bearing more than 10 processes; process conical to long triangular, relatively short, hollow, evenly distributed, unbranched, widened at base and sharp at tip; process hollow open freely into the cylindrical cavity; processes commonly homomorphic, but variable in sizes, usually longer at the apical extremity; cylindrical vesicle slightly constrained at the middle part and separating the spinose distal apex from proximal opening.

Dimensions. Cylindrical vesicles are 16–35 µm wide and 21–42 µm long (12 specimens, holotype: 25 µm wide and 40 µm long), process length 3–20 µm (holotype 4–11 µm) and number 10–20 seen at the distal apex (holotype 15).

Remarks. *C. opimolumum* differs from *C. aliquolumum* by its more abundant, short processes on distal apex and a middle constrain on the cylindrical vesicle.

Occurrence. SYC 101, depth 232.3 and 232.2 m, Parara Limestone, assemblage 6, Stansbury Basin; Minlaton 1, depth 357 m, lower Minlaton Formation, assemblage 7.

GENUS SKIAGIA DOWNIE, 1982

Type species. Skiagia scottica Downie, 1982
MEDOUSPALLA Wood and Clendening, 1982

Diagnosis (modified). Vesicle spherical; wall double layered, outer layer thin, membrane like and translucent, interior layer thick and robust, and commonly preserved as single-walled vesicle; process hollow, discrete, unbranched, homomorphic, evenly distributed, narrow or slightly widened at base and expanded distally to form funnel-shaped tip; process hollow open freely into the interior body cavity and sealed from the outer layer cavity; when preserved as single walled, outer layer sometimes strangled the junction between the process base and interior wall, forming a thickened, 'plug'-like structure; opening structure probably median split.

Discussion. Skiagia was erected by Downie (1982, p.262–263) to include spherical vesicle with processes of 'hollow and widen distally to form essentially funnel-shaped terminations'. In same year, *Medousapalla* was described as spherical vesicle with process 'hollow, closed proximally by inner wall layer, and expanded distally to funnel-shape' (Wood and Clendening, 1982, p.259). *Medousapalla* is considered to be a junior synonymy of *Skiagia*.

The modified diagnosis emphasises the funnel-shaped processes and double-layered wall structure which can be preserved as a single-walled vesicle and form a sort of 'plug' structure. Identification criteria among different species in this genus have been stated (Downie, 1982; Moczydlowska, 1991; Zang, 1992), but many 'transitional' forms are often present among species. *Baltisphaeridium* also has a double-layered wall, but lacking a funnel-shaped process tip.

SKIAGIA CILIOSA (VOLKOVA, 1969) DOWNIE, 1982

Plate 2G

Baltisphaeridium ciliosum, VOLKOVA, 1969, pp.224–225, pl.50, figs 1–3; pl.51, figs 11–12.

Baltisphaeridium ciliosum, VOLKOVA et al., 1979, p.8, pl.2, figs 1–5.

Skiagia ciliosa (Volkova), DOWNIE, 1982, figs 5, 7. p–q. p.263.

Skiagia ciliosa (Volkova, KNOLL and SWETT, 1987, p.921, figs 9.3, 9.6–9.8, 9.11, 9.14, 9.15, 10.2, 10.4, 10.7.

Skiagia ciliosa (Volkova), HAGENFELDT, 1989, pp.109–113, pl. 4, fig. 12; pl. 5, fig. 1.

Skiagia ciliosa (Volkova), MOCZYDLOWSKA, 1991, pp.65–67, Pl. 7, figs A–F.

Skiagia ciliosa (Volkova), ZANG, 1992, pp.104–105, pl.2, figs F–H.

Skiagia ciliosa (Volkova), VIDAL and PEEL, 1993, p.29, fig. 12a–d.

Description. Vesicle circular to subcircular, originally spherical; wall smooth to finely granular, usually folded, double layered, outer layer thin, membrane like and translucent, interior layer thicker and robust; process relatively short, slender, hollow, unbranched, homomorphic, moderately abundant, narrow or slightly widened at base and flared at tip; process hollow open freely into the interior body cavity, but sealed from the outer layer; vesicle usually preserved as single wall, some thickened 'plug'-like structure visible at process base; occasionally median split observed.

Dimensions. Vesicles are 25–40 µm in diameter (100 specimens measured), process length 4–10 µm and number 25–70 seen at outline.

Remarks. S. ciliosa is distinguished by its slender processes with slightly thickened funnel-shaped tip. Six specimens display double-layered wall structure among several hundred specimens observed in this study. Volkova (1969) suggested the differentiation of the wall between the vesicle and processes, which is probably due to the preservation of the double-layered wall.

Occurrence. Abundant in acritarch assemblage 5 and 6: Yalkalpo 2, lower Wilkawillina Limestone and Mernmerna Formation, Arrowie Basin; very abundant in assemblage 6: SYC 101, Parara Limestone, Stansbury Basin; and rare in assemblage 7: a single specimen in Minlaton 1, 357 m, lower Minlaton Formation, Stansbury Basin.

SKIAGIA COMPRESSA (VOLKOVA, 1968) DOWNIE, 1982

Plate 2D

Baltisphaeridium compressum, VOLKOVA, 1968, p.19, pl.2, fig. 6?, 7–9?; pl.11, fig. 2?.

Baltisphaeridium compressum, VOLKOVA et al., 1979, p.9, pl.2, figs 6–10.

Skiagia compressa (Volkova), DOWNIE, 1982, p.263, fig. 7, r–t.

Skiagia compressa (Volkova), KNOLL and SWETT, 1987, p.921, figs 9.4, 9.5, 9.10.

Skiagia compressa (Volkova), HAGENFELDT, 1989, pp.113–116, pl.5, fig. 2.

Skiagia compressa (Volkova), MOCZYDLOWSKA, 1991, p.67, pl.5, fig. A.

Skiagia compressa (Volkova), ZANG, 1992, pp.105–106, pl.2, figs L–M.

Skiagia compressa (Volkova), VIDAL and PEEL, 1993, p.29, fig. 14.g.

Description. Vesicle circular to subcircular, originally spherical; wall smooth to granular, usually folded, double layered, outer layer thin, membrane like and translucent, interior layer thicker and robust; process relatively long, slender, hollow, unbranched, homomorphic, moderately abundant, widened at base and expanded at tip; process hollow open freely into the interior body cavity, but sealed from the outer layer; vesicle often preserved as single-walled, occasionally thickened 'plug'-like structure present at process base; sometimes median split observed.

Dimensions. Vesicles are 25–46 µm in diameter (100 specimens measured), process length 7–15 µm and number 25–60 seen at outline.

Remarks. The species is characterised by its widened process base, but many transitional forms bridge this species to *S. ciliosa* and *S. ornata.* Two specimens in this group contain double-layered wall.

Occurrence. Fairly abundant in acritarch assemblage 4: Bute 2, depth 78.7 m, dolomitic unit, Kulpara Formation, Stansbury Basin; very abundant in acritarch assemblage 5 and 6: Yalkalpo 2, lower Wilkawillina Limestone and Mernmerna Formation, Arrowie Basin; abundant in assemblage 6: SYC 101, Parara Limestone, Stansbury Basin.

SKIAGIA ORBICULARE (VOLKOVA, 1968) DOWNIE, 1982

Plate 2C

Baltisphaeridium orbiculare, VOLKOVA, 1968, p.19, pl.2, figs 1–5; pl.11, fig. 3; p.19.
Baltisphaeridium orbiculare, VOLKOVA et al., 1979, p.10, pl.1, figs 1–3.
Skiagia orbiculare (Volkova), DOWNIE, 1982, fig. 8, e–f. p.264.
Skiagia orbiculare (Volkova), KNOLL and SWETT, 1987, p.921, figs 10.6, 10.8.
Skiagia orbiculare (Volkova), HAGENFELDT, 1989, p.119–121, pl.5, fig. 5.
Skiagia orbiculare (Volkova), MOCZYDLOWSKA, 1991, p.68, pl.5, figs B–D.
Skiagia orbiculare (Volkova), ZANG, 1992, p.106, pl.2, figs J–K.
Skiagia orbiculare (Volkova), VIDAL and PEEL, 1993, p.31, fig. 13d,e.

Description. Vesicle circular to subcircular, originally spherical; wall smooth to finely granular, usually folded, preserved as single-layered vesicle; process relatively short, thickened shaft, hollow, unbranched, homomorphic, abundant, slightly widened at base and moderately flared at tip; process hollow open freely into the interior body cavity; occasionally thickened 'plug'-like structure visible at process base; no opening structure observed.

Dimensions. Vesicle diameters are 25–40 µm (more than 50 specimens), process length 5–15 µm and number seen at outline 28–55.

Remarks. The species is distinguished by its relatively short, thickened processes, but transitional forms are often present, particularly related to *S. pura*.

Occurrence. Common in acritarch assemblage 4: Bute 2, 78.7 m, dolomitic unit, Kulpara Formation, Stansbury Basin; abundant in acritarch assemblage 5 and 6: Yalkalpo 2, lower Wilkawillina Limestone and Mernmerna Formation, Arrowie Basin; and common in SYC 101, Parara Limestone, Stansbury Basin.

SKIAGIA ORNATA (VOLKOVA, 1968) DOWNIE, 1982

Plate 2A–B

Baltisphaeridium ornatum, VOLKOVA, 1968, pp.18–19, pl.1, figs 10–14; pl.11, Fig. 1.
Baltisphaeridium ornatum, VOLKOVA et al., 1979, p. 11, pl.4; figs 9–11.
Skiagia ornata (Volkova), DOWNIE, 1982, fig. 5, p.264.
Medousapalla choanoklosma, WOOD and CLENDENING, 1982, p.259, pl.1, figs 1–2, 4–5.
Skiagia ornata (Volkova), KNOLL and SWETT, 1987, p.922, figs 10.1, 10.3, 10.5.
Skiagia ornata (Volkova), HAGENFELDT, 1989, pp.121–123, pl.5, fig 6.
Skiagia ornata (Volkova), MOCZYDLOWSKA, 1991, p.68–69, pl.5, figs E–F, pl.6, figs A–D.
Skiagia ornata (Volkova), ZANG, 1992, pp.106–107, pl.1, figs O–Q.
Skiagia ornata (Volkova), VIDAL and PEEL, 1993, p.31, fig. 13.a.

Description. Vesicle circular to subcircular, originally spherical; wall smooth to finely granular, usually folded, double layered, outer layer thin, membrane like and translucent, interior layer thicker and robust; process long to very long, slender, hollow, unbranched, homomorphic, moderately abundant, slightly widened at base and moderately widened at tip; process hollow open freely into the interior body cavity, but sealed from the outer layer; vesicle often preserved as single-walled and occasionally thickened 'plug'-like structure present at process base; occasionally median split observed.

Dimensions. Vesicle diameters are 20–50 µm (100 specimens measured), process length 12–24 µm, processes seen at outline number 25–70.

Remarks. This species is characterised by very long processes and contains well-preserved double-layered wall structure. Only 15 double-layered vesicles were found among several hundred specimens in this study.

Occurrence. Abundant in acritarch assemblage 4: Bute 2, 78.7 m, dolomitic unit, Kulpara Formation, Stansbury Basin; very abundant in acritarch assemblage 5 and some in assemblage 6: Yalkalpo 2, lower Wilkawillina Limestone and Mernmerna Formation, Arrowie Basin.

SKIAGIA SP. CF. S. PURA MOCZYDLOWSKA, 1988

Plate 2H–I

Skiagia pura, MOCZYDLOWSKA, 1988, pp.8–9, pl.2, figs 1–2; fig. 3.
Skiagia pura, MOCZYDLOWSKA, 1991, p.69, pl.7, figs G–H.

Description. Vesicle circular to oval, originally spherical; wall finely granular, commonly folded and preserved as single layered; process relatively short, very thick shaft, hollow, abundant, homomorphic, evenly distributed, narrow at base and very widened at tip where can be contacted with neighbouring processes; process hollow open freely into the vesicle cavity; no opening structure observed.

Dimensions. Vesicles are 30–40 µm in diameter (five specimens), process length 6–12 µm and number seen at outline 28–45.

Remarks. The present specimens are relatively rare in this study and sometimes difficult to be differentiated from *S. orbiculare*.

Occurrence. Yalkalpo 2, depth 775.9 m, lower Wilkawillina Limestone, Arrowie Basin.

SKIAGIA SCOTTICA DOWNIE, 1982

Plate 2E–F

Skiagia scottica, DOWNIE, 1982, p.264, figs 5, 8k–l, 9a–f.

Skiagia scottica, KNOLL and SWETT, 1987, p.922, figs 9.9, 9.12.

Skiagia scottica, MOCZYDLOWSKA, 1991, pp.69–70, pl.6, figs E–F.

Skiagia scottica, ZANG, 1992, p.107, pl.2, figs A–E.

Skiagia scottica, VIDAL and PEEL, 1993, p.31, fig. 14a–d.

Description. Vesicles circular to subcircular, originally spherical; wall finely granular, commonly folded, preserved as single layered; process numerous, moderately long, hollow, homomorphic, evenly and crowdedly distributed, slightly widened at base, moderate to widened funnel at tip; processes often contact distally; process hollow probably communicating with the vesicle cavity, but some thickened 'plug'-like structure observed at the process base; no opening structure observed.

Dimensions. Vesicle diameters are 22–38 µm (10 specimens), process length 6–12 µm and number seen at outline 60–>100.

Remarks. S. scottica is distinguished by its crowded distribution of processes and its tendency to contact distally; no double-layered vesicles were found in this species.

Occurrence. Yalkalpo 2, depth 782.7 and 775.9 m, lower Wilkawillina Limestone, Arrowie Basin.

GENUS VERYHACHIUM DEUNFF EMEND. SARJEANT AND STANCLIFFE, 1994

Type species. Veryhachium trisulum (Deunff, 1951, p.323) Deunff, 1954

Discussion. Sarjeant and Stancliffe (1994a) emended the genus and, later, further divided into two subgenera: *Veryhachium* subgenus *Veryhachium* and *Veryhachium* subgenus *Tetraveryhachium* (1994b).

VERYHACHIUM (VERYHACHIUM) TRISENTIUM SP. NOV.

Plate 3F–G

Etymology. Tri-, Latin, three; sentis, Latin, thorn, brier, bramble.

Holotype. Fig. 14.13, slide 6535RS69–3, England Finder coordinates:H42/2, Old Motpena 1, depth 479.7 m, Parachilna Formation, ∈1.1A sequence, acritarch assemblage 3, Arrowie Basin.

Description. Vesicle triangular to irregular, bi-symmetrical with one major and two minor processes; wall moderately thick (~0.5 µm), smooth to finely granular, commonly folded; no obvious boundary between the processes and central body, processes drawn out smoothly; major process very thick, relatively long, hollow, continuously tapering to a sharp tip; minor processes homomorphic, relatively short, hollow and smaller; process hollow open freely into the central body cavity; vesicle commonly split from the base of the major process.

Dimensions. Vesicles are 40–120 µm across (30 specimens, holotype: 45 µm).

Remarks. The present species is distinguished by its bilaterally symmetrical triangular vesicle and the combination of one major and two minor processes. Most specimens in this study are more or less damaged and the major process resembles *Ceratophyton vernicosum* Kirjanov, 1979 when it completely split from the central body.

Occurrence. Old Motpena 1, depth 479.7, 480 and 474.5 m, Parachilna Formation, acritarch assemblage 3, Arrowie Basin; Yalkalpo 2, depth 780 m, lower Wilkawillina Limestone, assemblage 5, Arrowie Basin.

GENUS VULCANISPHAERA DEUNFF, 1961 EMEND. RASUL, 1976

Type species. Vucanisphaera africana Deunff, 1961

VULCANISPHAERA PSEUDOFAVEOLATA

(Fridrichsone, 1971) comb.
Plate 3J
Baltisphaeridium pseudofaveolatum, FRIDRICHSONE, 1971, p.13, pl.3, figs 17–20.
Baltisphaeridium pseudofaveolatum, VOLKOVA et al., 1979, p.12, pl.7, figs 1–6.
Baltisphaeridium pseudofaveolatum, HAGENFELDT, 1989, pp.188–190, pl.1, fig. 1.

Description. Vesicle circular to subcircular, originally spherical; wall thin to moderately thick (~0.2–0.5 µm), finely granular to granular, usually folded; process relatively long, slender, wiry, probably solid, homomorphic, unbranched, narrow or slightly wide at base and sharp at tip; process could be single at base, but often 2, 3 or 4 grouped into tuft, sharing a common base; common base often thickened, discrete or spaced from neighbours; no opening structure observed.

Dimensions. Vesicles are 28–40 µm in diameter (nine specimens), process length 12–20 µm and number seen at outline 15–37.

Remarks. Two to four processes grouped as a tuft is characteristic of this species and this feature distinguishes it from *Baltisphaeridium*, which always has a single-based process. The type specimens (cf. Volkova et al., 1979, p.12) contain some five-process-tufts and this is not observed in the present specimens.

Occurrence. SYC 101, depth 232.2 and 232.3 m, Parara Limestone, acritarch assemblage 6, Stansbury Basin; Minlaton 1, depth 352.5 m, lower Minlaton Formation, acritarch assemblage 7, Stansbury Basin.

ACKNOWLEDGEMENTS

This study is a cooperative project between the University of South Australia and Office of Minerals and Energy Resources (PIRSA). The late Dr. David I. Gravestock supervised the project and his work forms part of this study. We are indebted to him for his contribution and valuable discussions. The staff in the PIRSA Core Library are thanked for their assistance with core inspection. Wolfgang Preiss read the manuscript.

PLATES

Plate 1

A–C	*Abadiella huoi* Zhang 1966. A, SAMP39077, partial cranidium (783.67 m), x4. B, SAMP 39078, librigena (785.62) m, x3. C, SAMP 39079, librigena (785.31), x4.
D	Pelagiellid, SAMP 39080 (784.25 m), x19.
E	*Pararaia tatei* (Woodward 1884), SAMP 39081, cranidium (Yalkalpo 1, 218.12 m), x7.
F	*Pararaia* sp., SAMP 39082, partial cranidium (717.85 m), x6.
G–H, K	*Pararaia ?bunyerooensis* Jell 1990. G, SAMP 39083, partial cranidium (694.50 m), x12. H, SAMP 39084, partial cranidium (689.14 m), x6. K, SAMP 39087, partial cranidium (675.95 m), x15.
I	Lingullelid, SAMP 39085 (675.95 m), x8.
J	Obolellid, SAMP 39086 (685.02 m), x7.
L	*Emuella polymera* Pocock 1970, SAMP 39088, largely complete specimen (409.90 m), x12
M	Emuellid, SAMP 39089, parts of two thoracic segments including macropleural segment (418.46 m), x6
N	Redlichiid indet. SAMP 39090, partial cranidium (575.24 m), x3.
O	Librigena indet. SAMP 39091 (558.16 m), x7.
P	Redlichiid indet. SAMP 39092, part of large librigena (561.43 m), x1.5.
Q	*Planolites* sp. SAMP 39093 (383.00 m), x2
R	*Pararaia ?janeae* Jell 1990, partial cranidium (636.83 m), x8
S	Conocoryphid, part of fixigena (537.76 m), x3.

All the catalogue numbers noted herein refer to the palaeontology collection of the South Australian Museum. All the specimens, figured above, except that shown in E, come from Yalkalpo 2. The down hole depths are shown in brackets. Specimen E comes from Yalkalpo 1.

Plate 1

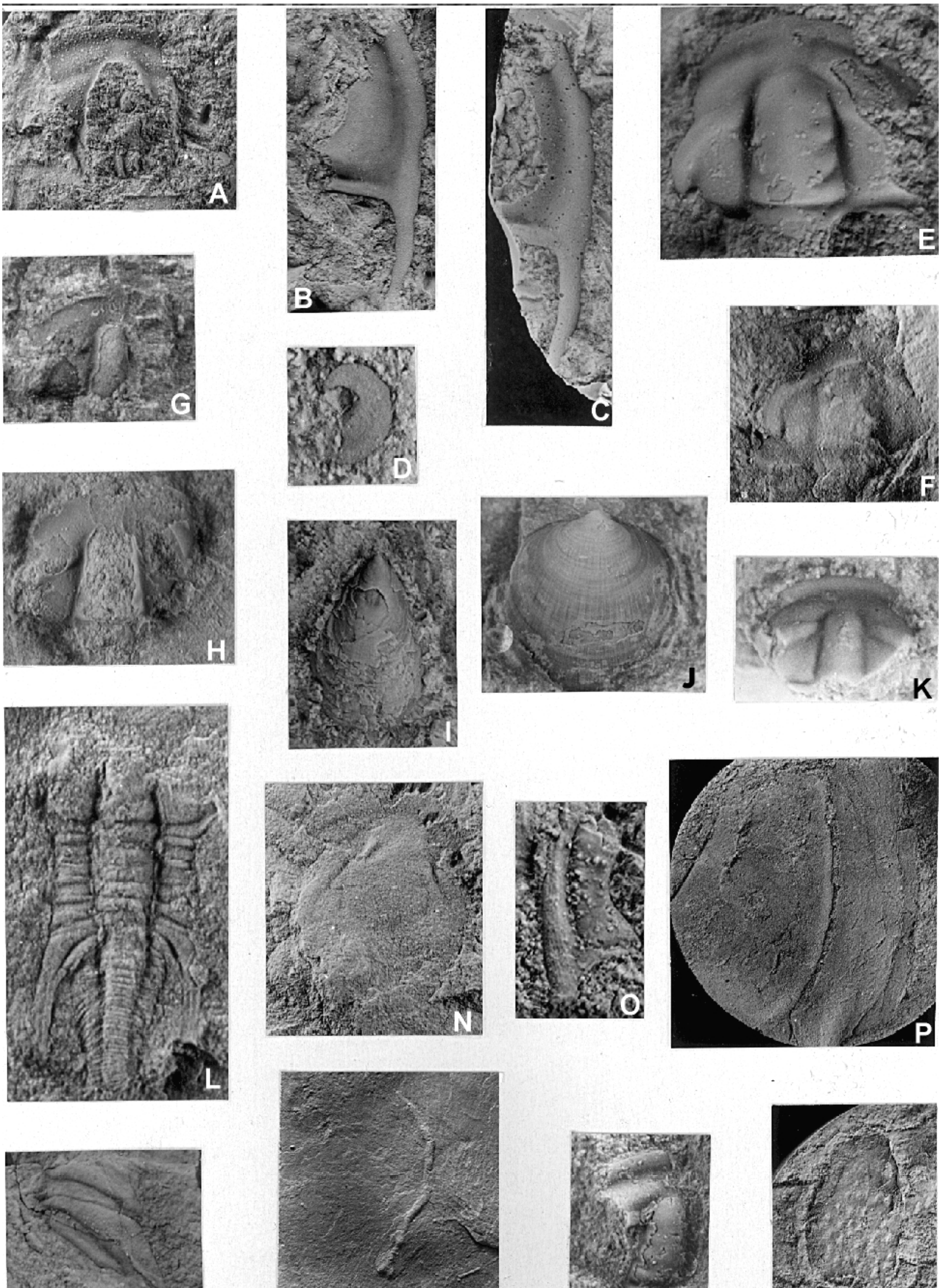


Plate 2

A–B	*Skiagia ornata* (Volkova, 1968) Downie, 1982
A	Slide 7036RS143–2, L58/2.
B	Slide 7036RS137–1, Q47/2.
C	*Skiagia orbiculare* (Volkova, 1968) Downie, 1982
	Slide 7036RS137–4, Q59/4.
D	*Skiagia compressa* (Volkova, 1968) Downie, 1982
	Slide 7036RS141–1, T35/2.
E–F	*Skiagia scottica* Downie, 1982
E	Slide 7036RS141–1, P55/3.
F	Slide 7036RS141–1, K31/4.
G	*Skiagia ciliosa* (Volkova, 1969) Downie, 1982
	Slide 6428RS118–1, SYC 101, N63/4.
H–I	*Skiagia* sp. cf. *S. pura* Moczydlowska, 1988
H	Slide 7036RS141–1, J49.
I	Slide 7036RS141–2, Q43/1.

Specimens A–F, H–I are from Yalkalpo 2 and G from SYC 101. Magnification: all specimens X1000.

Plate 2

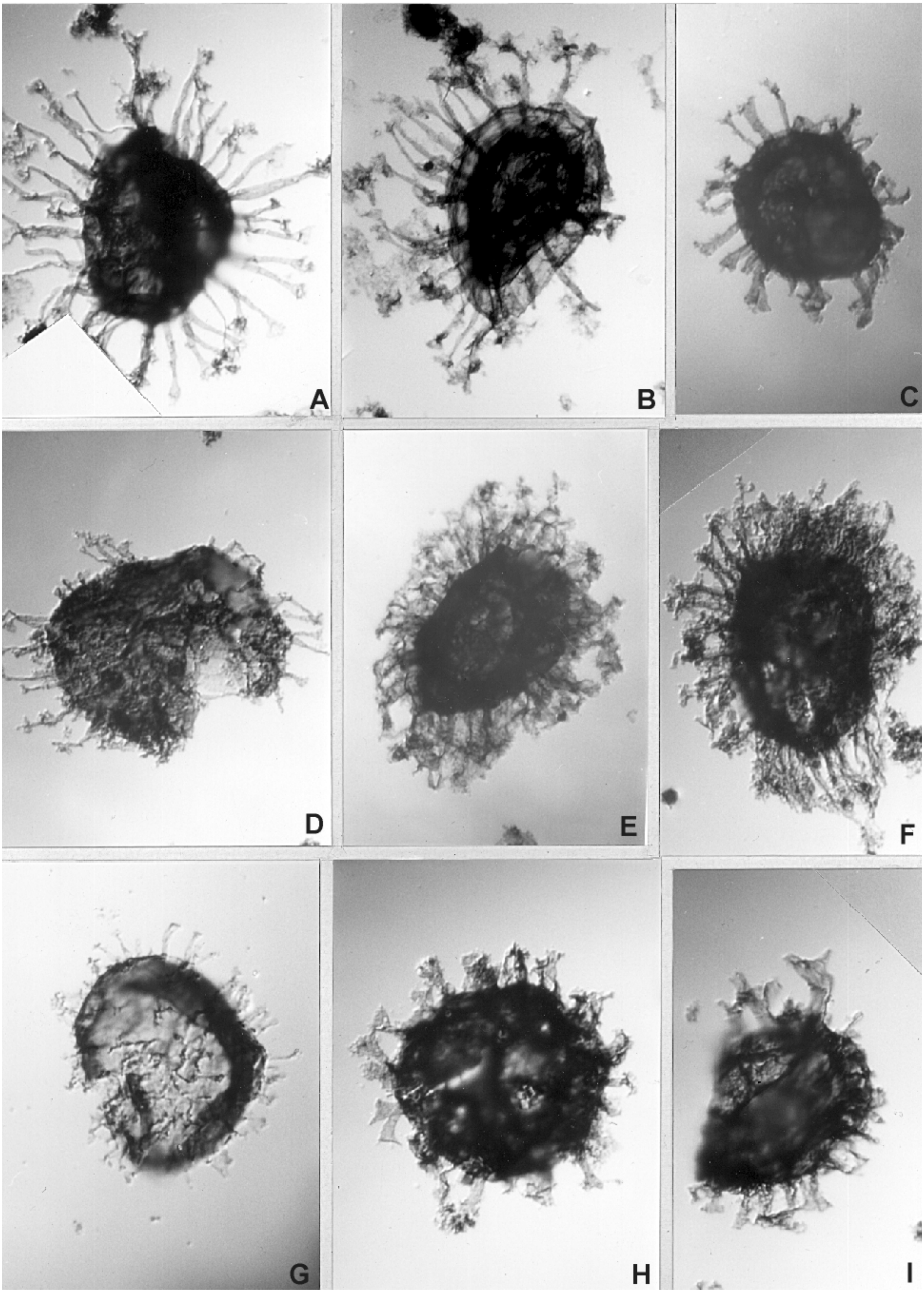


Plate 3

A–B	*Baltisphaeridium bimacerium* sp. nov.
A	Slide 7036RS137–3, D56/4, HOLOTYPE.
B	Slide 7036RS137–3, H57/2.
C	*Comasphaeridium strigosum* (Jankauskas, 1976) Downie, 1982 Slide 7036RS143–2, V47.
D	*Dorsennidium* sp. Slide 7036RS137–3, O60/2.
E	*Dorsennidium primarium* (Jankauskas, 1979) Sarjeant and Stancliffe, 1994 Slide 7036RS137–2, J50/2.
F–G	*Veryhachium* (*Veryhachium*) *trisentium* sp. nov.
F	Slide 6535RS69–3, H42/2, HOLOTYPE.
G	Slide, 7036RS142–1, Q55/2.
H	*Multiplicisphaeridium dendroideum* (Jankauskas, 1976) Jankauskas and Kirjanov, 1979. Slide 7036RS137–2, K66.
I	*Polygonium varium* (Volkova, 1969) Sarjeant and Stancliffe, 1994 Slide 7036RS137–1, Z53/1.
J	*Vulcanisphaera pseudofaveolata* (Fridrichosone, 1971) comb. Slide 6428RS118–2, D63/3.

Specimen F is from Old Motpena 1, J from SYC and the others are from Yalkalpo 2. Magnification: specimen D–X800; G–X625 and the others X1000.

Plate 3

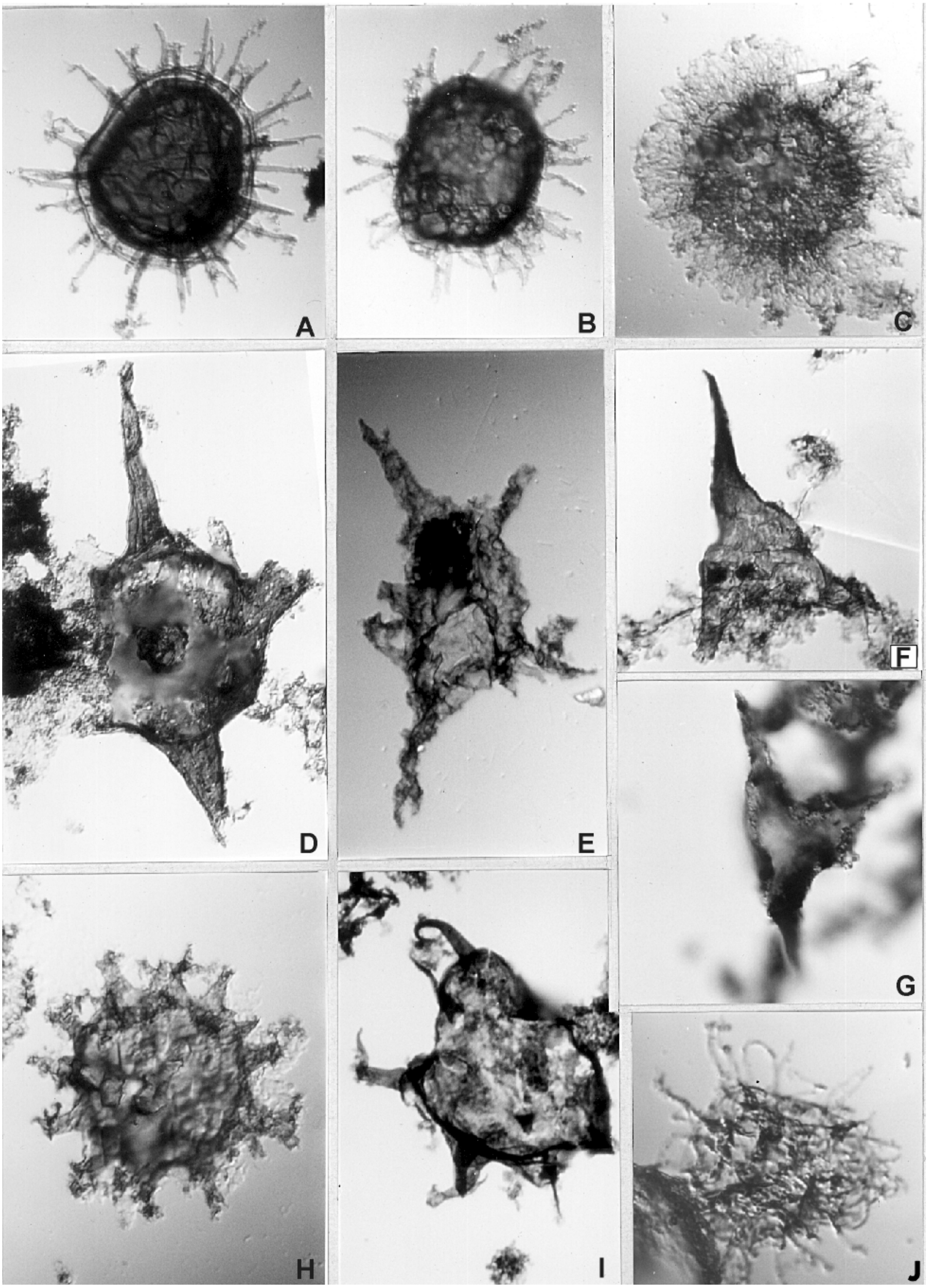
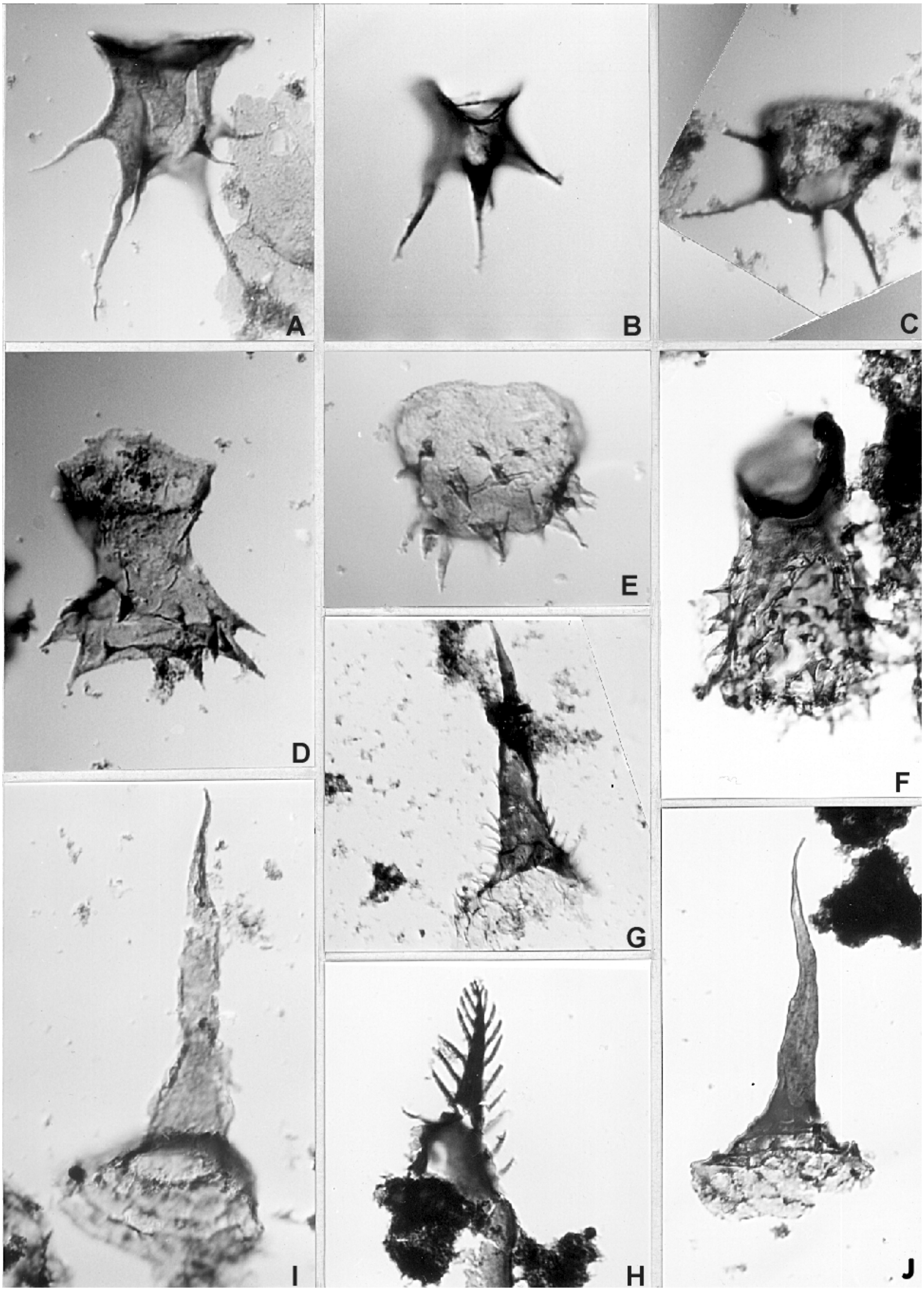


Plate 4

A–C	*Corollasphaeridium aliquolumum* sp. nov.
A	Slide 6428RS118–1, T53, HOLOTYPE.
B	Slide 6428RS118–2, K67/3.
C	Slide 7036RS137–4, M53/4.
D–E	*Corollasphaeridium opimolumum* sp. nov.
D	Slide 6428RS160, P50/3, HOLOTYPE.
E	Slide 6428RS118–1, H40/3.
F	*Corollasphaeridium* sp. cf. *C. opimolumum* sp. nov.
	Slide 7036RS129–1, V61.
G–H	*Ceratophyton spinuconum* sp. nov.
G	Slide 6337RS285–1, O41/1, HOLOTYPE.
H	Slide 6535RS69–2, K47/2.
I	*Ceratophyton circufuntum* sp. nov.
	Slide 6428RS118–1, G62/1, HOLOTYPE.
J	*Ceratophyton dumufuntum* sp. nov.
	Slide 5642RS222, L46/1, HOLOTYPE.

Specimens A–B, D–F, I are from SYC 101; C from Yalkalpo 2; G from SCYW 1; H from Old Motpena 1; and J from Manya 6. Magnification: specimen G–X500; F, I–X625; H, J–X800 and A–E, X1000.

Plate 4



APPENDIXES

Appendix 1 Samples for Cambrian acritarchs

Well name	Depth (m)	Lithological units	Assemblage number
Yalkalpo 2 (Arrowie Basin)			
R166273	319.75	Billy Creek Formation	0*
7036RS118	408.1	Billy Creek Formation	0
7036RS119	435.1	Billy Creek Formation	0
7036RS120	456.1	Billy Creek Formation	0
7036RS121	485.1	Billy Creek Formation	0
7036RS122	500.6	Billy Creek Formation	0
7036RS123	525.5	Moorowie Formation	0
7036RS124	540.9	Moorowie Formation	0
7036RS125	593.3	Moorowie Formation	0
7036RS126	602.6	Moorowie Formation	0
R166274	624.4	Moorowie Formation	0
7036RS127	631.8	Moorowie Formation	0
R166275	633	Moorowie Formation	0
7036RS128	634	Moorowie Formation	7
R166276	644.7	Mernmerna Formation	6
7036RS129	671.6	Mernmerna Formation	0
R166277	695	Mernmerna Formation	6
7036RS130	697.3	Mernmerna Formation	6
7036RS131	703.2	Mernmerna Formation	6
R166278	703.4	Mernmerna Formation	6
7036RS132	710.3	Mernmerna Formation	6
7036RS133	719	Mernmerna Formation	6
7036RS134	724.7	Mernmerna Formation	6
7036RS135	732.3	Mernmerna Formation	6
7036RS139	768.9	Mernmerna Formation	5
7036RS136	769.2	Mernmerna Formation	5
7036RS140	770.5	lower Wilkawillina Limestone	5
7036RS141	775.9	lower Wilkawillina Limestone	5
7036RS142	780	lower Wilkawillina Limestone	5
7036RS143	781.2	lower Wilkawillina Limestone	5
7036RS137	782.7	lower Wilkawillina Limestone	5
7036RS138	793.4	Parachilna Formation	0
(0*, unclassified acritarch assemblages, likely dominated by *Leiosphaeridia* spp.)			
Bute 2# (Stansbury Basin)			
6530RS868	78.7	Kulpara Formation (lower dolomite)	4
6530RS869	80	Kulpara Formation (lower dolomite)	0
6530RS870	81.4	Kulpara Formation (lower dolomite)	0
6530RS871	87.3	Kulpara Formation (lower dolomite)	3
6530RS872	90.7	Kulpara Formation (lower dolomite)	0
6530RS873	93.3	Kulpara Formation (lower dolomite)	0
6530RS874	95.8	Kulpara Formation (lower dolomite)	0
6530RS875	98.4	Winulta Formation	0
Castle Rock Section (Arrowie Basin)			
6636RS20	30	Uratanna Formation	2
6636RS35	50	Uratanna Formation	2
6636RS36	57	Uratanna Formation	2
6636RS37	65	Uratanna Formation	1
6636RS38	68	Uratanna Formation	1
6636RS21	70	Uratanna Formation	1

Well name	Depth (m)	Lithological units	Assemblage number
6636RS22	75	Uratanna Formation	1
6636RS23	85	Uratanna Formation	1
6636RS24	94	Uratanna Formation	1
6636RS25	97	Uratanna Formation	1
6636RS26	101	Uratanna Formation	1
6636RS27	107	Uratanna Formation	1
6636RS28	110	Uratanna Formation	1
6636RS29	115	Uratanna Formation	1
6636RS39	128	Uratanna Formation	1
6636RS30	135	Uratanna Formation	1
6636RS31	140	Uratanna Formation	1
6636RS32	145	Uratanna Formation	1
6636RS33	150	Uratanna Formation	1
6636RS34	153	Uratanna Formation	1
6636RS41	172	Uratanna Formation	1
6636RS42	179	Uratanna Formation	1
6636RS43	195	Uratanna Formation	1
6636RS44	205	Uratanna Formation	1
LNM 10–1 (Arrowie Basin)			
R112219	192	Edeowie Limestone	0
R112220	194.1	Edeowie Limestone	0
R112221	196.4	Edeowie Limestone	0
Manya 6 (Officer Basin)			
5642RS197	695.9	Ouldburra Formation	0
5642RS198	779.6	Ouldburra Formation	0
5642RS199	802.5	Ouldburra Formation	0
5642RS200	816.1	Ouldburra Formation	0
5642RS201	1398.6	Ouldburra Formation	0
5642RS202	1476.5	Ouldburra Formation	0
5642RS213	613.2	Ouldburra Formation	0
5642RS214	644.4	Ouldburra Formation	0
5642RS215	674.1	Ouldburra Formation	0
5642RS216	660	Ouldburra Formation	0
5642RS217	772	Ouldburra Formation	0
5642RS218	778	Ouldburra Formation	0
5642RS219	792.4	Ouldburra Formation	0
5642RS220	999.3	Ouldburra Formation	0
5642RS221	1283.2	Ouldburra Formation	0
5642RS222	1568.9	Ouldburra Formation	5
Minlaton 1 (Stansbury Basin)			
R177708	150	Ramsay Limestone	0
6428RS92	206.4	Ramsay Limestone	0
R177709	221.5	Ramsay Limestone	0
R177710	222.4	Ramsay Limestone	0
R177711	223	Ramsay Limestone	0
6428RS93	248.5	upper Minlaton Formation	0
6428RS94	270.7	upper Minlaton Formation	0
6428RS95	277.6	upper Minlaton Formation	0
6428RS127	352.5	lower Minlaton Formation	7
6428RS128	357.8	lower Minlaton Formation	7
6428RS96	357	lower Minlaton Formation	7
6428RS97	394.5	Parara Limestone	0
6428RS98	545	Parara Limestone	0
6428RS99	679.5	Parara Limestone	0

Well name	Depth (m)	Lithological units	Assemblage number
6428RS100	718.5	Parara Limestone	0
6428RS101	881	Kulpara Formation (lower dolomite)	0
6428RS102	888.5	Kulpara Formation (lower dolomite)	0
6428RS103	927	Kulpara Formation (lower dolomite)	0
6428RS104	959	Winulta Formation	3
6428RS105	990.5	Winulta Formation	3
Mt Frome DDM 1 (Arrowie Basin)			
R437362	55.4	Moorowie Formation	0
R437363	59.8	Moorowie Formation	0
R437364	63.8	Moorowie Formation	0
R437365	65.6	Moorowie Formation	0
R437366	69.1	Moorowie Formation	0
R437367	302	?Oraparinna Formation	7
R437368	315.7	?Oraparinna Formation	7
R437369	333.8	?Oraparinna Formation	7
R437370	337.8	?Oraparinna Formation	7
R437371	346.8	?Oraparinna Formation	7
Old Motpena 1 (Arrowie Basin)			
6535RS65	379.6	Woodendinna Dolomite	0
6535RS66	401.3	Woodendinna Dolomite	0
6535RS67	450.5	Woodendinna Dolomite	0
6535RS71	473.6	Parachilna Formation	3
6535RS72	474.4	Parachilna Formation	3
6535RS68	474.5	Parachilna Formation	3
6535RS69	479.7	Parachilna Formation	3
6535RS73	480	Parachilna Formation	3
SCYW 1 (Arrowie Basin)			
6337RS284	15	upper Andamooka Formation	0
6337RS285	205.05	lower Andamooka Formation	3
SYC 101 (Stansbury Basin)			
6428RS116	165.1	Parara Limestone	6
6428RS117	208.1	Parara Limestone	6
6428RS118	232.2	Parara Limestone	6
6428RS160	232.3	Parara Limestone	6
6428RS119	258.7	Parara Limestone	5
6428RS120	297.4	Kulpara Formation (upper limestone)	0
6428RS121	330	Kulpara Formation (upper limestone)	0
6428RS122	367.1	Kulpara Formation (upper limestone)	0
6428RS123	394.7	Kulpara Formation (lower dolomite)	0
6428RS124	399.2	Kulpara Formation (lower dolomite)	0
6428RS125	415.9	Kulpara Formation (lower dolomite)	0

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