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STRATIGRAPHY, CORRELATION AND SEDIMENTARY HISTORY OF ADELAIDEAN (LATE PROTEROZOIC) BASINS IN AUSTRALIA

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ABSTRACT

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Adelaidean (late Proterozoic) time is represented by the Precambrian portion of the thick sequence in the Adelaide geosyncline (its stratotype basin) in South Australia. Comparable Adelaidean sedimentation, including the deposition of glaciogenic sediments, is recorded in other intracratonic and epicratonic basins extending northwards across Australia.

In the Adelaide geosyncline, which lies to the east of the Gawler craton and its cratonic platform cover (the Stuart shelf), up to 15 km of mainly shallow-water sediments accumulated, partly in intracratonic troughs and perhaps partly on a miogeoclinal continental shelf. The earliest sedimentation is associated with rifting and basic volcanism, with an estimated age of ca. 1100 Ma. It commenced with basal blanket sands, shelf carbonates and basaltic volcanics, followed by mixed carbonate, clastic and evaporitic beds (Callanna Beds). The overlying Burra Group consists of a number of west-derived, possibly deltaic cycles and magnesite-bearing platform carbonates. The unconformably overlying late Adelaidean Umberatana Group contains the lower glacial beds (including the Sturt Tillite), interglacial siltstone (dated at about 750 Ma) and carbonate, and the upper glacial beds. The post-glacial Wilpena Group commences with a distinctive 'cap' dolomite above the upper glacials, and contains mainly fine to medium clastics and the Ediacara metazoan assemblage.

Late Adelaidean sedimentation patterns are sufficiently similar in the Officer, Amadeus, Ngalia and Georgina basins of central Australia, and in the Kimberley Region, Western Australia, to suggest interconnection with the Adelaide geosyncline to the south. In the Amadeus basin, the early Adelaidean sequence is younger than about 1050 Ma, but cannot be directly correlated with the early Adelaidean formations of the Adelaide geosyncline. However, the late Adelaidean glacial and younger sequences are readily correlated; they include the lower glacial Areyonga Formation, and the Arumbera Sandstone I containing elements of the Ediacara assemblage. In the Georgina and Ngalia basins, mainly late Adelaidean sequences, including thick glacials, can mostly be correlated with the Amadeus basin.

In the Kimberley Region, earliest Adelaidean clastics may be represented, but only the late Adelaidean glaciogenic and associated sediments can be correlated with confidence. The tillites commonly overlie glaciated pavements. The lower glacials are represented only in a graben, while the upper glacials and succeeding sequence are more widespread. Post-glacial shales have been dated at ca. 670—640 Ma.

The dominantly carbonate and clastic sequences of the Bangemall basin, Western Australia, cannot be directly correlated with any type Adelaidean, but geochronology suggests an earliest Adelaidean age (ca. 1050 Ma).

In western Tasmania, there are thick, partly metamorphosed sequences of probable Adelaidean age.
Because Australian Adelaidean stromatolites are mostly endemic, biostratigraphic correlations with the U.S.S.R. are limited to comparison of the Bitter Springs Formation (Amadeus basin) assemblage with the Late Riphean, and of the interglacial Umberatana Group assemblage with the Late Riphean to Vendian.

INTRODUCTION

Global stratigraphic subdivision and correlation in the Precambrian is as yet an unattainable goal, because of the lack of a refined biostratigraphic zonation. Currently, a number of different methods of correlation are being used, but there has not been a worldwide consensus on the principles of Precambrian chronostratigraphy.

In Australia, most Precambrian stratigraphers have taken the view that Precambrian time-subdivisions, like those of the Phanerozoic, should be keyed-in to rock sequences and that each should be represented by a stratotype. Such subdivisions are then independent of analytical uncertainties and future refinements. Dunn et al. (1966) proposed a three-fold subdivision of the Proterozoic of Australia.

The Adelaide geosyncline is accepted as the stratotype basin of the Adelaidean, the youngest of these subdivisions, whose age is now estimated at ca. 1100 Ma to the base of the Cambrian. Its sequences are the thickest, and in general provide the most complete record of late Proterozoic sedimentation in Australia. Lithostratigraphic correlation of late Adelaidean (younger than ca. 800 Ma) sequences that contain tillites is now possible for all major Australian basins (Preiss et al., 1978; Coats and Preiss, 1980; Walter, 1981). Early Adelaidean (ca. 1100—800 Ma) sequences are different in the various basins and cannot all be directly correlated.

Nature and age of Adelaidean basins

The Adelaide geosyncline (Fig. 1) is situated to the east of the Gawler craton (established by about 1500 Ma) and its cratonic cover, the Stuart shelf, and is viewed as a complex of partly rift-controlled intracratonic basins grading to a possible miogeoclinal shelf in the southeast. Although thicknesses are very variable, aggregate maximum thicknesses of Adelaidean sediments increase from west to east across the Adelaide geosyncline (e.g. ca. 5—15 km in the southern Flinders Ranges).

In central Australia (see Fig. 1), three east—west-oriented basins (Officer, Amadeus and Ngalia), with broadly similar tectonic histories, have present limits defined by prominent Palaeozoic tectonic trends, and each basin has undergone compressional deformation during the Palaeozoic. During the late Proterozoic, however, they may not have been discrete basins, and palaeogeographic trends were probably at an angle to the superimposed tectonic trends. In the late Adelaidean record, lithological comparisons with the Adelaide geosyncline are so close as to imply interconnection of all these basins through to the Kimberley Region of northern Western Australia. A fourth central Australian basin, the Georgina basin, generally contains relatively thin Adelaidean sequences, but great thicknesses, especially of late Adelaidean glacials, are developed in grabens.

ADELAIDE GEOSYNCLINE

Stratigraphic classification

Mawson and Sprigg (1950) defined the late Proterozoic sequence, with a type area near Adelaide, as the Adelaide System, divided into three 'series': Torrensian (oldest); Sturtian; and Marinoan (youngest). Sprigg (1952) added the pre-Torrensian Willouran 'Series' in northern regions. Subsequent regional mapping by the Geological Survey of South Australia led to the definition of an independent lithostratigraphic subdivision of the Adelaidean rocks (Thomson et al., 1964), based on stratotypes in the Flinders Ranges. The old 'Series' terms are now employed in a chronostratigraphic sense (Table I).

Tectonic setting

The Adelaide geosyncline (Sprigg, 1952) is the depositional basin of the thick Adelaidean and Cambrian sequences that were folded during the Cambro-Ordovician Delamerian orogeny (Thomson, 1969). The Torrens Hinge-Zone (17, Fig. 1) is an approximately meridional zone of transition between the thick sequences of the fold belt and the thinner, less complete and relatively flat-lying sequences of the Stuart shelf to the west. Inliers of pre-Adelaidean metamorphics occur within the fold belt (Fig. 1). During the Delamerian orogeny, a complex, sinuous and branching system of folds was imposed on the sedimentary fill of the Adelaide geosyncline. Zones of differing tectonic style and trend to a large extent parallel earlier sedimentary facies belts.

The central Flinders Ranges (18, Fig. 1) occupy a zone of gently folded thick Adelaidean and Cambrian cover, bounded by marginal faults, and symmetrical between the Stuart shelf and the relatively stable Curnamona cratonic nucleus (19, Fig. 1). Fold arcs to the north and south tend to be asymmetrical, with tectonic trends parallel to depositional facies boundaries. Across the southern arc, for example, the inferred depositional depth of water and the intensity of subsequent folding and metamorphism increase from west to east. Most of the clastic sediment, especially in the Burra and Wilpena Groups, had a westerly provenance. However, the Sturtian and Marinoan glacials had at least a partial easterly source of clasts, the tillites of the Marinoan glacials being mainly confined to the inferred deeper water zones of the fold arcs. Willouran, Sturtian and Marinoan sequences occur in the Barrier Ranges of western New South Wales, in an easterly extension of

TABLE I

Summary of lithostratigraphy*, chronostratigraphy, geochronology and biostratigraphy of the Adelaide geosyncline

Chronostratigraphic subdivisions	Lithostratigraphic subdivisions	Geochronology and biostratigraphy
Early Cambrian	Hawker Group	Abundant shelly faunas
	—Disconformity—	
Late Adelaidean	Wilpena Group	
	Pound Subgroup	Ediacara assemblage of metazoa.
Marinoan	Wonoka Formation	Stromatolite *Tungussia* cf. *julia*
	Brachina Formation	Rb—Sr isochron 676 ±204 Ma (Stuart shelf)
	Umberatana Group	
	Upper glacials	
	Interglacial sequence including carbonates	Stromatolite assemblage suggesting Late Riphean—Vendian boundary
	Tapley Hill Formation	Rb—Sr isochron 750 ±53 Ma (Stuart shelf)
Sturtian	Lower glacials (Upper phase)	
	—Disconformity—	
	Lower glacials (lower phase)	
	—Disconformity/angular unconformity—	
Early Adelaidean	Burra Group	
	Belair Subgroup	
	Mixed carbonates and clastics	
		Stromatolites
Torrensian	Skillogalee Dolomite	*Baicalia burra*
	Rhynie Sandstone	*Tungussia Wilkatanna*
	Callanna Beds	
Willouran	Mixed carbonates, clastics, former evaporites	
	Wooltana Volcanics (geosyncline);	Rb—Sr isochron ca. 800 Ma?
	Beda Volcanics (shelf)	Rb—Sr isochron 1076 ±34 Ma
	Carbonates	Stromatolites *Acaciella*, *Gymnosolen*
	Basal clastics	
		Pre-Burra Group metamorphics Rb—Sr isochron ?849 ±32 Ma

*Only selected formations shown.

the Adelaide geosyncline. There is widespread evidence of intrabasinal syn-depositional tectonism especially in the Sturtian, partly related to basement faulting and partly to diapiric intrusion of Callanna Beds. Coats (1973) presents evidence of phases of diapirism from early Sturtian to the Delamerian orogeny.

Sedimentary history

The sedimentary history of the Adelaide geosyncline has recently been summarised by Preiss et al. (1981). Widespread Willouran volcanics indicate early rifting, followed by the development of shelf-carbonate and deltaic cycles in the Torrensian. Glaciation in the early Sturtian was followed by marine transgression and regression in the late Sturtian, and a second major glaciation in the Marinoan (Table I).

Callanna Beds (Table II)

Deposition in the Adelaide geosyncline began with basal clastics followed by shelf carbonates which are locally stromatolitic. Basic volcanics are known from all areas, including uplifted blocks in central Flinders Ranges diapirs, and from the equivalent Poolamacca Group of the Barrier Ranges (Cooper and Tuckwell, 1971), reflecting a major tensional phase. In the Peake and Dension Ranges and north-west Flinders Ranges very thick sequences of mixed clastics and carbonates, with evaporite pseudomorphs, accumulated under restricted conditions. Similar sequences, though probably thinner, occur in more or less disrupted fashion, in anticlinal cores and diapirs in the central Flinders Ranges.

Callanna Beds are not known from the Adelaide region, where the type Torrensian sediments transgressed directly on to crystalline basement highs.

On the Stuart shelf, the Callanna Beds have possible equivalents in the Beda Volcanics and Backy Point Formation (coarse clastics) (Mason et al., 1978). These rest unconformably on weathered, feldspathic, kaolinitic red sandstone of the Pandurra Formation, which has never been found within the Adelaide geosyncline, and could be either basal Willouran or pre-Adelaidean.

Burra Group (Table III)

The early Sturtian Belair Subgroup is now included in the Burra Group, as is the River Wakefield Subgroup, originally thought to be Willouran. The base of the Burra Group is marked by an influx of relatively immature feldspathic and pebbly sands with abundant heavy mineral lamination (grains are of rutile-bearing hematite) that occur in the Rhynie Sandstone, lower Aldgate Sandstone and Emeroo Quartzite, Humanity Seat Formation and Blue Mine Conglomerate. In the Adelaide area, the Aldgate Sandstone rests unconformably on basement metamorphics, but elsewhere the Burra Group rests either disconformably on Willouran volcanics, or with possible transition on the upper parts of the Callanna Beds. The remainder of the Burra Group is

TABLE II

Stratigraphy of the Callanna Beds, Adelaide geosyncline, and equivalents in New South Wales

Stuart shelf	Peake and Denison Ranges (18)	Central Flinders Ranges (16)	Mount Painter	Barrier Ranges, N.S.W.
Hiatus	Very thick sequences (up to 8 km) of mixed clastics and evaporitic carbonates: carbonaceous silts; immature micaceous sands with halite casts; dolomites and limestones with gypsum casts; cryptalgal laminates; LLH stromatolites.		Hiatus	Hiatus
	- - - -Contacts generally disrupted- - -			
Backy Point Formation and Beda Volcanics (150 m)	Cadlareena Volcanics (750 m) Coominaree Dolomite (80 m) (stromatolites: *Acaciella* f.; *Gymnosolen* f.)	Unnamed volcanics Sequences cannot be identified with certainty	Wooltana Volcanics (2400 m) Wywyana Formation (460 m) marble, amphibolite	Poolamacca Group Wilangee Volcanics (60 m) Boco Formation (30 m) Dolomite with stromatolites: ?*Omachtenia* f.
- -Disconformity- -	Younghusband Conglomerate (30 m)		Paralana Quartzite (1220 m)	Christine Judith Conglomerate (150 m) Lady Don Quartzite (150 m)
?Pandurra Formation				
- -Unconformity- -	- -Unconformity- -		- -Unconformity- -	- -Unconformity- -
Roopena Volcanics (or metamorphic basement)	Peake Metamorphics (basement)	Inferred granitic basement not exposed	Radium Creek Metamorphics (basement)	Wilyama Complex (basement)

Thicknesses are extremely variable; figures give only an approximate indication of maximum thicknesses.

characterized by repeated cycles of silts, sands and carbonates. Typically, such cycles commence with platform carbonates deposited in marginal marine to lagoonal environments (e.g. the organic-rich dolomites, sandy dolomites, siltstones, black cherts, reworked sedimentary magnesite and stromatolites of the Skillogalee Dolomite described by Forbes, 1961; Preiss, 1973a; Uppill, 1979) and pass up into fine clastics (e.g. the siltstones and fine sandy siltstones of the Woolshed Flat Shale), that grade laterally westward into more sandy sequences. The fine clastics are capped by eastward-thinning coarse feldspathic sandstones (e.g. the Undalya Quartzite). These cycles may be interpreted as eastward prograding deltaic complexes. Carbonate sequences similar to the Skillogalee Dolomite also occur in the River Wakefield and in the upper Burra Group.

The Burra Group is not known from the Stuart shelf, nor from the Barrier Ranges of western New South Wales.

Umberatana Group (Table IV)

The Umberatana Group and its equivalents everywhere rest disconformably or unconformably on lower Adelaidean sediments, reflecting widespread early Sturtian tectonism. In the central and south-east Flinders Ranges the oldest tillites (Pualco Tillite) and associated fine clastics and ironstones (Holowilena Ironstone, Benda Siltstone and Braemar Iron Formation facies) occur in structurally-controlled basins, and reflect the first phase of Sturtian glaciation. The second phase is represented by the disconformably overlying basinal sandstone, siltstones (with some dropstones) and minor tillites of the Wilyerpa Formation, which passes southwestwards into equivalents of the well-known Sturt Tillite of the Adelaide region.

Around the Mount Painter Inliers, very thick Sturtian glacial successions occur in a fault-controlled basin. Coats (1973) now considers these glacials (the Yudnamutana Subgroup) to be equivalent to the older phase in the southeastern part of the Adelaide geosyncline, being unconformably overlain by conglomerates related to the younger phase, but this correlation is still in dispute.

The Yancowinna Subgroup of the Barrier Ranges, comprising the Yangalla, Mulcatcha and Waukeroo Formations, and McDougalls Well Conglomerate, includes tillites that represent the Sturtian glaciation, possibly its younger phase (R.P. Coats, personal communication, 1979).

The younger Sturtian tillites are overlain by very thinly laminated siltstones of the Tapley Hill Formation, with thin black shales and flaggy carbonaceous dolomites at the base. These beds reflect a major post-glacial transgression, and are very widespread over all the Adelaide geosyncline and much of the Stuart shelf, and have equivalents in western New South Wales (lower part of Euriowie Subgroup: Cooper and Tuckwell, 1971).

The upper Tapley Hill Formation displays evidence of a decrease in depositional water depth, and an important regression is inferred, culminating in the Brighton Limestone (Preiss, 1973a; Preiss and Kinsman, 1978). The top

TABLE III

Stratigraphy of the Burra Group, Adelaide geosyncline. (There is no record of Burra Group deposition on the Stuart shelf and in the Barrier Ranges, New South Wales)

Adelaide region	Flinders Ranges			
	South-west	South-east	North-west	North-east
		Umberatana Group		
		Regional disconformity or angular unconformity		
		Burra Group		
Belair Subgroup (300 m) Alternating siltstones, feldspathic quartzites		Belair Subgroup (up to 3600 m) Alternating siltstones, feldspathic quartzites	Hiatus	Hiatus
Glen Osmond Slate (450 m) Siltstone		Saddleworth Formation (4000 m) Siltstone		
Beaumont Dolomite (130 m) Carbonaceous dolomite, siltstone	Unnamed dolomitic sandstones	Auburn Dolomite (600 m) Carbonaceous, cherty dolomite, siltstone	Unnamed dolomitic siltstone, dolomite (280 m+)	
		Watervale Sandstone Member		
Stonyfell Quartzite (300 m)		Undalya Quartzite (200—600 m)		
Woolshed Flat Shale (300 m)		Woolshed Flat Shale (300 m)	Myrtle Springs Formation Siltstone, sandstone, minor dolomite	
Montacute Dolomite (120 m) Blue-grey, cherty, with magnesite	Skillogalee Dolomite (upper Member) (380 m) Blue-grey dolomite, black chert, magnesite, dolomitic sandstone. (Stromatolites: *Baicalia burra*)		Skillogalee Dolomite (upper Member) (Maximum thickness 4000 m)	

Castambul Dolomite (350 m)	Skillogalee Dolomite (lower Member)		Skillogalee Dolomite (lower Member)	
Pale dolomite, siltstone	Pale dolomite, siltstone, sandstone, sandy dolomite (stromatolites: *Baicalia burra, Tungussia wilkatanna*)			
Aldgate (300—1000 m)	Emeroo (1370 m)	Bungaree Quartzite (500 m) River Wakefield Subgroup (700 m) Siltstone, sandstone, dolomite	Copley Quartzite (1980 m) Unnamed siltstones, quartzites	Wortupa Quartzite (300 m) Opaminda Formation (380 m) Dolomitic siltstone Blue Mine Conglomerate (460 m) Woodnamoka Phyllite (1370 m) Humanity Seat Formation (2080 m)
Sandstone	Quartzite	Rhynie Sandstone (1200 m)		
- - - - - - - -	- - - - - - - -	Feldspathic sandstones with heavy mineral laminations - - - - -		
—Major unconformity—	- -Disconformity- -	- -?Transition- -	- -?Transition- -	- -Disconformity- -
	Callanna Beds Unnamed volcanics	Callanna Beds Equivalents	Callanna Beds	Callanna Beds Wooltana Volcanics
Metamorphics of Houghton inlier				

Thicknesses are extremely variable; figures give only an approximate indication.

TABLE IV

Stratigraphy of the Umberatana Group, Adelaide geosyncline

South-west	Central Flinders Ranges	South-east	North-east
		Wilpena Group	
		Umberatana Group	
Reynella Siltstone Member (110 m) Granule-bearing red siltstone	Elatina Formation (60 m) Sandstone, minor tillite	Unnamed siltstones Grampus Quartzite (50 m) Pepuarta Tillite (1500 m) Gumbowie Arkose Member (80 m)	Yerelina Subgroup: Balparana Sandstone (215 m) Mount Curtis Tillite (90 m) Fortress Hill Formation (1830 m)
Willochra Subgroup (600 m) Red, grey, green sandstone, siltstone, shale; mudcracks, ripple marks	Trezona Formation (150 m) Stromatolitic and intraclastic limestone		- -Disconformity- - - Enorama Shale (150 m) Green silty shale
	Enorama Shale (360 m)	Enorama Shale (800 m) Green silty shale	Amberoona Formation (1220 m)
Brighton Limestone (0—300 m) Oolitic and stromatolitic limestone	Etina Formation (1000 m) Sandy, oolitic and stromatolitic limestone; siltstone	Tarcowie Siltstone (660 m) Grey siltstone, fine sandy	Grey-green siltstone
		Tapley Hill Formation (1550 m) Very thinly laminated carbonaceous siltstone, calcareous in upper part, basal very thinly laminated black shale, dark grey flaggy dolomite	
Sturt and Appila Tillites (540 m) - -Disconformity- - Hiatus	Wilyerpa Formation (0—850 m) Siltstone, sandstone, minor tillite - -Disconformity- - Holowilena Ironstone (120 m)	Wilyerpa Formation (0—6000 m) Siltstone, sandstone, minor tillite - -Disconformity- - Benda Siltstone Braemar Iron Formation facies (260 m) Pualco Tillite (3300 m) - -Unconformity- -	?Conglomerate (900 m) - -Disconformity- - ?Yudnamutana Subgroup Lyndhurst Formation (1300 m) Bolla Bollana Tillite (1900 m) Fitton Formation (2600 m) - -Unconformity- -
		Burra Group	

Thicknesses are extremely variable; figures give only an approximate indication of maximum thicknesses.

of the Brighton Limestone defines the Sturtian—Marinoan boundary in the type area near Adelaide, but the limestone lenses out towards the east, reflecting the deeper water conditions of the eastern Adelaide geosyncline, where the deposition of drab-coloured silts persisted uninterrupted into the Marinoan.

Along the southwestern margin of the Adelaide geosyncline, and over much of the Stuart shelf, early Marinoan red silts, sands and muds were deposited in marginal marine (e.g. mudflat) environments. In the central Flinders Ranges, the early Marinoan sequences largely comprise platform carbonates, with interbedded silts (e.g. the Etina and Trezona Formations). The Marinoan glaciation is best represented in the southeastern (e.g. Pepuarta Tillite) and northeastern (e.g. Mount Curtis Tillite) regions of the Adelaide geosyncline. The approximate equivalents of these tillites to the west are the sandstones (with local tillite at the top) of the Elatina Formation. The Reynella Siltstone Member (Thomson, 1966a), a poorly sorted gritty red siltstone resembling the matrix of the Elatina Formation tillite, is widespread over the Adelaide and south Flinders Ranges regions. Although it is not a tillite, it does contain rare pebbles that may be of glacial derivation.

In the Barrier Ranges, New South Wales, the Marinoan glaciation is represented by the Teamsters Creek Subgroup, comprising the Nunduro Conglomerate, Dering Siltstone with dropstones, Gairdner's Creek Quartzite and Alberta Conglomerate (Cooper and Tuckwell, 1971).

Wilpena Group (Table V)

The Marinoan glacials and their non-glacial equivalents are generally conformably overlain by the Nuccaleena Formation, which marks the onset of post-glacial transgression. It grades up into the overlying succession, and is regarded as the basal formation of the Wilpena Group, except in the Adelaide region, where the Seacliff Sandstone at the base of the Wilpena Group contains interbeds of similar pink dolomite. The Brachina Formation and overlying ABC Range Quartzite reflect a major transgressive—regressive deltaic cycle, as described by Plummer (1978), who also demonstrated intertonguing of the two formations in the south-west Flinders Ranges. The upper Wilpena Group represents a second major transgressive—regressive cycle, the sediments of which are mainly restricted to the Flinders Ranges; they were either not deposited, or were subsequently eroded off before the Early Cambrian transgression, on the Stuart shelf and in the Adelaide region. Early Cambrian sediments are everywhere disconformable on the Adelaidean, e.g. in the Flinders Ranges on the Pound Subgroup.

In the Barrier Ranges, the Farnell Group (commencing with a laminated dolomite) is at least in part equivalent to the Wilpena Group: it contains siltstones and quartzites, but exact correlation with units of the Wilpena Group is uncertain. The uppermost formation of the Farnell Group (Lintiss Vale Formation) has been correlated by Daily (1974) with the basal Cambrian Uratanna Formation on the basis of trace fossils.

TABLE V

Stratigraphy of the Wilpena Group, Adelaide geosyncline and Stuart shelf

Stuart shelf	Adelaide region	Flinders Ranges
Lower Cambrian		
Andamooka Limestone	Normanville Group	Hawker Group
——— Disconformity ———		
	Wilpena Group	
Hiatus	Hiatus	Pound Subgroup (2400 m) Rawnsley Quartzite (white) Bonney Sandstone (red)
		Wonoka Formation (3360 m) Silty limestone, calcareous siltstone
Yarloo Shale Red shale, siltstone		Bunyeroo Formation (1500 m) Red shale, siltstone
Simmens Quartzite (100 m) White quartzite	ABC Range Quartzite equivalent (460 m) White quartzite	ABC Range Quartzite (150 m) White quartzite with mud-cracks, clay intraclasts
Corraberra Sandstone (75 m) Red sandstone		
Woomera Shale, Tregolana Shale (160 m) Mainly red silty shale	Brachina Formation equivalent (560 m) Red and green siltstone, fine grained sandstone	Brachina Formation (2750 m) Red and green siltstone, fine grained sandstone; grades basinwards into green Ulupa Siltstone
Nuccaleena Formation (0—3 m) Laminated pink dolomite	Seacliff Sandstone (93 m) White to brown sandstone with interbedded pink laminated dolomite	Nuccaleena Formation (0—140 m) Laminated pink to red brown dolomite; purple shale
——— Conformable but relatively sharp contact ———		
	Umberatana Group	

Thicknesses are very variable; figures give only an approximate indication of maximum thicknesses.

Geochronology

Geochronological data on the Adelaidean stratotype, although extremely limited, include equivocal Rb—Sr data on basement metamorphics and early Adelaidean volcanics, and Rb—Sr whole-rock isochrons from sediments and volcanics on the Stuart shelf. Within the Adelaide geosyncline, however, the overprinting effects of the Early Palaeozoic Delamerian orogeny prevent unambiguous interpretation of the data. Where necessary, dates quoted in this paper have been recalculated using the decay constant $\lambda^{87}Rb = 1.42 \times 10^{-11}\ y^{-1}$.

On the Gawler craton, high-grade metamorphism and subsequent extrusion of acid volcanics (Gawler Range Volcanics) had ceased by ca. 1400 Ma ago. Although early work favoured correlation of the possibly 1300 Ma-old Roopena Volcanics on the Stuart shelf with the Willouran Wooltana Volcanics of the geosyncline (Thomson, 1966b), recent studies have revealed a younger suite of basic volcanics, the Beda Volcanics, on the eastern Stuart shelf (Mason et al., 1978), now dated at 1076 ±34 Ma (Webb and Coats, 1980).

The Wooltana Volcanics of the fold belt occur not far above the base of the Adelaidean sequence in the Flinders Ranges. Compston et al. (1966) suggested an age of about 800 Ma for these volcanics, although this estimate is based on very poorly defined isochrons. Mason et al. (1978) now prefer correlation with the Beda Volcanics of the Stuart shelf, but this would suggest that the Wooltana Volcanics have been partially updated by a younger event. Giles and Teale (1979) present geochemical data that support the Beda—Wooltana correlation.

Within the fold belt just east of Adelaide, the Houghton inlier (see Fig. 1) of high-grade metasedimentary rocks has been strongly affected by Palaeozoic retrograde metamorphism. Cooper and Compston (1971) dated some of the freshest metasediments in the inlier at 849 ±32 Ma. The metasediments are unconformably overlain by basal Burra Group (Aldgate Sandstone).

On the Stuart shelf, upper Adelaidean sediments are essentially flat-lying. There the Tapley Hill Formation has been dated at 750 ±53 Ma, and the Willochra Subgroup at 724 ±40 Ma while a less well-defined isochron on the Woomera Shale Member (equivalent to the Brachina Formation) gives an age of 676 ±204 Ma (Thomson, 1980; Webb and Coats, 1980). Despite the large error, these dates are mutually consistent, and show that the sediments have escaped Delamerian overprinting.

The following conditional conclusions may be drawn:

(1) The Sturtian glaciation commenced not long before ca. 750 Ma.

(2) If the dating of ca. 850 Ma on the Houghton inlier really represents the age of a high-grade metamorphism, then the Torrensian at least must be younger than ca. 800—850 Ma, thus leaving only a short span of time for deposition of the Burra Group. On the other hand, the 850 Ma basement age has not been duplicated elsewhere, and awaits confirmation as representing a discrete geological event.

(3) Either the Wooltana Volcanics could be about 800 Ma old (as tentative-

ly accepted by Preiss, 1977), thus postdating the possible young metamorphism of the Houghton inlier basement, or, more probably, they correlate with the Beda Volcanics of the Stuart shelf (ca. 1100 Ma). There is no evidence of Willouran sediments being involved in the Houghton inlier.

Biostratigraphy

Stromatolites of the Adelaide geosyncline have been studied and described (Preiss, 1972, 1973a, b, 1974) and their biostratigraphic application and problems summarised (Preiss, 1977). Most were newly-described forms, not previously known from other regions, although they could be assigned to groups defined by Russian authors. In previous publications, it has been considered that the Russian forms *Linella ukka*, *Inzeria* cf. *I. tjomusi*, *Gymnosolen* cf. *G. ramsayi* and *Conophyton garganicum* occur in the Adelaide geosyncline. Recently, however, Krylov has examined this material and concluded that only *Conophyton garganicum* can be validly assigned to a Russian form (Preiss and Krylov, 1981); the others are all endemic to South Australia, although a close comparison can be made of those from the Umberatana Group with certain as yet unpublished forms from the Late Riphean (1050 ±50—680 ±20 Ma) and Vendian (680 ±20—570 ±20 Ma) of the Patom Region of the U.S.S.R.

Adelaidean stromatolite occurrences may be summarised as follows:

Callanna Beds. Acaciella cf. *A. australica* and *Gymnosolen* f.; *Conophyton garganicum* (Preiss, 1973b).

Burra Group. Baicalia burra, Tungussia wilkatanna (Preiss, 1972, 1974).

Umberatana Group. Acaciella augusta, ?Boxonia melrosa (Preiss, 1972); *Inzeria conjuncta, I. multiplex, Inzeria* f., *Jurusania burrensis, Katavia costata, Kulparia kulparensis* (Preiss, 1973b) *Linella munyallina, Linella* f., *?Omachtenia* f., *Tungussia etina* (Preiss, 1974); *Gymnosolen* f. occurs in boulders in the Tapley Hill Formation (Preiss, 1973b).

Wilpena Group. Tungussia cf. *T. julia* (Walter et al., 1979a). *Linella* f. (W.V. Preiss, unpublished data).

It is now clear that, with the exception of *Conophyton garganicum*, none of the critical early Adelaidean stromatolites is identical to known Russian forms, and that correlations should not be based on group-level identifications alone. Thus, from a biostratigraphic point of view, the age of the base of the Adelaidean remains unresolved. If the Beda Volcanics—Wooltana Volcanics correlation and the Beda age estimate of ca. 1100 Ma are accepted, then the Callanna Beds are, at least in part, Middle Riphean (which would be in agreement with the known time-range of *Conophyton garganicum* in the U.S.S.R., but would require a downward extension in the time ranges of *Acaciella* and *Gymnosolen*).

The Ediacara assemblage (Jenkins and Gehling, 1978) of soft-bodied metazoan fossils is so far known only within a relatively narrow interval in the lower part of the Rawnsley Quartzite. Its biostratigraphic significance was discussed by Glaessner (1971), who listed the known distribution of similar faunas throughout the world. Their age range can be defined only in general terms; they generally overlie the youngest Late Precambrian tillites and appear to be restricted to beds between ca. 700 Ma and the base of the Cambrian in age.

THE AMADEUS BASIN

The late Proterozoic succession of the Amadeus basin (Table VI) has long been recognised, (Madigan, 1932; Wells et al., 1967; Wells et al., 1970; Walter, 1972; Preiss et al., 1978). It can be correlated in part with the Adelaidean of the Adelaide geosyncline on lithostratigraphic grounds, in particular on the basis of late Adelaidean tillites. However, the early Adelaidean successions of the two basins are only broadly similar, and cannot be matched directly on a formation by formation basis. Nor is the age relationship between the bases of the successions known.

The basal Heavitree Quartzite unconformably overlies various granitic and metamorphic basement rocks belonging to the Arunta Complex, along the present northern limit of exposure of the Amadeus basin. At the southern margin, the equivalent Dean Quartzite rests unconformably partly on metamorphic basement of the Musgrave block, and partly on older sediments and volcanics.

The predominantly carbonate Bitter Springs Formation overlies the Heavitree Quartzite conformably along the northern margin of the Basin. A more shaly sequence in the south is referred to the Pinyinna Beds. The lower Gillen Member of the Bitter Springs Formation contains minor stromatolitic dolomite not far above the base, but most of it consists of siltstone, shale and fine-grained dolomite, with local evaporites (Stewart, 1979). Sediments of the Gillen Member are frequently complexly deformed in response to basinward directed thrusts originating in the Arunta Complex to the north. The overlying Loves Creek Member consists of stromatolitic limestone and dolomite (Walter, 1972). Microfossils are abundantly preserved in very early diagenetic black cherts. Red silty dolomite, spilitic volcanics, siltstone and sandstone are minor constituents. The contact with overlying (late Adelaidean) sediments is everywhere a disconformity (cf. the base of the Umberatana Group in South Australia). The Areyonga Formation, of Sturtian age, is characterised by tillite, with associated conglomerate, sandstone, siltstone and dolomite. This unit was originally thought to be very extensive, but Preiss et al. (1978) showed that the more widespread upper arkosic sandstone, formerly included in the Areyonga Formation, lies disconformably on the tillites or on older units. The Areyonga Formation (redefined to exclude the sandstone) is preserved only as erosional remnants along this disconformity; the sandstone was

TABLE VI

Adelaidean stratigraphy of the Amadeus basin

Southern Amadeus basin	Alice Springs area	North-east Amadeus basin
Mount Currie Conglomerate (?Cambrian)	Arumbera Sandstone II (Early Cambrian)	Arumbera Sandstone II
– –Unconformity– –	– –Disconformity– –	– –Disconformity– –
Late Adelaidean	Arumbera Sandstone I Red siltstone, red sandstone Julie Formation Flaggy dolomite, partly oolitic (ca. 10 m)	Arumbera Sandstone I (260 m) Red siltstone, red sandstone Julie Formation (540 m) Grey oolitic and stromatolitic limestone, silty limestone
Winnall Beds (2100 m) Cross-bedded sandstone, siltstone (precise correlation uncertain)	Pertatataka Formation (650 m) Red, green and dark grey siltstone, shale. Quartzite interbed	Pertatataka Formation Red, green and dark grey siltstone, shale Waldo Pedlar Member and Cyclops Member (60 m) Thin-bedded sandstone, siltstone Unnamed pink flaggy dolomite
	Pioneer Sandstone (170 m) Medium to coarse feldspathic sandstone	Olympic Formation (190 m) Red diamictite with numerous glaciated clasts; minor sandstone, sandy dolomite
– – – – – – – –	– – – – – – – -Disconformity-	– – – – – – – – – – – –
Hiatus		Aralka Formation (1000 m) Laminated green and grey siltstone Limbla Member (140 m) Festoon cross-bedded sandstone, sandy limestone Ringwood Member (160 m) Sandy, oolitic and stromatolitic limestone, dolomite

	Lowest beds of Aralka Formation (10 m)	
(Precise correlation uncertain) Inindia Beds (2100 m) Sandstone, siltstone, diamictite, minor oolitic chert	Areyonga Formation (240 m) Grey-green diamictite, conglomerate, sandstone	Areyonga Formation (300 m) Grey-green diamictite, conglomerate, sandstone
-Disconformity-		
Early Adelaidean Pinyinna Beds (210 m) Dolomite, limestone, rare stromatolites, siltstone	Bitter Springs Formation Loves Creek Member (200 m) Grey stromatolitic limestone black chert, dolomite, dolomitic red siltstone	Bitter Springs Formation Loves Creek Member (110 m) Grey stromatolitic limestone, black chert, dolomite, siltstone, spilitic volcanics
	Gillen Member (400 m) Siltstone, grey dolomite	Gillen Member (360 m) Siltstone, grey dolomite, gypsum
Dean Quartzite (1170 m) Quartzite, conglomeratic quartzite	Heavitree Quartzite (300 m) Quartzite, pebbly sandstone, siltstone	Heavitree Quartzite (300 m) Quartzite, pebbly sandstone, siltstone
- -Conformable to unconformable contact- -	- -Major unconformity- -	- -Major unconformity- -
Dixon Range Beds, Bloods Range Beds	Arunta Complex	Arunta Complex

Thicknesses give an indication of approximate maxima only.

defined as a new formation (Pioneer Sandstone), and was regarded as a possible non-glacial equivalent of the upper (Marinoan) tillites. In the extreme east of the Amadeus basin, the most complete section of rocks equivalent to the Umberatana Group is preserved above the Areyonga Formation. The Aralka Formation is a sequence of thinly-laminated grey to green siltstones closely comparable with the Tapley Hill and Amberoona Formations of South Australia. Although included by Walter and Wells (in Preiss et al., 1978) in the Areyonga Formation, thinly laminated carbonaceous dolomites and shales (cf. at the base of the Tapley Hill Formation in South Australia) overlie the tillites with a sharp contact and grade into the overlying siltstones, and are better included in the Aralka Formation, marking the beginning of the post-glacial transgression. The middle and upper parts of the Aralka Formation contain many of the facies represented in the Umberatana Group of South Australia, e.g. the Ringwood Member consists of sandy, oolitic and stromatolitic limestones indistinguishable from the Etina Formation; the Limbla Member contains gritty limestones (cf. Etina Formation) and festoon cross-bedded sandstones, similar to sandstone interbeds in the upper parts of the Willochra Subgroup. In these eastern sections, the Olympic Formation represents the Marinoan glaciation; it contains tillite with abundant glaciated clasts and a red silty matrix, minor sandstone, conglomerate, siltstone and sandy dolomite. It is probably disconformable on the Aralka Formation (Wells, 1969).

Upper Marinoan sequences of the Amadeus basin are also closely comparable to those of the Adelaide geosyncline. A thinly laminated pink to buff dolomite, analogous to the Nuccaleena Formation, caps the Olympic Formation tillites, and was included by Walter and Wells (in Preiss et al., 1978) in that formation. The overlying Pertatataka Formation is dominantly siltstone and shale with fine grained sandstone interbeds. In the western Amadeus basin, the Pertatataka Formation overlies the Pioneer Sandstone conformably, and contains a thin, lenticular orthoquartzite with clay intraclasts near the middle of the section, which may represent a similar regressive phase to that of the ABC Range Quartzite. The Pertatataka Formation thus correlates best with the Brachina Formation to Bunyeroo Formation of the Adelaide geosyncline. In the eastern part of the Amadeus basin, the Cyclops Member (thin-bedded platy sandstone) and the Waldo Pedlar Member (siltstone, thin-bedded sandstone and minor quartzite) may reflect similar regressive phases. The Julie Formation gradationally overlies the Pertatataka Formation and consists of oolitic limestone and dolomite and minor silty limestone. Stromatolites are locally present in the eastern sections where the formation is thicker (Walter et al., 1979). The Julie Formation has a similar stratigraphic position to the Wonoka Formation but although there are lithological similarities the Julie Formation contains more limestone with obvious shallow water features.

The lower part of the Arumbera Sandstone is the youngest Precambrian unit in the Amadeus basin. The Arumbera Sandstone, which conformably overlies the Julie Formation, has been divided into three members (Daily, 1972), the upper two of which contain probably Early Cambrian trace fossils and disconformably overlie the lower member. This disconformity may reflect the Peterman Ranges orogeny recorded in the south-west Amadeus basin. The lower member may be a partial correlative of the Pound Subgroup; it is of similar facies to the Bonney Sandstone.

Geochronology

The sedimentary sequence in the Amadeus basin is younger than the most recent metamorphic event in the Arunta block, dated at 1053 ±50 Ma (Marjoribanks and Black, 1974). An earlier estimate of an 'apparent maximum age' of the Bitter Springs Formation of 1145 Ma (quoted by Wells et al., 1967) was based on a single sample and an assumed initial $^{87}Sr/^{86}Sr$ ratio and is thus clearly too old. The age of the Bitter Springs Formation must lie between 1050 Ma and 700—800 Ma (approximate age of the Sturtian glacials); this age range is consistent with Walter's (1972) correlation with the Late Riphean 1050 ±50 Ma—680 ±20 Ma) of the U.S.S.R.

The Winnall Beds and Pertatataka Formation yielded a Rb/Sr isochron age of 715 ±45 Ma, but the significance of this date is uncertain, since the rocks contain a large proportion of detrital minerals (e.g. 'subgreywackes') and the samples span almost the whole thickness of the formation (Walter, 1972). Such a date is a little older than ages obtained from presumed equivalents on the Stuart shelf and the Kimberley Region (see below).

Biostratigraphy

Stromatolites from the Amadeus basin have been described by Walter (1972). The Bitter Springs Formation contains an assemblage that has no groups in common with the Burra Group of South Australia. The stromatolites are mainly new forms of groups known from the Late Riphean of the U.S.S.R.: *Inzeria intia*, *Boxonia pertaknurra*, *Minjaria pontifera*, *Jurusania nisvensis*, *Kotuikania juvensis*, *Tungussia erecta*. Also present are new groups (*Acaciella australica*, *Kulparia alicia*, *Basisphaera irregularis*) and *?Linella avis* (previously known from the Vendian of the U.S.S.R.). Walter (1972) interpreted this as a typical Late Riphean assemblage, and assigned a Late Riphean age to the Bitter Springs Formation.

The Boord Formation (a probable western equivalent of the Areyonga Formation) contains a distinctive but completely new stromatolite, *Tesca stewartii* (Walter et al., 1979a).

The Ringwood Member and the Julie Formation both contain new forms of the long-ranging stromatolite group *Tungussia* (*T. inna* and *T. julia*, respectively) (Walter, 1972; Walter et al., 1979a).

The Arumbera Sandstone I contains *Rangea*, an element of the Ediacara metazoan assemblage (Daily, 1972), supporting correlation with the Pound

Subgroup, and *Arumberia banksi*, provisionally regarded as a coelenterate (Glaessner and Walter, 1975).

NGALIA BASIN

The Ngalia basin is tectonically similar to the Amadeus basin, and is situated to the north of it. It contains a less complete record of Adelaidean sedimentation (Table VII), principally because of more marked hiatuses and disconformities.

The basal Vaughan Springs Quartzite, which unconformably overlies the basement of the Arunta Complex, is closely comparable to the Heavitree Quartzite, and correlation of these units is widely accepted. Indeed, outcrops of quartzite, tightly infolded into the basement, are almost continuous be-

TABLE VII

Adelaidean stratigraphy of the Ngalia basin

Early Cambrian	Yuendumu Sandstone II	Red-brown sandstone
– – – – – – – – Disconformity – – – – – – – –		
Late Adelaidean	Yuendumu Sandstone I (200 m) Red-brown sandstone, basal arkose	
—Unconformable relationship over Vaughan Springs Quartzite— – – – – –		
	Hiatus Unnamed red shale Unnamed pink-buff laminated dolomite Mount Doreen Formation (240 m) Diamictite, pebbly sandstone, conglomerate	
– – – – – – – – Disconformity – – – – – – – –		
	Rinkabeena Shale (100 m) Green silty shale, unnamed black shale, laminated grey dolomite Naburula Formation (2 m) Diamictite	
—Non-conformable relationship on basement of Arunta Complex— – – – – –		
Early Adelaidean	Unnamed dolomite, black shale, chert Vaughan Springs Quartzite (1650 m) Quartzite, pebbly sandstone Treuer Member Thin bedded glauconitic sandstone, siltstone	
– – – – – – – – -Major nonconformity- – – – – – – –		
Pre-Adelaidean	Arunta Complex	

Note that not all of these units are exposed in any single section.

tween the two basins. The Vaughan Springs Quartzite is mostly a well sorted pink quartzite, with siltstones and fine, glauconitic sandstones of the Treuer Member in the lower part. Wells (1978) reported "foetid stromatolitic dolomite, in places with black chert and shale" a possible equivalent of the Bitter Springs Formation of the Amadeus basin.

Along the northwestern margin of the Ngalia basin, local remnants of upper Adelaidean sediments are preserved beneath the more widespread Palaeozoic sequences. A very thin diamictite (ca. 2 m) with a greenish silty matrix (the Naburula Formation) unconformably overlies the granitic basement and represents the Sturtian glacials; this is overlain by thinly laminated silty shales with grey dolomite interbeds similar to those above the Areyonga Formation in the Amadeus basin and above the Sturtian tillites in South Australia (Preiss et al., 1978). The overlying green Rinkabeena Shale correlates, in part, with the Aralka Formation. It is followed, with erosional contact, by tillites of Marinoan age — the Mount Doreen Formation (Wells, 1972), with large glaciated erratics set in a greenish silty matrix, pebbly sandstone and conglomerate. A laminated pink-buff dolomite, locally stromatolitic, and similar to the 'cap dolomite' overlying tillite of the Olympic Formation, caps the glaciogenic sequence, and grades up into red shales. The whole Adelaidean succession is truncated by Ordovician sandstones in this section.

Elsewhere, the latest Precambrian—Early Cambrian Yuendumu Sandstone unconformably overlies the older sequences. It is a red-brown detrital sequence equivalent to the Arumbera Sandstone of the Amadeus basin. Like the Arumbera Sandstone, it contains trace fossils in its upper part, and has been divided into three members. Burek et al. (1979) found an unconformity separating the lower member from the upper part with trace fossils, and correlated the lower member with the Precambrian Arumbera Sandstone I. Magnetostratigraphic (polarity) data given by them are consistent with this correlation, though not conclusive.

Geochronology

Cooper et al. (1971) dated glauconite from the Treuer Member of the Vaughan Springs Quartzite by both K—Ar and Rb—Sr isochron techniques. K—Ar dating of five samples gave ages in the range of ca. 1000—1200 Ma, while the Rb—Sr isochron (obtained by joining only two points, as the others lie off the line) gave an estimated minimum age of 1253 Ma. These dates are all older than the youngest basement metamorphism at 1053 ±50 Ma occurring between the Amadeus and Ngalia basins (Marjoribanks and Black, 1974). The basal quartzites of the two basins can be confidently correlated. These old glauconite ages are therefore of uncertain significance.

OFFICER BASIN

The Officer basin is a third area of late Proterozoic to mid-Paleozoic sedimentation in central Australia. Like the Amadeus and Ngalia basins to the north, its present area of outcrop is oriented east—west, and its northern margin is at least partly determined by Palaeozoic tectonics. The Adelaidean portion of the Officer basin succession (Table VIII) shows close links with the Adelaide geosyncline. The Musgrave block of high-grade metamorphic basement rocks now separates the Amadeus from the Officer basin. Although

TABLE VIII

Adelaidean stratigraphy of the Officer basin

Early Cambrian	Observatory Hill Beds
---------- Disconformity to angular unconformity ----------	
Late Adelaidean	Punkerri Beds (1200 m) Red and white sandstone, metazoan fossils of Ediacara assemblage
---------- No stratigraphic relationship seen ----------	
	Hiatus Unnamed siltstone, fine sandstone, minor tillite (600 m) Rodda Beds (1200 m) Siltstone, limestone, dolomite, calcareous sandstone Tapley Hill Formation (700 m) Laminated siltstone. Basal ferruginous feldspathic quartzite, conglomerate at base
---------- Disconformity ----------	
	Wantapella Volcanics (290 m) Vesicular basalt Chambers Bluff Tillite (520 m) Diamictite, gritty siltstone, quartzite, ironstone
---------- Disconformity ----------	
	Belair Subgroup equivalents (1000 m) Siltstone, shale, quartzite
Non-conformable relationship on basement of Musgrave block	
Early Adelaidean	Wright Hill Beds (3400 m) Oolitic chert, quartzite, sandstone, siltstone (Ilma Beds of Western Australian portion of Officer basin may be equivalents and contain stromatolite *Baicalia* cf. *B. burra.*)
---------- No stratigraphic relationship seen ----------	
	Pindyin Beds (430 m) Sandstone, quartzite, conglomerate, shale, chert, dolomite (Townsend Quartzite of Western Australian portion of Officer basin probable equivalent)
---- Major nonconformity or unconformity on Musgrave-block basement ----	
	(Townsend quartzite unconformable on ?earliest Adelaidean volcanics)

Not all of these units are found in any single section.

the age of the basement has been variously interpreted, early Adelaidean clastic—carbonate sequences (the Pindyin Beds and Wright Hill Beds) are known to be younger than 1100 Ma granitic intrusives (Major, 1973a, b). However, at the western end of the Musgrave block, a largely volcanic complex (the Bentley Supergroup of Daniels, 1974) overlies the metamorphic basement and has been dated at 1037 ±140 Ma (Compston and Nesbitt, 1967). These are unconformably overlain by the Townsend Quartzite, which is generally correlated with the Pindyin Beds to the east. These sequences are tentatively correlated with parts of the Burra Group. In the Western Australian part of the Officer basin, there are isolated outcrops of carbonate rocks that may be partial equivalents of these early Adelaidean sequences, e.g. the Ilma Beds and dolomites at the central Neale area (14, 15, Fig. 1) contain stromatolitic dolomites with *Baicalia* cf. *B. burra* (Preiss, 1976), suggesting comparison with the Burra Group of South Australia. The Woolnough Hills diapir (12, Fig. 1) apparently intrudes a sequence of dolomites containing *Acaciella* f. indet. (Preiss, 1976) and microfossiliferous cherts comparable with those of the Bitter Springs Formation have been found in the Madley diapirs (13, Fig. 1) by M.R. Water (personal communication, 1978).

At the eastern end of the Officer basin, Krieg (1973) recorded a sequence of siltstones with interbedded white quartzites, resting unconformably on the Musgrave block basement. These were tentatively correlated with the earliest Sturtian Belair Subgroup, and are unconformably overlain by the Chambers Bluff Tillite (see Table VIII), a unit of greenish pebbly siltstones and shales with glaciated clasts and with feldspathic quartzite interbeds, associated with sedimentary ironstones. It may represent the earlier of the two Sturtian glacial phases (Coats, 1981). The Wantapella Volcanics conformably overlie the Chambers Bluff Tillite and are the only volcanics known to be associated with Sturtian tillites. Equivalents of the remainder of the Umberatana Group (Tapley Hill Formation and Rodda Beds) disconformably overlie the volcanics. A second tillite unconformably overlying this sequence probably represents the Marinoan glaciation (R.B. Major, personal communication in Krieg, 1973; Coats, 1981). In the western Officer basin, the Punkerri Beds are a lithostratigraphic equivalent of the Pound Subgroup, and also contain elements of the Ediacara metazoan assemblage (Major, 1974). The whole Adelaidean sequence in the north-east Officer basin was folded prior to the deposition of the succeeding Early to mid-Palaeozoic clastic sequences.

Geochronology

Six shale samples from the Chambers Bluff Tillite yielded a Rb—Sr whole-rock isochron of 651 ±87 Ma (Webb, 1978). This is younger than the expected age of sedimentation, but may reflect the folding that produced the angular unconformity between Adelaidean and Palaeozoic rocks in the area.

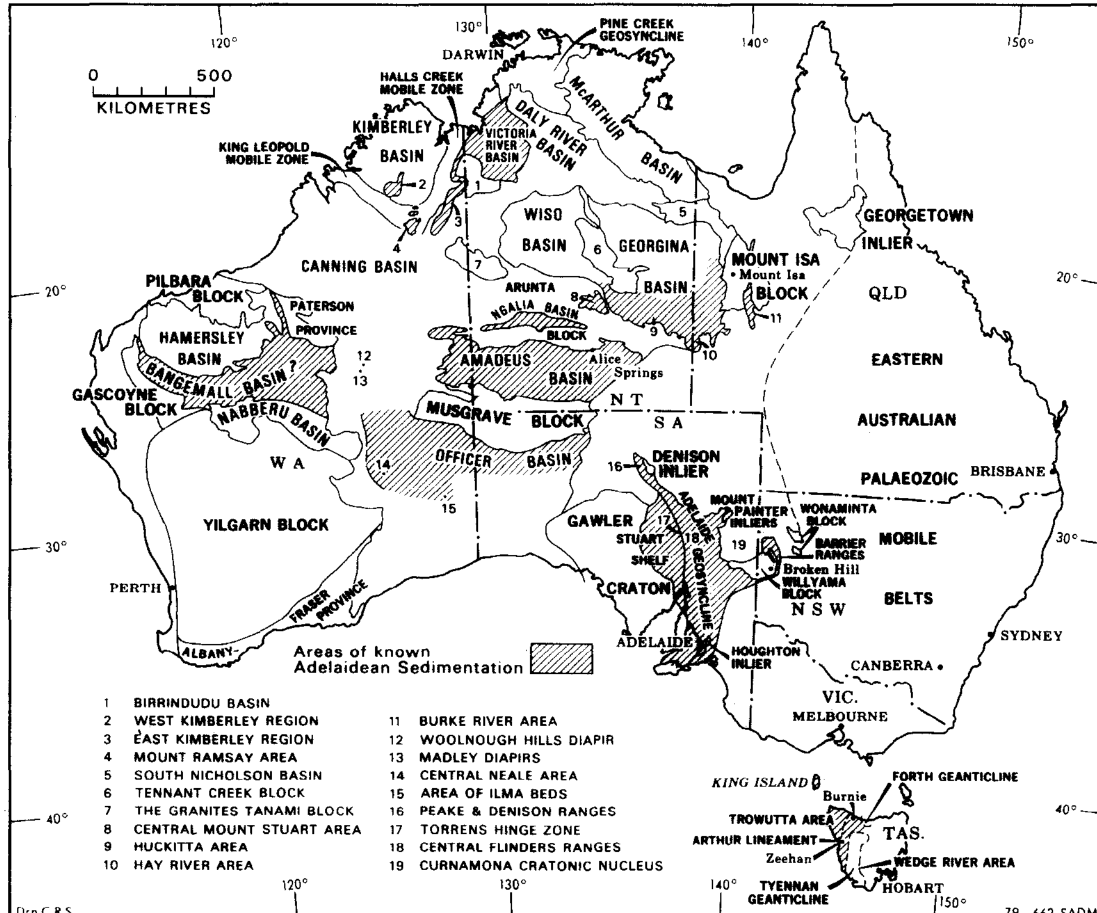


Fig. 1. Location of major Precambrian sedimentary basins, basement blocks and provinces in Australia, showing those basins that received Adelaidean sedimentation.

BANGEMALL BASIN

Although predating the bulk of the Adelaidean, deposition occurred also to the west of the Musgrave block in the important Bangemall basin. The Bangemall Group unconformably overlies folded early Proterozoic sequences, and forms an east—west oriented arcuate outcrop area; it shows important facies changes (Brakel and Muhling, 1976). The sequence in the western zone consists predominantly of dolomite, shale and chert, overlying basal coarse sandstone, in the lower part, and passes upwards into siltstones, shales, black cherts and fine sandstones with an intercalation of turbidites introduced from the north-west. There are local minor acid volcanic contributions. The basal sequence in the northern zone is dominantly dolomitic, but with a local wedge of arkose and conglomerate. The eastern zone contains basal terrestrial coarse clastics, passing up into finer clastics.

Geochronology

Gee et al. (1976) dated small rhyolite bodies not far above the base of the Bangemall Group in the central part of the basin at 1075 ±42 Ma (Rb—Sr whole-rock isochron) while black shales from higher in the sequence yielded an age of 1057 ±80 Ma by the same method (Compston and Arriens, 1968). These dates suggest a correlation with the Bentley Supergroup acid volcanics of the western Musgrave block, and also approximate contemporaneity with the Beda Volcanics of the Stuart shelf.

Biostratigraphy

The Bangemall Group contains numerous stromatolites, of which *Baicalia capricornia* and *Conophyton garganicum australe*, although not identical to any Russian forms, are most closely comparable to those of Middle Riphean (1350 ±50 Ma to 1050 ±50 Ma) assemblages (Walter, 1972). The occurrence of *Acaciella* cf. *A. australica* in the Bangemall Group (Grey, 1978) is thus older than the type occurrences in the Bitter Springs Formation; it may however be of similar age to *Acaciella* cf. *A. australica* from an early Willouran dolomite of the Peake and Denison Ranges, South Australia.

GEORGINA BASIN

Late Proterozoic sequences in the southwestern Georgina basin were originally referred to the Field River Beds and the Mopunga Group. In the Huckitta area (9, Fig. 1), the Arunta Complex basement is unconformably overlain by the Mount Cornish Formation, locally a very thick sequence of

TABLE IX

Adelaidean stratigraphy of the southern Georgina basin

	Huckitta area*	Hay River area**
Early Cambrian	Mount Baldwin Formation Red sandstone, siltstone	Adam Shale Green pyritic shale
	——Disconformity——	
Late Adelaidean	Mopunga Group Elkera Formation (220 m) Siltstone, dolomite, sandstone, shale (stromatolite *Georginia howchini*)	Hiatus
	Grant Bluff Formation (160 m) Thin bedded sandstone, siltstone Elyuah Formation (130 m) Green and red shale, basal pebbly arkose	Mopunga Group Grant Bluff Formation (210 m) Thin bedded sandstone, siltstone Gnallan-a-Gea Arkose (1450 m) Coarse arkose
	——Disconformity——	
	Keepera Group Oorabra Arkose (25 m)	Keepera Group Wonnadinna Dolomite (460 m) Black Stump Arkose (700 m)
	——Disconformity——	
	Mount Cornish Formation (380 m) Diamictite, varve-like siltstone	Unnamed dolomite, shale Yardida Tillite (2900 m) Diamictite, varve-like siltstone
	——Disconformity——	
Early Adelaidean	Yackah Beds (26 m) Feldspathic grit, dolomite	Yackah Beds (240 m) Feldspathic sandstone, shale, dolomite (stromatolite *Acaciella australica*)
	——Major nonconformity——	
Pre-Adelaidean	Arunta Complex	Arunta Complex

* See 9, Fig. 1.
**See 10, Fig. 1.

green silty diamictite and green varve-like siltstone. The basal 26 m of the originally-defined type section are lithologically distinct from the remainder of the sequence (Table IX) and have now been assigned to the early Adelaidean Yackah Beds (Walter, 1981). Elsewhere in the Huckitta area, thinner glacial sequences of the Mount Cornish Formation are overlain disconformably by the coarse-grained Oorabra Arkose and succeeding Mopunga Group. Walter's (1972) record of the stromatolite *Georginia howchini* from the Mount Baldwin Formation is now placed in a dolomite in the Elkera Formation, which Walter (1981) correlates with the Julie Formation of the Amadeus basin. The Mount Baldwin Formation is now considered to be entirely Cambrian.

In the Hay River area (10, Fig. 1), all the Adelaidean rocks were formerly assigned to the Field River Beds. A new subdivision is proposed by Walter (1981). The early Adelaidean is represented by the Yackah Beds, with the stromatolite *Acaciella australica*, suggesting possible correlation with the Bitter Springs Formation of the Amadeus basin (Walter et al., 1979a). The late Adelaidean succession commences with the disconformably overlying Yardida Tillite, which is lithologically similar to the Mount Cornish Formation and also attains great thicknesses in grabens. The succeeding formations are assigned to the Keepera Group (Walter, 1981): the Black Stump Arkose correlates in lithology and stratigraphic position with the Oorabra Arkose, and by analogy with the Pioneer Sandstone of the Amadeus basin, it is considered a possible facies variant of the Marinoan tillites. The overlying Wonnadinna Dolomite is considered by Walter (1981) as equivalent to the 'cap dolomites' above Marinoan glacials elsewhere, but it is much thicker and is lithologically dissimilar. The disconformably overlying Gnallan-a-Gea Arkose appears to have no lithological equivalent elsewhere, but Walter (1981) suggests that it may correlate approximately with the Waldo Pedlar Member of the eastern Amadeus basin. The thinly bedded sandstone, locally with interbedded siltstone, of the Grant Bluff Formation (type section on the Huckitta map sheet area) was originally considered as Early Cambrian, but Burek et al. (1979) have argued from litho- and magnetostratigraphy that it and its underlying formations are older than this. It is now considered equivalent to the lithologically very similar Cyclops Member of the Amadeus basin, and a significant time break is inferred before the deposition of the Adam Shale, from which Walter et al. (1979b) have described poorly preserved acritarchs that may be Early Cambrian.

At Central Mount Stuart (8, Fig. 1), and in its vicinity, diamictite unconformably overlies the Arunta Complex. Preiss et al. (1978) noted lithological similarities with the older of the Sturtian glacials in South Australia. At Central Mount Stuart, where it occurs at the base of the Central Mount Stuart Formation, the diamictite passes up without obvious unconformity into a thick clastic sequence, equivalents of which contain a late Precambrian coelenterate fauna near the top (Wade, 1969; Walter, 1981). If the glacials are indeed earliest Sturtian, this would imply a major hiatus within the Central Mount Stuart Formation but this is far from certain. Parts of the formation resemble the Cyclops and Waldo Pedlar Members of the Pertatataka Formation of the Amadeus basin. Walter (1981) correlates the upper part with the Arumbera Sandstone I, on lithologic and biostratigraphic grounds.

De Keyser (1972) described an isolated down-faulted wedge of Late Proterozoic sediments, lying unconformably over metamorphic basement and dipping under fossiliferous Middle Cambrian strata, in the Burke River area

(11, Fig. 1). This sequence, the Mount Birnie Beds, commences with a tillite, containing rounded to sub-rounded facetted and polished clasts in a purple to brown silty matrix (the Little Burke Tillite). As pointed out by de Keyser (1972) the Mount Birnie Beds are closely comparable to the Moonlight Valley Tillite and overlying sequence of the East Kimberley Region (see below). The Tillite is overlain by a typical pink to cream 'cap dolomite', followed by red ferruginous sandstone, then red and green shale, with thinly bedded red micaceous quartz sandstone, sandy siltstone, shaly sandstone with rare dolomite lenses at the top. On lithologic/stratigraphic grounds, it is most likely to be a Marinoan glacial and post-glacial sequence.

Geochronology

Shales from unspecified levels in the Field River Beds have yielded Rb—Sr whole-rock isochron ages of ca. 770 and 600 Ma (Compston and Arriens, 1968).

KIMBERLEY REGION, WESTERN AUSTRALIA

The geology of the Kimberley Region has recently been summarised by Plumb and Gemuts (1976). Thick platform cover sequences overlie an 1800 Ma-old basement. The youngest of these are of Adelaidean age (Table X), and include well-documented tillites, (e.g. Dow, 1965). The radiometric ages of possible early Adelaidean sequences in the Kimberley Region are not yet well defined, nor can they be confidently correlated with those of other basins.

In the East Kimberleys (3, Fig. 1), east of the basement inlier exposed in the Halls Creek Mobile Zone, clean quartz sandstone (Wade Creek Sandstone) unconformably overlaps sediments of probable mid-Proterozoic age and passes upwards into laminated green Helicopter Siltstone. Compston and Arriens (1968) quote an age of 1106 ±110 Ma for the Mount John Shale Member of the Wade Creek Sandstone.

In places within the Halls Creek Mobile Zone, the Glidden Group (black shale, micaceous sandstone, well-sorted quartz sandstone, shale and subgreywacke) unconformably overlies the early Proterozoic basement; a shale from the Glidden Group has been dated at 1008 ±25 Ma. In the northern part of the Halls Creek Mobile Zone, the Carr Boyd Group of grossly similar lithologies has been dated by shale whole-rock isochrons from three successive horizons: 1160 ±125 Ma, 1057 ±80 Ma and 881 ±85 Ma (Compston and Arriens, 1968). Thus, these three areas of the Kimberley Region received clastic sediments between 800 and 1200 Ma ago, and the sequences are in part at least of early Adelaidean age, and in part older. To the east of the Kimberleys lies the pre-Adelaidean Birrindudu basin (1, Fig. 1), unconformably overlain by a number of mutually unconformable sequences, all of which underlie the eastern extension of the late Adelaidean Duerdin Group; Sweet

TABLE X

Adelaidean stratigraphy of the Kimberley Region

West Kimberley	Mount Ramsay area	East Kimberley
Early Cambrian	Lally conglomerate and Antrim Plateau Volcanics	
— — — — — — —	Angular unconformity	— — — — — — —
Late Adelaidean		Albert Edward Group Flat Rock Formation (300 m) Shale, dolomitic sandstone, conglomerate Nyuless Sandstone (40 m)
	Louisa Downs Group	Timperley Shale (1250 m) Boonall Dolomite (30 m)
Mount House Group	Lubbock Formation (1800 m) Sandstone, siltstone	Elvire Formation (100 m) Maroon shale, siltstone 639 ±47 Ma
Estaughs Formation (80 m) Orthoquartzite overlying purple sandstone, siltstone	Tean Formation (120 m) Orthoquartzite, conglomerate	Mount Forster Sandstone (100 m) Orthoquartzite, conglomerate - -Disconformity- -
		Duerdin Group
Throssell Shale (150 m) Micaceous siltstone, shale	McAlly Shale (1500 m) Micaceous siltstone, shale	Ranford Formation (560 m) Micaceous siltstone, fine sandstone
670 ±84 Ma		Johnny Cake Shale Member 672 ±72 Ma
Traine Formation (50 m) Sandstone	Yurabi Formation (210 m) Sandstone	Jarrad Sandstone Member
Unnamed dolomite	Unnamed dolomite	Unnamed dolomite
Walsh Tillite (60 m)	Egan Formation (190 m) Diamictite, shale sandstone, dolomite	Moonlight Valley Tillite (0—140 m)
- -Major disconformity- -		- -Disconformity- -
	- -Disconformity- -	Frank River Sandstone (230 m) Fargoo Tillite (0—200 m) - -Unconformity- -
	Kuniandi Group Mount Bertram Sandstone (180 m) Wirara Formation (480 m) Stein Formation (0—210 m) Landrigan Tillite (20—330 m)	
— — — — — — —	- -Major disconformity-	— — — — — — —
?Early Adelaidean		Helicopter Siltstone (160 m) Wade Creek Sandstone Mount John Shale Member 1106 ±110 Ma - -Unconformity- -

(1977) considered these sequences, deposited in the Victoria River Basin, to be Adelaidean also. The lowest of them, the Wattie and Bullita Groups (consisting of sandstone, siltstone, shale, dolomite and chert) are probably equivalents of the Tolmer Group that outcrops south of Darwin (Sweet, 1977). Cloud and Semikhatov (1969) described the stromatolite *Inzeria tjomusi* from the Tolmer Group, and indicated that the then accepted age estimate of the Tolmer Group (600—700 Ma) was consistent with the known age range of that form of stromatolite (Late Riphean, 1050—680 Ma). However, on the basis of Sweet's (1977) correlation, the Tolmer Group may be older than this, for its equivalent the Bullita Group is unconformably overlain by the Wondoan Hills Formation, from which glauconite has yielded a K—Ar minimum age of 1080 ±14 Ma and a Rb—Sr isochron age of 1165 ±30 Ma. The Wondoan Hill Formation and overlying Stubb Hill Formation (both consisting of sandstone, siltstone, shale and minor dolomite) are followed unconformably by the Auvergne Group of the Victoria River basin. Sweet (1977) correlated the Angalarri Siltstone of the Auvergne Group with the Helicopter Siltstones of the East Kimberleys, but quotes a Rb—Sr whole rock isochron age of 820 ±80 Ma. If this is the age of deposition, it would imply a long time-break between the Angalarri Siltstone and the 1100 Ma-old Wade Creek Sandstone in the East Kimberleys.

Late Adelaidean glaciogenic sequences are widespread in the Kimberley Region, commonly being associated with glaciated pavements (Harms, 1959; Dow and Gemuts, 1969). Use of the tillites as stratigraphic markers has been widely accepted. Separate stratigraphic nomenclature has been developed in the three major areas of outcrop of glaciogenic sequences, i.e. the East Kimberleys, the Mount Ramsay area, and the West Kimberleys (Table X). Only in the Mount Ramsay area are there lower and upper glacials together in the same sections. Dow and Gemuts (1969) tentatively correlated the glacials of the East Kimberleys (Moonlight Valley and Fargoo Tillites) with the first glacials of the Mount Ramsay area (Landrigan Tillite), while Plumb and Gemuts (1976) added correlation with the Walsh Tillite of the West Kimberleys. Dunn et al. (1971) considered these earlier tillites to be of Sturtian age, and the younger tillites of the Egan Formation (Mount Ramsay area only) to be Marinoan. Coats and Preiss (1980) reexamined these sections and suggested more precise correlations (Table X). The glaciations in the Kimberleys should be named after tillites that occur together in the same stratigraphic sections, i.e. Landrigan and Egan glaciations, and the revised correlations imply that only the Landrigan Tillite is of Sturtian age, while the more widespread tillites (Moonlight Valley and Fargoo Tillites of the East Kimberleys, Egan Formation of the Mount Ramsay area and Walsh Tillite of the West Kimberleys) are all of Marinoan age. These correlations are based on specific lithological comparisons of sequentially consistent successions, both within the three areas of the Kimberleys, and with other late Proterozoic basins in Australia. Continuity of sedimentation in shallow shelf seas across a large part of the Australian continent is implied.

In the Mount Ramsay area, the late Adelaidean comprises a relatively thick sequence of diamictites with interbedded sandstone and laminated siltstone (the Landrigan Tillite) accumulated in a graben, while the thickness of its equivalent outside the graben is greatly reduced. Greywacke of the Stein Formation occurs above the Landrigan Tillite only within the graben, and is followed by thinly laminated siltstones of the Wirara Formation. Outside the graben, the base of the Wirara Formation is marked by a lenticular brown-weathering dolomite and thinly laminated silty shale. The Wirara Formation resembles the Tapley Hill Formation of the Adelaide geosyncline, but is dominantly mauve coloured. It grades up into the cross-bedded Mount Bertram Sandstone. The Wirara Formation and Mount Bertram Sandstone represent the late Sturtian—early Marinoan interglacial phase.

Marinoan glaciation is represented in the West Kimberleys by the Walsh Tillite, in the Mount Ramsay area by the Egan Formation, and in the East Kimberleys by the Fargoo Tillite and overlying Moonlight Valley Tillite (best regarded as representing two phases of Marinoan glaciation). These tillites are all characterised by a predominantly red, silty, argillaceous or dolomitic matrix, and become shaly and sparsely pebbly in their upper parts. They are overlain by well-laminated pink dolomites, with interbedded red shale, that are similar to the 'cap dolomites' of the other basins. The overlying sequences in the three areas reflect transgression and then regression: they commence with red-brown to grey-green medium grained sandstone with grit bands, ripple marks, water-escape structures and minor flute casts (Jarrad Sandstone Member and equivalents, Table X).

These pass up into finer clastics similar to the Brachina Formation of the Adelaide geosyncline and Pertatataka Formation of the Amadeus basin (Ranford Formation and equivalents, Table X). Regression is marked by the influx of coarse clastics above these formations, in particular the very mature orthoquartzites and quartz-pebble conglomerates of the Mount Forster Sandstone (East Kimberleys) and Tean Formation (Mount Ramsay area). In the West Kimberleys, it is represented by the orthoquartzite in the upper part of the Estaughs Formation. These all correspond in lithology and stratigraphic position to the regressive ABC Range Quartzite of the Adelaide geosyncline, and possibly the sandstone units in the Pertatataka Formation of the Amadeus basin.

A second Marinoan transgressive phase is represented only in the Mount Ramsay area (reddish-brown immature feldspathic sandstone with interbedded siltstone of the Lubbock Formation) and East Kimberleys (maroon micaceous shale, siltstone and rare fine-grained sandstone of the Elvire Formation). The latter corresponds closely in lithology and stratigraphic position to the Bunyeroo Formation of the Adelaide geosyncline and the upper part of the Pertatataka Formation of the Amadeus basin. Similarly, the overlying Boonall Dolomite corresponds to the Wonoka and Julie Formations, though the three formations at the top of the East Kimberley succession appear to lack obvious lithostratigraphic equivalents elsewhere (Timperley

Shale, Nyuless Sandstone and Flat Rock Formation). These formations could be expected to be time-equivalents of the Pound Subgroup. The Late Adelaidean units of the Kimberleys are overlain unconformably in many places by the Early Cambrian Antrim Plateau Volcanics.

Geochronology

The widely quoted dating (Compston and Arriens, 1968) of the earlier glaciation (724 ±30 Ma) is unreliable because it was based on a combination of data from the lower glacials, upper glacials and interglacials (Coats and Preiss, 1980). However, the data from Marinoan post-glacial shales are more reliable, and support the correlation of the Ranford Formation and Throssell Shale (672 ±70 Ma and 670 ±84 Ma, respectively) and the correlation of these formations with the Stuart shelf equivalents of the Brachina Formation of the Adelaide geosyncline (676 ±204 Ma) as proposed by Coats and Preiss (1980). The dating of the Elvire Formation at 639 ±47 Ma (Bofinger, 1967) is consistent with its stratigraphic position.

TASMANIA

Exposures of Precambrian rocks in Tasmania are confined largely to the western half of the island (Fig. 1); the oldest rocks containing animal fossils are of Middle Cambrian age. The structural complexity and separation of segments of the unfossiliferous rocks, and the scarcity of radiometric data, render regional stratigraphic interpretation difficult. This summary is based largely on Williams (1978) and references quoted therein.

The less metamorphosed upper Precambrian sequences (generally of upper greenschist facies) are thought to be younger than the multiply-folded meta-sediments of the Tyennan and Forth geanticlines (Fig. 1). The upper Precambrian may be tentatively subdivided into three main sequences representing three depositional basins.

The oldest of these, the Rocky Cape Group, of siltstone, orthoquartzite, dolomite and subgreywacke is widespread in the north-west corner of Tasmania. It appears to represent a stable shelf environment with palaeoslope toward the north-west, a shoreline to the south-east (Tyennan geanticline) and a possible foreland to the north-west.

The next main sequence is the 500 m-thick Burnie Formation of black mudstone, quartz-wacke and minor pillow lavas considered to have been deposited in a slightly younger trough to the east of the basin in which the Rocky Cape Group accumulated. The Keith Metamorphics in the Arthur Lineament metamorphic belt separate these depositional areas and are considered to have been derived from the adjacent Rocky Cape Group, Burnie Formation, and their correlatives. Turbidity currents in the Burnie Formation flowed in a northerly direction transversely to a north-northeasterly-trending trough. East of Burnie, the Badger Head Group is a probable correlative. To the south, near Zeehan, the Oonah Formation (minimum thickness 2100 m) and its correlatives contain quartzite, siltstone and black shale with local carbonates, spilitic lavas and pyroclastics.

The uppermost sequence of the Upper Precambrian comprises mainly the Smithton Dolomite, (up to 1500 m of carbonate and chert, locally stromatolitic, and with basal clastics), deposited in the Smithton trough with angular unconformity on the Rocky Cape Group. The Penguin orogeny (minimum age ca. 720 Ma) is inferred to have preceded deposition of the Smithton Dolomite. To the south, near Zeehan, the Success Group (820 m of fine- and coarse-grained sandstone), is a probable equivalent.

A 30 m thick diamictite bed overlies the Smithton Dolomite. It contains dolomite and chert clasts up to 2 m in size, some of which are clearly derived from the Smithton Dolomite. Others, however, are fine grained dark grey dolomites containing the stromatolite *Baicalia* cf. *B. burra* (Griffin and Preiss, 1976). These have no obvious local source, but closely resemble the Skillogalee Dolomite of the Adelaide geosyncline. A distant provenance would support a glacial origin for the diamictite, although proven glacial characteristics are lacking. Although the age and origin of the diamictite are uncertain, it may be tentatively correlated with the Cottons Breccia of King Island (Jago, 1974), which unconformably overlies metasediments intruded by granites (817 ±60—724 Ma) and contains diamictites overlain by a sequence of siltstones and basic volcanics. A laminated pink dolomite, similar to the Nuccaleena Formation and other Marinoan 'cap dolomites' occurs immediately above the breccia.

A third occurrence of possible glaciogenic sediments (Jago, 1981) is the Wedge River Beds in the Wedge River area (Fig. 1). These lie unconformably below fossiliferous Middle Cambrian, but appear not to have been involved in the Frenchman orogeny that produced the Tyennan geanticline basement.

Vidal (1976) described the acritarch? *Bavlinella faveolata*, which he considers an index fossil for the Vendian, in the Cottons Breccia and in the diamictite overlying the Smithton Dolomite. Though this is consistent with other stratigraphic data, neither the biogenicity nor the stratigraphic range of *Bavlinella* are beyond dispute.

CONCLUSIONS AND SUMMARY OF GEOLOGICAL HISTORY OF ADELAIDEAN BASINS

Interpretation of the age of the beginning of the Adelaidean at present depends on the correlation of early Willouran volcanics in the geosyncline with the Beda Volcanics of the Stuart shelf. On this basis, and the dating of the Beda Volcanics, all Precambrian sediments younger than ca. 1100 Ma in the other basins have been tentatively included in the Adelaidean. Age control on early Adelaidean sediments in the Adelaide geosyncline and in the central Australian basins is still extremely limited.

The ages and correlation of late Adelaidean sediments, including the

TABLE XI

Correlation of representative Late Adelaidean formations across Australia

Age	East Kimberleys	Ngalia basin	East Amadeus basin
Early Cambrian	Antrim Plateau Volcanics	Yuendumu Sandstone III	Arumbera Sandstone III
		Yuendumu Sandstone II	Arumbera Sandstone II
- - - - - -	- - - - - -	- - - - - -	- - - - - -
Late Adelaidean	Albert Edward group Flat Rock Formation		
Marinoan	Nyuless Sandstone		
	Timperley Shale	Yuendumu Sandstone I	Arumbera Sandstone I
	Boonall Dolomite		Julie Formation
	Elvire Formation		Pertatataka Formation
	Mount Forster Sandstone		Cyclops Member
	- - - - - -		
	Duerdin Group Ranford Formation: Johnny Cake Shale Member Jarrad Sandstone Member		
	Unnamed dolomite	Unnamed dolomite, shale	Unnamed dolomite
	Moonlight Valley Tillite	Mount Doreen Formation	Olympic Formation
	- - - - - -	- - - - - -	- - - - - -
	Frank River Sandstone Fargoo Tillite - - - -		
			Aralka Formation: Limbla Member Ringwood Member
Sturtian			
		Rinkabeena Shale unnamed dolomite, shale Naburula Formation	Unnamed dolomite, shale Areyonga Formation
		- - - - - -	- - - - - -
Early Adelaidean (no correlation implied)	Helicopter Siltstone	Unnamed dolomite, shale	Bitter Springs Formation

- - - - - - indicates disconformity/unconformity.

SE Georgina basin	Adelaide geosyncline	
Red Heart Dolomite	Parachilna Formation	
Adam Shale	Uratanna Formation	
	Wilpena group	
	Pound Subgroup:	
	Rawnsley Quartzite	
Keepera Group	Bonney Sandstone	
	Wonoka Formation	
	Bunyeroo Formation	
Grant Bluff Formation	ABC Range Quartzite	
Gnallan-a-gea Arkose	Brachina Formation	Ulupa Siltstone
Mopunga group		Seacliff Sandstone
Wonnadinna Dolomite	Nuccaleena Formation	
Black Stump Arkose	Umberatana group	
	Reynella Siltstone Member	
	Elatina Formation	
	Willochra	
	Etina Formation	
	Subgroup	
	Brighton Limestone	
	Tapley Hill Formation:	
Unnamed dolomite, shale	Tindelpina Shale Member	
Yardida Tillite	Sturt Tillite, Wilyerpa Formation	
		Benda Siltstone
		Pulaco Tillite
Yackah Beds	Burra Group	

products of two major glaciations, chiefly in the South Australian, central Australian and Kimberley Region basins, are now better defined (Table XI) as a result of new Rb/Sr shale dates on the Stuart shelf, and of stratigraphic reinterpretation of previous radiometric data (Kimberley Region). The Sturtian glaciation is probably only a little older than ca. 750 Ma, while the Marinoan one took place ca. 750—670 Ma ago, but probably closer to the latter. In all basins there is a stratigraphic break between the latest Adelaidean sediments and the overlying Early Cambrian sequences.

Biostratigraphy has assisted very broad correlation and age assessment. Because of the predominance of endemic stromatolites in the late Precambrian of Australia, only limited correlation is possible with the stromatolitic sequences of the U.S.S.R. The best agreement between stromatolite-based correlations and those based on lithostratigraphy and geochronology is in the Bitter Springs Formation and in the Umberatana Group. The early Adelaidean of the Adelaide geosyncline is anomalous from a stromatolite biostratigraphy point of view, since the oldest stromatolites (early Willouran) have a Late Riphean 'aspect', while overlying Torrensian forms resemble those of the Middle Riphean of the U.S.S.R.

The history of Adelaidean basins and surrounding regions may be summarised as follows:

Approximately 1100—1000 Ma period (Fig. 2a)

Stuart shelf. Rifting with basic volcanics and deposition of coarse clastics in grabens.

Adelaide geosyncline. Initial platform sands and carbonates, then rifting with basic volcanics possibly also during this period, followed by mixed carbonates and immature clastics deposited under evaporitic conditions.

Musgrave block. Folding and granite intrusion in east; thick acid volcanic complexes at western end; basic and acidic volcanics and sediments in northwest (Amadeus basin).

Bangemall basin. Mixed clastics and carbonates, with very minor acid volcanics. Finer clastics and turbidites in later stages.

Arunta block. Metamorphism and migmatisation in an east—west zone between the future Amadeus and Ngalia basins.

Kimberley region and Victoria River basin. Fine and medium clastic deposition.

Tasmania. Deposition of clastics of the Rocky Cape region, but age unknown.

Approximately 1000—800 Ma period (Fig. 2b)

Adelaide geosyncline. A high-grade metamorphic belt in the south, questionably during this period, followed unconformably by deposition of mixed clastic—carbonate sequences. Cyclic sedimentation of west-derived deltaic complexes; platform carbonates in marginal marine to lagoonal environments. Minor tectonism at end of this time.

Stuart shelf. No deposition known.

Central Australian basins. Basal blanket quartzites, followed by shelf carbonates. Minor tectonism in all basins at end of this time; early Adelaidean sequence best preserved in Amadeus basin, but severely eroded in other basins.

Approximately 800—700 Ma period (Fig. 3a)

Tasmania. A period of folding and intrusion of granite, dolerite (Penguin orogeny). Widespread Sturtian glaciation is recorded in all other basins.

Adelaide geosyncline. Oldest Sturtian glacials deposited in fault controlled troughs, and frequently associated with sedimentary iron formations. Younger Sturtian glacials more widespread — tillites with associated sandstones, laminated siltstones. Post-glacial transgression, covering whole Adelaide geosyncline and Stuart shelf.

Officer basin. Sturtian glacials possibly of earlier phase. Basic volcanics. Post-glacial transgression.

Amadeus, Ngalia and Georgina basins. Probable younger Sturtian glacials; post-glacial transgression. Glacials of Central Mount Stuart could be earlier phase, but this is not certain.

Kimberley region. Probable younger Sturtian glacials and post-glacial transgression, chiefly in graben.

Approximately 700—570 Ma period (Fig. 3b)

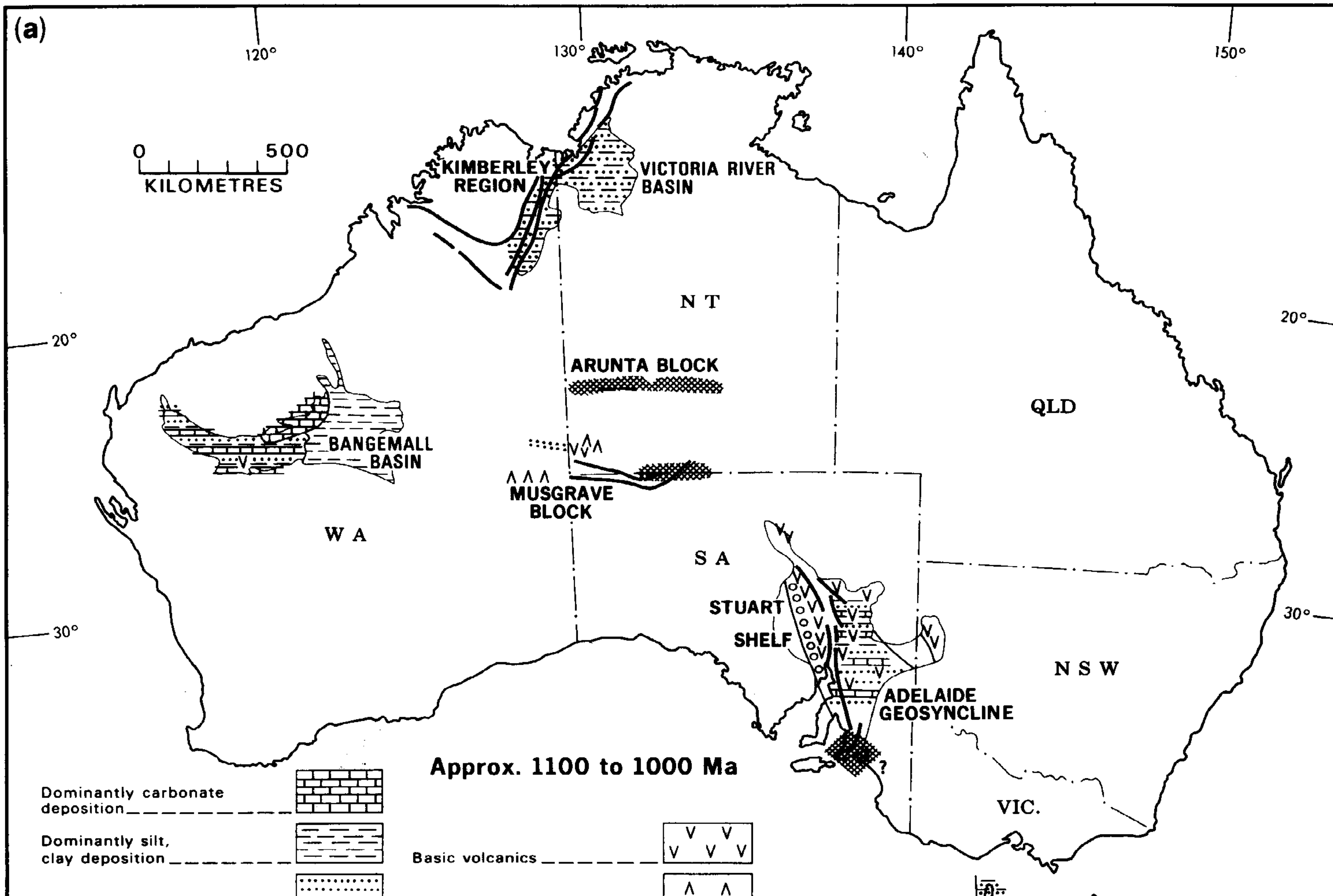
Regressive phase in all basins. Reflected in the western Amadeus basin, the Georgina basin and in the Ngalia basin as a major hiatus. Adelaide geosyncline, Officer basin, eastern Amadeus basin and graben in Kimberley Region. Deposition more or less continuous, but regressive phase continued. Minor hiatus before Marinoan glaciation.

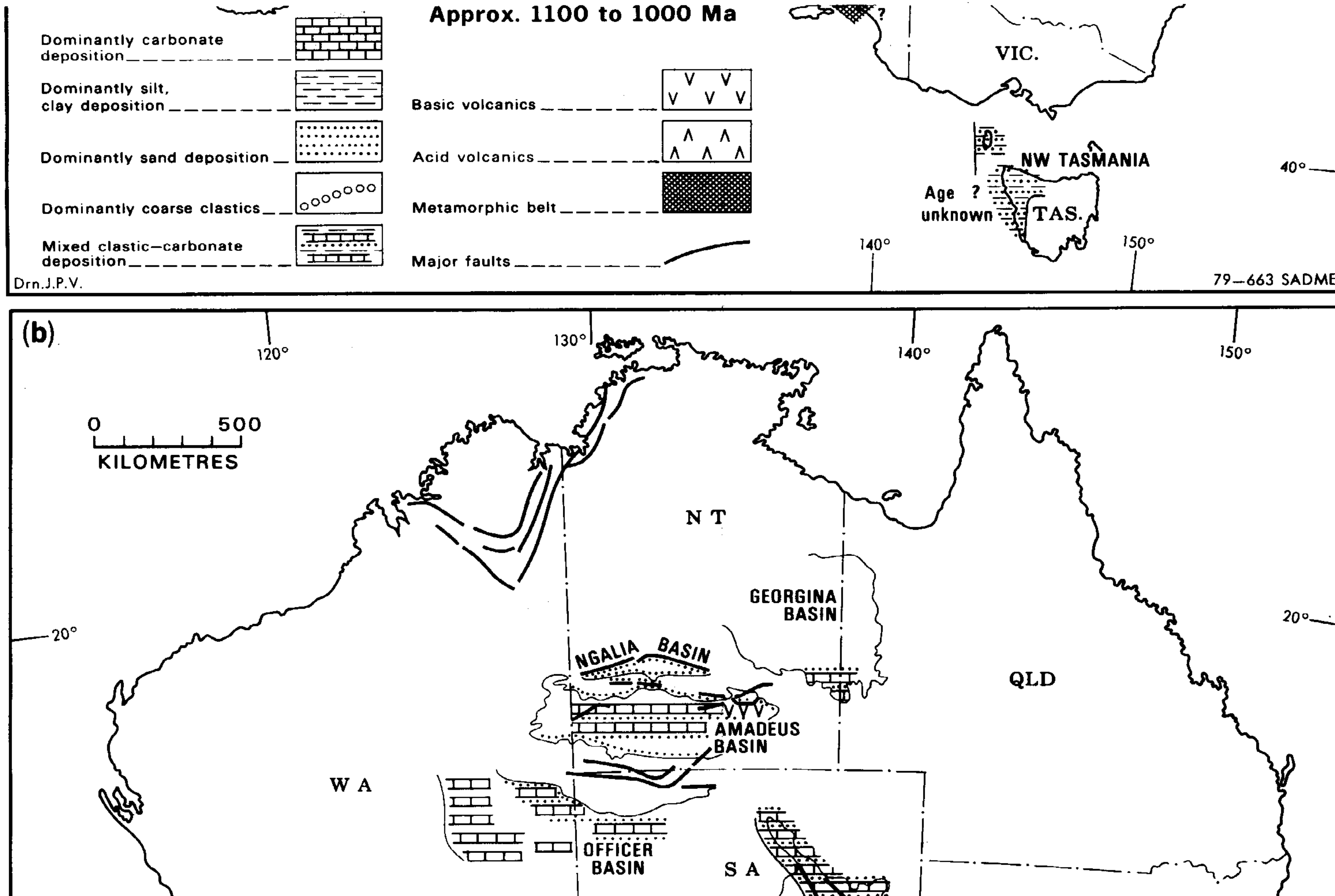
Marinoan glaciation. Tillites deposited in the eastern Adelaide geosyncline, Barrier Ranges, eastern Amadeus basin, Burke River area, and widespread in the Kimberley region. Predominantly feldspathic sandstone deposition in the western Adelaide geosyncline, Stuart shelf, western Amadeus basin, Georgina basin.

Post-glacial transgression. Followed by regressive phase, represented in Adelaide geosyncline, Stuart shelf, Amadeus basin, Georgina basin, Burke River area, the Kimberley region, and perhaps also in the Ngalia basin, though subsequently mostly eroded there.

Further major transgressive. Regressive cycle, recorded only in the Adelaide geosyncline, (not Stuart shelf), Amadeus, Ngalia and western Georgina basins and East Kimberley region only.

Adelaidean sedimentation. Terminated by tectonism. Hiatus between latest Adelaidean and Early Cambrian sequences in all basins.


(a)
120°
130°
140°
150°
20°
30°
0
500
KILOMETRES
KIMBERLEY REGION
VICTORIA RIVER BASIN
N T
ARUNTA BLOCK
QLD
BANGEMALL BASIN
MUSGRAVE BLOCK
W A
S A
STUART SHELF
ADELAIDE GEOSYNCLINE
N S W
VIC.
Approx. 1100 to 1000 Ma
Dominantly carbonate deposition
Dominantly silt, clay deposition
Basic volcanics



Approx. 1100 to 1000 Ma
Dominantly carbonate deposition
Dominantly silt, clay deposition
Dominantly sand deposition
Dominantly coarse clastics
Mixed clastic–carbonate deposition
Basic volcanics
Acid volcanics
Metamorphic belt
Major faults
Drn.J.P.V.
VIC.
NW TASMANIA
Age ? unknown
TAS.
140°
150°
40°
79—663 SADME
(b)
120°
130°
140°
150°
0 500
KILOMETRES
20°
20°
N T
GEORGINA BASIN
NGALIA BASIN
AMADEUS BASIN
QLD
W A
OFFICER BASIN
S A

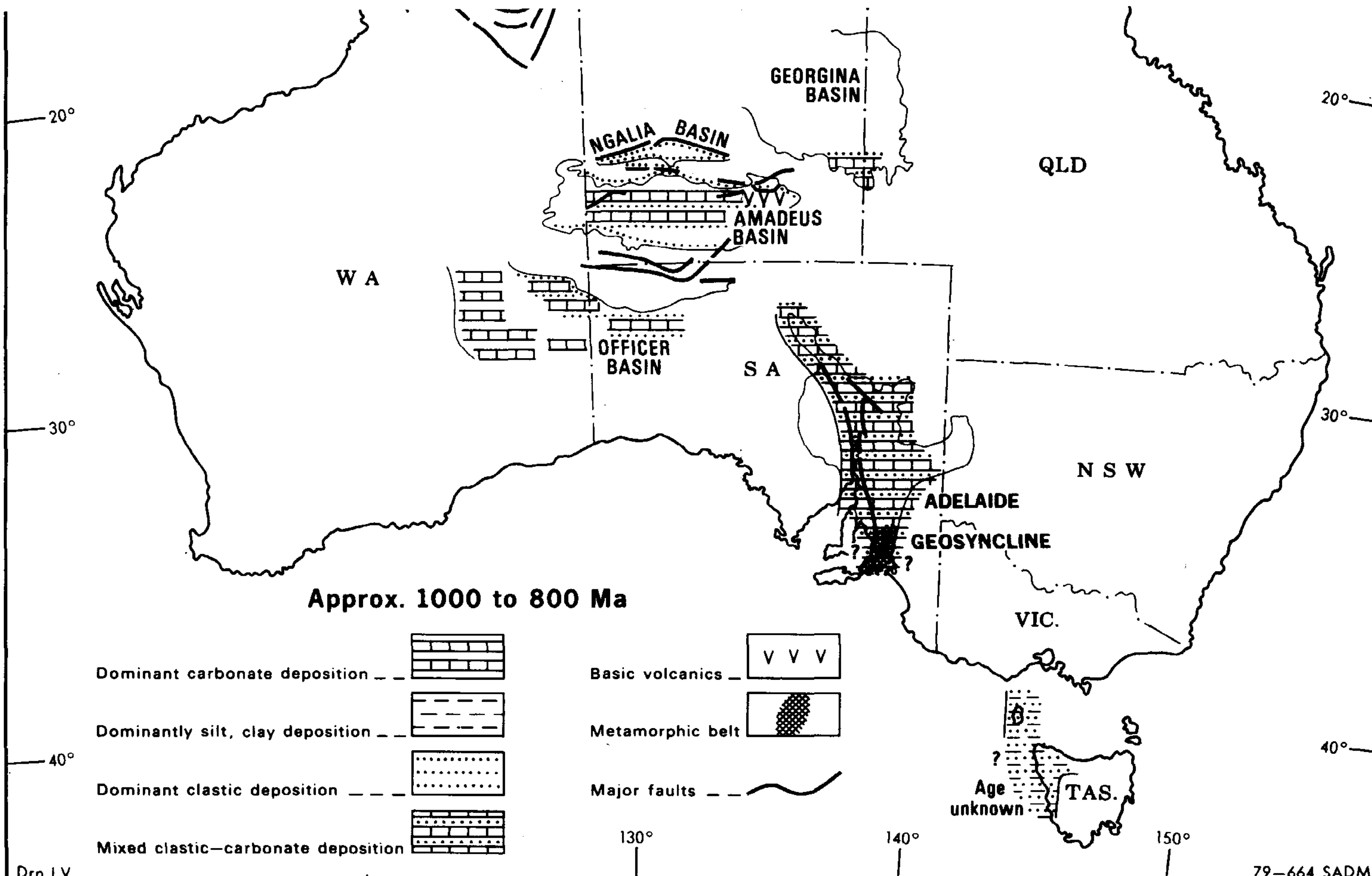
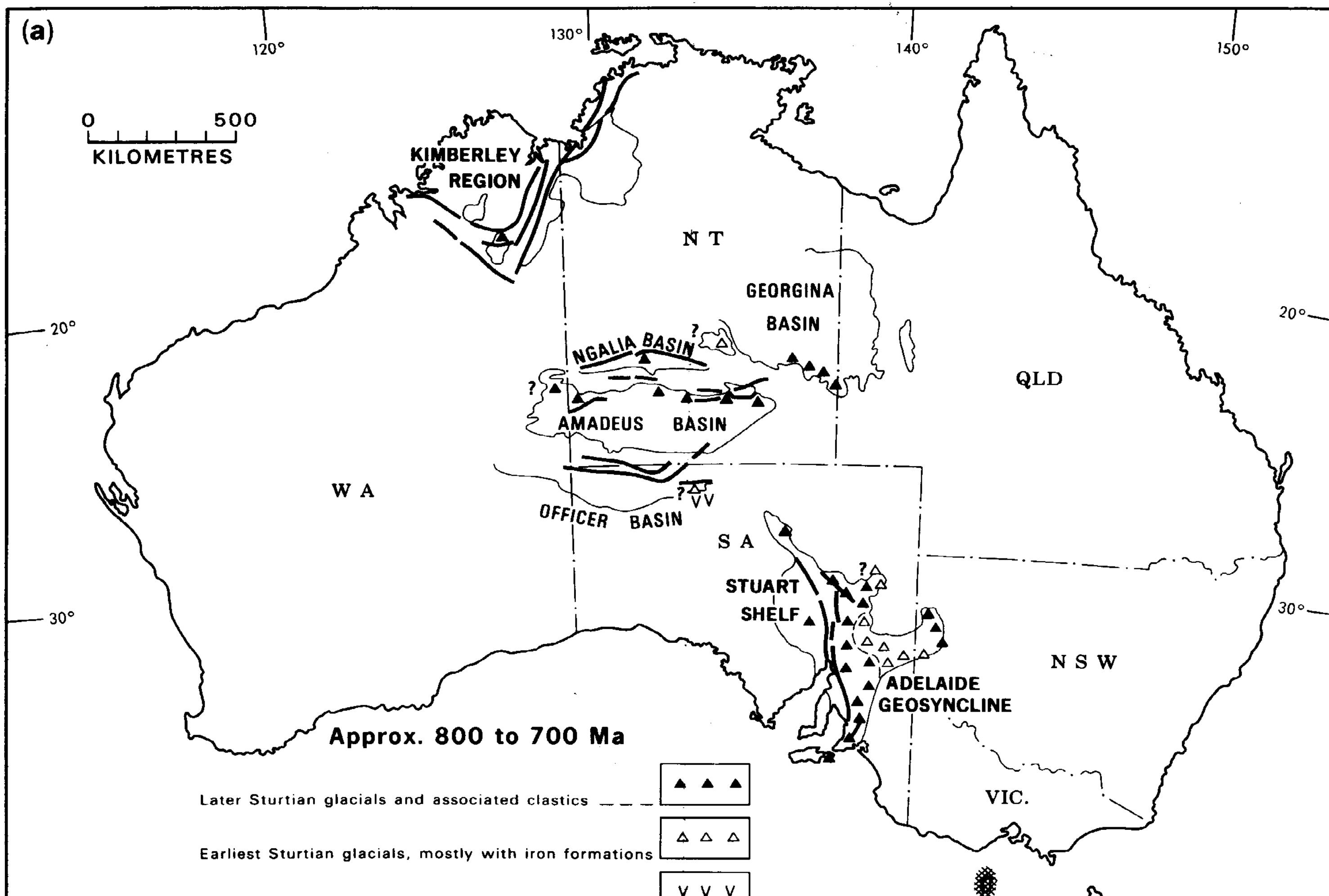
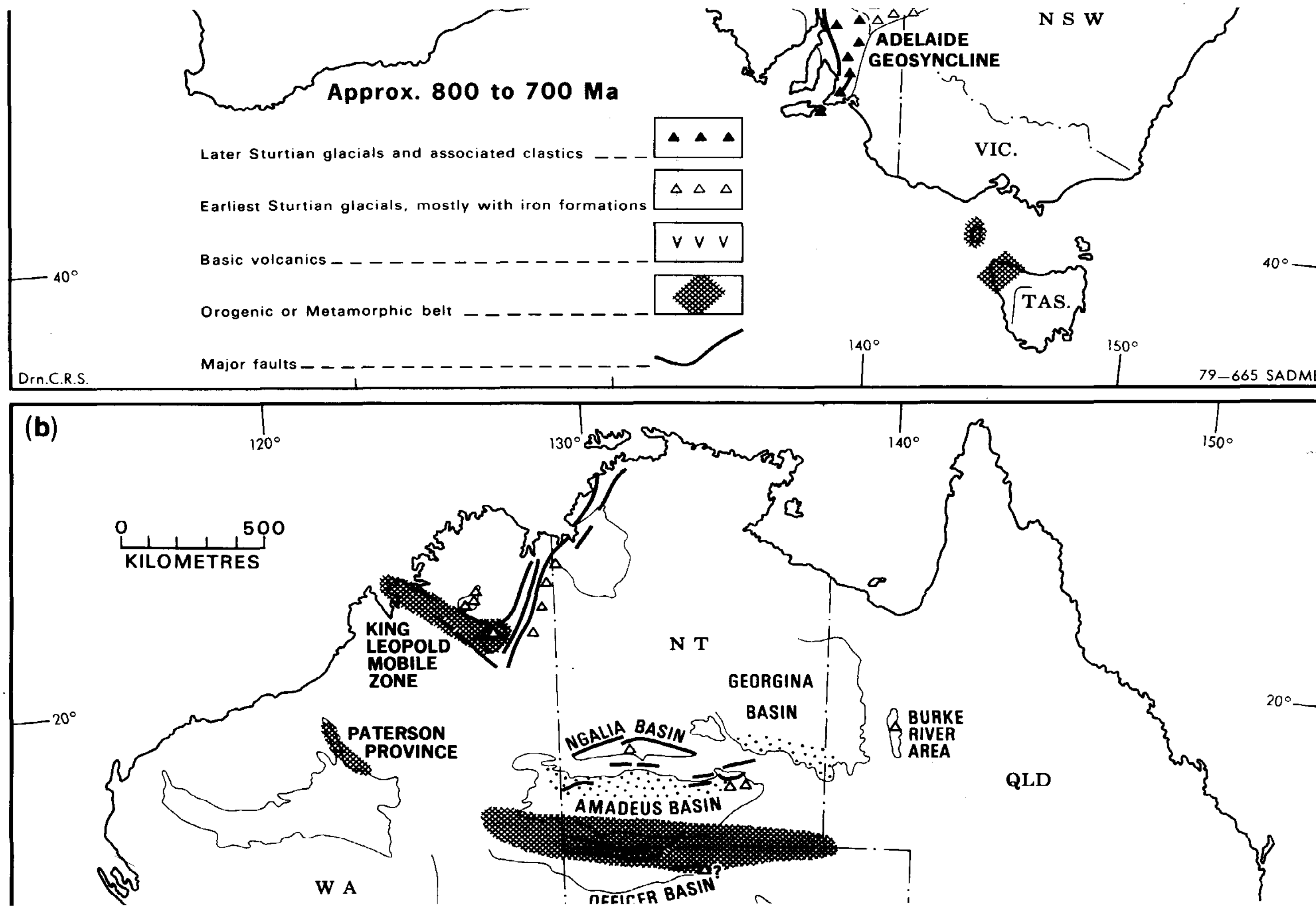


Fig. 2. Distribution and dominant facies of Early Adelaidean sedimentation in Australia: (a) period ca. 1100—1000 Ma; (b) period ca. 1000—800 Ma.


(a)
120°
130°
140°
150°
20°
30°
0 500
KILOMETRES
KIMBERLEY REGION
N T
GEORGINA BASIN
NGALIA BASIN
AMADEUS BASIN
OFFICER BASIN
QLD
W A
S A
STUART SHELF
ADELAIDE GEOSYNCLINE
N S W
VIC.
Approx. 800 to 700 Ma
Later Sturtian glacials and associated clastics
Earliest Sturtian glacials, mostly with iron formations



Approx. 800 to 700 Ma
Later Sturtian glacials and associated clastics
Earliest Sturtian glacials, mostly with iron formations
Basic volcanics
Orogenic or Metamorphic belt
Major faults
ADELAIDE GEOSYNCLINE
N S W
VIC.
TAS.
40°
140°
150°
Drn.C.R.S.
79—665 SADME
(b)
120°
130°
140°
150°
20°
0 500
KILOMETRES
KING LEOPOLD MOBILE ZONE
PATERSON PROVINCE
N T
GEORGINA BASIN
NGALIA BASIN
AMADEUS BASIN
BURKE RIVER AREA
QLD
W A

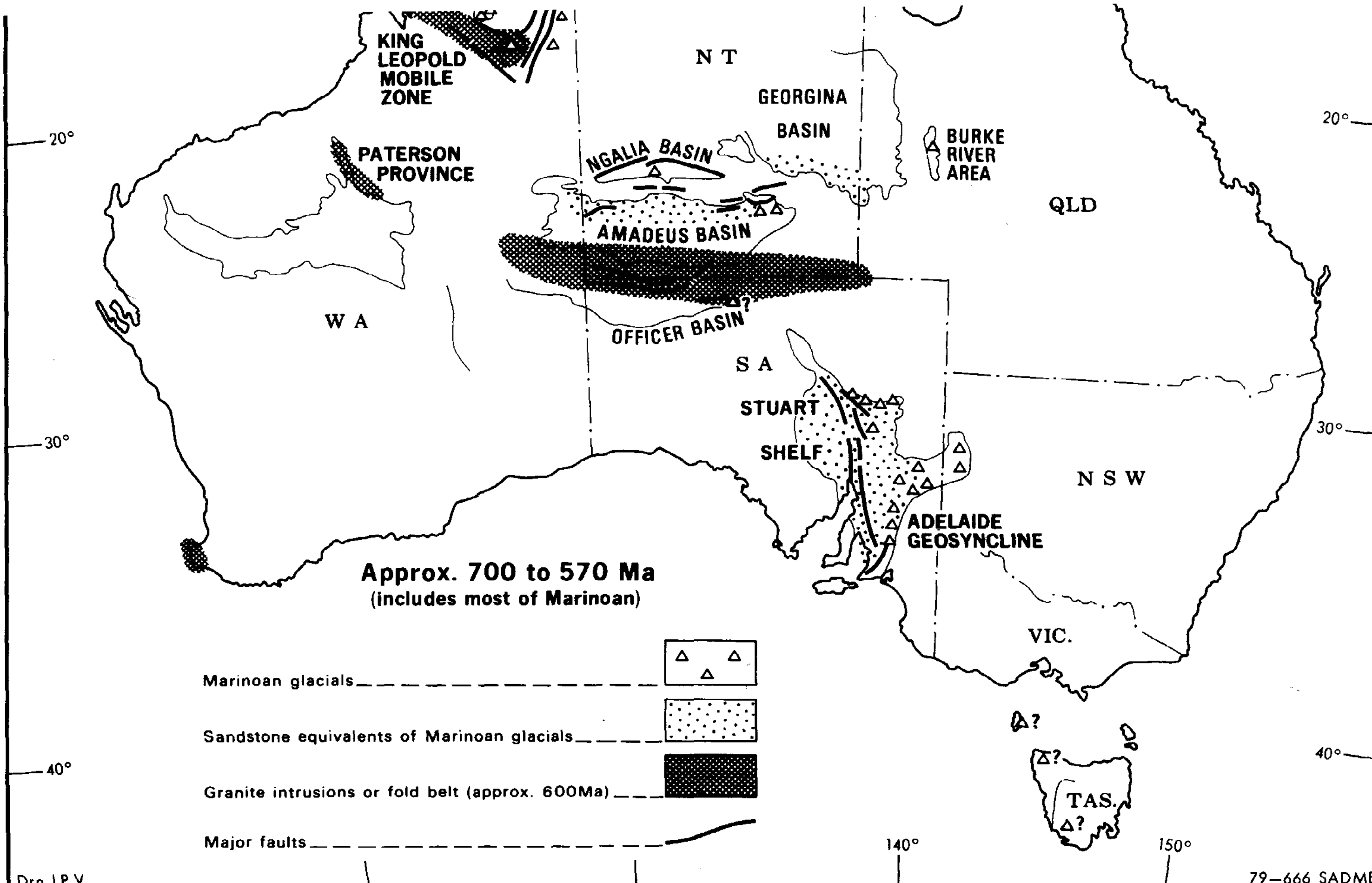


Fig. 3. Distribution and dominant facies of Late Adelaidean sedimentation in Australia: (a) period approximately 800—700 Ma; (b) period approximately 700—570 Ma (base of Cambrian).

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