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1. LATE ADELAIDEAN GLACIAL SUCCESSIONS OF THE KIMBERLEY REGION - NORTHWESTERN AUSTRALIA

2. THE AGE OF THE CARPENTARIAN - A PROGRESS REPORT

by

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K.A. Plumb

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LATE ADELAIDEAN GLACIAL SUCCESSIONS OF THE KIMBERLEY REGION - NORTHWESTERN AUSTRALIA *

by

K.A. Plumb

The Kimberley Region of northwestern Australia contains some of the best exposed and least disturbed Precambrian glacial rocks in the world. Twenty separate glacial pavements are recorded so far, allowing reconstruction of ice movements and pre-glacial topography. Two distinct successions of glacigene rocks, passing up into normal marine sediments, are separated by an unconformity, and can be correlated with reasonable confidence with the South Australian Sturtian and Marinoan sequences. Unmetamorphosed shales have provided the most reliable isotopic dating of late Adelaidean glaciation so far obtained in Australia.

Stratigraphy:

The stratigraphy is summarized in Table 1 and Figure 1. Three separate areas are recognized, between which the successions show excellent correlations. In the western Victoria River Basin (Dow, 1965; Dow and Gemuts, 1969) the Duerdin Group is unconformably overlain by the Albert Edward Group. The Kuniandi Group is unconformably overlain by the Louisa Downs Group in the Mount Ramsay area (Dow and Gemuts, 1969; Roberts, Gemuts and Halligan, 1972). In the Mount House area (Gellatly and Derrick, 1967; Perry and Roberts, 1968; Roberts and Perry, 1969; Derrick and Playford, 1973), only the lower sequence, the Mount House Group, is found.

The glacial successions overlie, with marked unconformity, a wide range of (?)Archaean, Lower Proterozoic, Carpentarian and Adelaidean rocks and are, in turn, overlain with comparatively gentle unconformity by Lower Cambrian rocks.

The older tillites have an abundant green, or sometimes purple-brown, clay or silt matrix in which are suspended megaclasts ranging in size from coarse sand up to 4.5 m. Sand lenses, containing megaclasts, are common. Megaclasts show a polymict source and are commonly highly polished and striated. Faceted clasts are rare. The tillite commonly passes upwards into faintly bedded green siltstone. A characteristic fine-grained laminated dolomite always caps the tillite.

The post-glacial sequences of the Duerdin, Kuniandi and Mount House Groups are characterized by green, fissile, slightly micaceous shale, with regular reddish-purple interbeds, grading into more arenitic beds above and below. Scattered erratics in the lower arenites attest to a continuation of glacial conditions.

The upper tillite, confined to the Egan Formation, again has a massive purple or grey-green clay or silt matrix and scattered poorly sorted megaclasts, but few exceed 15 cm in diameter. Associated carbonates and sandstones, of both the Egan and Yurabi Formations, show complex facies changes.

The overlying shales into which the sequence grades are characteristically darker in colour than the older successions. The Lubbock Formation has abundant well developed turbidite sets alternating with non-turbidites, a feature apparently at variance with the area's tectonic setting.

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Attention is drawn to the ubiquitous association between tillites and dolomites.

Fossils:

Stromatolites are known from the Walsh Tillite, Egan Formation, and Boonall Dolomite. The Jarrad Sandstone Member contains vertical worm burrows and possible jellyfish are described from the Ranford Formation (Dunnet, 1965).

Geochronology:

Bofinger (1967) has obtained the results summarized in Table 2 from Rb-Sr isochrons on shales.

TABLE 2: LATE ADELAIDEAN ISOTOPIC AGES - KIMBERLEY REGION

Formation	Age (million years)	Initial Sr^{87}/Sr^{86} ratio	Number of samples
McAlly/Timperley Shales (pooled)	665 ± 43	0.7321 ± 0.0084	6
Elvire Formation	653 ± 48	0.7262 ± 0.0100	5
Throssell Shale	686 ± 75	0.7285 ± 0.0121	7
Johnny Cake Shale Member	686 ± 72	0.7333 ± 0.0082	12
Throssell/Johnny Cake (pooled)	686 ± 44		19
Moonlight Valley/Landrigan Tillites (pooled)	739 ± 30	0.7331 ± 0.0060	8

Interregional Correlations:

As mentioned excellent comparisons can be made between the Kimberley successions and the Sturtian and Marinoan sequences of the Adelaide Geosyncline. Late Adelaidean sequences in Central Australia, the Areyonga and Pertatataka Formations of the Amadeus Basin (Wells et al., 1970) and the Field River Beds beneath the Georgina Basin (Smith, 1972), have long been known to contain glacigene sediments and yield poorly defined ages in the range of 790-600 m.y. (Compston and Arriens, 1968). De Keyser (1972) has recently described tillites in northwestern Queensland which show remarkable lithological correlation with the Duerdin Group. Roberts (1966) remarks on the close comparisons between the Kimberley glacial sequences and those of South Africa.

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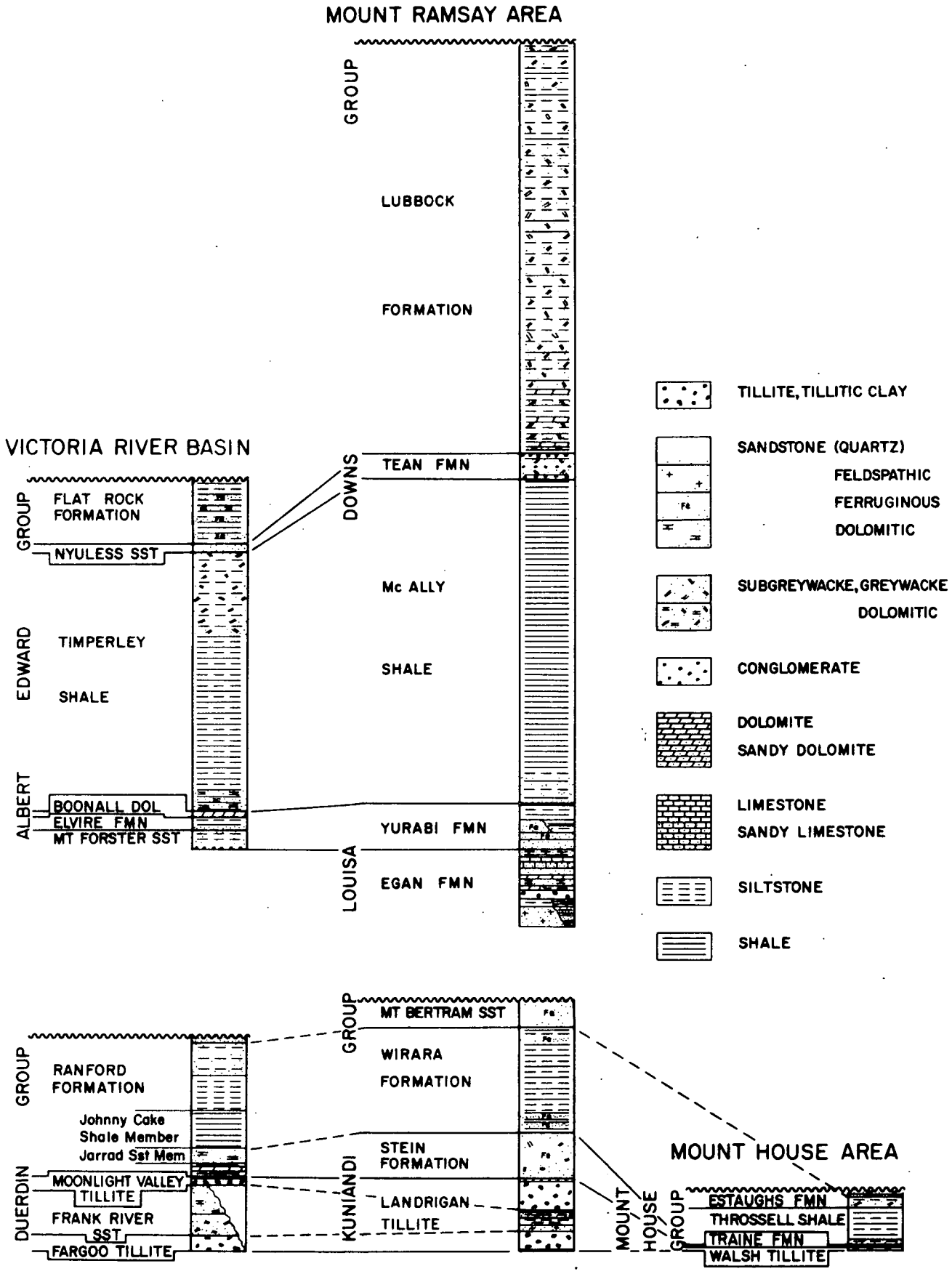
TABLE 1. STRATIGRAPHY OF KIMBERLEY GLACIAL SUCCESSIONS

	UNIT	THICKNESS (metres)	ROCK TYPE
ALBERT EDWARD GROUP	Flat Rock Formation	300 +	Purple shale, siltstone; interbedded fine ferruginous or dolomitic sandstone.
	Nyuless Sandstone	37.5	Quartz sandstone.
	Timperley Shale	900 - 1500	Uniform green, dark grey shale, siltstone. Minor subgreywacke, calcareous sandstone.
	Boonall Dolomite	30 - 60	Yellow and grey dolomite.
	Elvire Formation	60	Maroon, chocolate-brown shale, green siltstone; minor sandstone, dolomite.
	Mount Forster Sandstone	92	Quartz sandstone; minor shale, siltstone.
LOUISA DOWNS GROUP	Lubbock Formation	1900 +	Grey, green, purple siltstone and subgreywacke; some dolomite.
	Tean Formation	120	Feldspathic sandstone, subgreywacke; minor conglomerate, shale, dolomite.
	McAlly Shale	1500	Black, grey, green shale, siltstone, silty sandstone.
	Yurabi Formation	30 - 210	Quartz and feldspathic sandstone; interbeds shale, siltstone, dolomite.
	Egan Formation	30 - 200	Tillite: dolomite, limestone (sandy and silty); arkose conglomerate, quartz sandstone.
DUERDIN GROUP	Ranford Formation	642	Khaki-green siltstone, shale (micaceous); fine quartz sandstone, subgreywacke.
	Johnny Cake Shale Member	180	Interbanded green, reddish-purple shale. Rare dolomitic subgreywacke.
	Jarrad Sandstone Member	60-105	Dolomitic sandstone, ferruginous subgreywacke, scattered erratics.
	Moonlight Valley Tillite	2 - 150	Tillite and clay; lenses dolomitic quartz sandstone, conglomerate; pink, cream laminated dolomite.
	Frank River Sandstone	0 - 230	Dolomitic sandstone, subgreywacke; dropped erratics; lenses boulder conglomerate.
	Fargoo Tillite	45 - 200	Tillite and clay; lenses dolomitic boulder conglomerate
KUNIANDI GROUP	Mount Bertram Sandstone	120 - 180	Micaceous, ferruginous sandstone; minor siltstone, shale towards base.
	Wirara Formation	440 - 490	Green shale, siltstone; interbeds purple sandstone; pyritic sandstone near base.
	Stein Formation	0 - 212	Purple ferruginous greywacke.
	Landrigan Tillite	11 - 336	Tillite and clay; lenses feldspathic sandstone, conglomerate; cream to purple laminated dolomite.
MOUNT HOUSE GROUP	Estaughs Formation	107 +	Black to purple-brown ferruginous sandstone, micaceous siltstone; quartz sandstone, micaceous subgreywacke.
	Throssell Shale	170 - 235	Grey-green micaceous shale, fine sandstone; red-brown shale, sandstone at base; minor dolomite.
	Traine Formation	0 - 60	Ferruginous, lithic and dolomitic sandstone; scattered erratics; minor dolomite.
	Walsh Tillite	5 - 160	Tillite and clay; lenses pebbly sandstone; pink to purple-brown laminated dolomite.

FIGURE 1



ADELAIDEAN GLACIAL SUCCESSIONS KIMBERLEY REGION

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THE AGE OF THE CARPENTARIAN - A PROGRESS REPORT*

by

K.A. Plumb

Dunn et al (1966) proposed subdivision of the Australian Proterozoic into three time-rock units, based on clearly defined type sections with bases capable of isotopic age determination. The Carpentarian was defined from the McArthur Basin in the Northern Territory, following the proposal of McDougall et al (1965); the base is the Cliffdale Volcanics. The volcanics overlie the Nicholson Granite and are intruded by the Norris Granite. These are unconformably overlain by the Tawallah Group, which is in turn conformably overlain by the McArthur Group. The Packsaddle Microgranite is comagmatic with the Hobblechain Rhyolite Member of the Masterton Formation, the top unit of the Tawallah Group. The McArthur Group is unconformably overlain by the Roper Group, the latter being correlated with the South Nicholson Group, and the Roper Group is intruded by dolerite sills.

The most significant ages obtained from McDougall et al's reconnaissance study are summarized in Table 1. From these data Dunn et al tentatively placed the age of the base of the Carpentarian at about 1800 m.y. The Roper Group was placed in the Adelaidean (younger than 1400 m.y.) but Compston and Arriens (1968) have since suggested it may be Carpentarian, based on a Rb/Sr whole-rock shale isochron of 1510 ± 120 m.y. from the South Nicholson Group.

TABLE 1. Summary of Results after McDougall et al (1965)

UNIT	AGE	METHOD
Dolerite	1280 m.y.	K/Ar minerals
ROPER GROUP		
Crawford Formation	1390 m.y.	K/Ar, Rb/Sr, glauconite
McARTHUR GROUP		
H.Y.C. Deposit	1560 m.y.	Model lead
TAWALLAH GROUP		
Packsaddle Microgranite	1520 m.y.	Rb/Sr, single total-rock
Aquarium Formation	1600 m.y.	Rb/Sr, glauconite
NORRIS GRANITE	1790 ± 30 m.y.	K/Ar, minerals
NICHOLSON GRANITE	1815 m.y.	K/Ar, Rb/Sr, minerals, total-rock

A new program of age determinations of the McArthur Basin sequence has been undertaken to attempt to correct deficiencies in the original data. The major aim is to provide a direct age of the Cliffdale Volcanics. The laboratory work is being carried out by A.W. Webb of AMDEL and preliminary results are summarized in Table 2; work is continuing.

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TABLE 2. Summary of New Results (Webb, pers. comm.)

UNIT	AGE	METHOD
TAWALLAH GROUP		
Hobblechain Rhyolite	1617 ± 60 m.y.	Rb/Sr whole-rock isochron
Aquarium Formation	1473 ± 56 m.y.	Rb/Sr glauconite isochron
Peters Creek Volcanics	ca 1700? m.y.	Rb/Sr whole-rock isochron
NORRIS GRANITE	1773 ± 24 m.y.	Rb/Sr whole-rock isochron
CLIFFDALE VOLCANICS	1770 ± 20 m.y.	Rb/Sr whole-rock isochron
NICHOLSON GRANITE	1843 ± 83 m.y.	Rb/Sr whole-rock isochron

Eight total-rock samples of Cliffdale Volcanics have given an excellent Rb/Sr isochron of 1770 ± 20 m.y. with all variance attributable to experimental error. The initial Sr^{87}/Sr^{86} ratio was 0.7078 ± 0.0017. The close agreement with the Norris and Nicholson Granite data allows the age of the base of the Carpentarian to be confidently defined as 1770 ± 20 m.y.

Attempts to obtain Rb/Sr shale isochrons from the Roper Group were unsuccessful and the age of the dolerites could not be improved. Work is continuing on samples from the McArthur Group. The Hobblechain Rhyolite age is considered to be reasonable although extra samples are to be analysed. The underlying Aquarium Formation data supports the common tendency for glauconite to yield young ages. The older Peters Creek Volcanics data shows a wide scatter and the 1700 m.y. age is unreliable without the other supporting ages.

Basement rocks from Arnhem Land, the Bradshaw Granite, previously considered to be of possible Archean age have given a whole-rock Rb/Sr isochron of 1944 ± 75 m.y. This agrees with new interpretations of geological relationships in the Lower Proterozoic Pine Creek Geosyncline (Needham, pers. comm.).

The new McArthur Basin data agrees well with data from the Pine Creek Geosyncline (Compston & Arriens, 1968) and with preliminary results from current work in the Mount Isa region (Page, pers. comm.).

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