COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

1944/24

FORAMINIFERA IN THE PERMIAN ROCKS OF AUSTRALIA

by

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Report No. 1944/24.

INTRODUCTION.

The presence of foraminifera in the Permian sediments of Australia was recorded as early as 1882. Some systematic work was done up to 1905, but there was no further investigation into these micro-fossils until 1937. Since that date, four papers on Permian foraminifera have been published (1937, 1940 (2), 1944). However, it was not until about ten years ago that systematic sampling of outcrops, cores and cuttings from bores was commenced with the object of seeing whether micro-faunal zones could be established.

Since 1933 extensive collections of Permian rocks have been made in New South Wales and Western Australia and smaller ones in Queensland, by geologists attached to private companies who were carrying out a search for oil in Australia. Subsidiary companies of Oil Search Limited drilled two deep bores in New South Wales, and two in Queensland, which were partly or wholly in Permian sediments; and the Freney Kimberley Oil Company was drilling a deep bore in Western Australia, which is wholly in Permian beds and which, when operations were suspended in 1942 owing to the war, had reached a depth of 4,271 feet. Core samples and drill cuttings from these bores have been examined and a micro-fauna revealed. There has been little investigation of the micro-fauna of Permian rocks in Tasmania, and the only foraminifera recorded are those described by Howchin in 1895 from the Piper River, near Karoola.

A considerable amount of research is still necessary before it can be stated whether or not a definite system of zoning, based on the micro-faunas, can be applied to the Permian rocks of Australia. It seems possible, however, that certain species may be characteristic of the Upper and Middle Permian deposits. In the extensive collections of Permian rocks examined from the Hunter River District in New South Wales, assemblages of foraminifera rather than restricted species have proved useful for zonal purposes and this method of zoning should prove valuable when more material is examined from the Permian deposits of other States.

A notable feature of the foraminiferal assemblage in the Permian rocks of Australia, is the almost complete absence of the world-wide zonal forms, the Fusulinidae. The only record of their occurrence is the two poorly preserved specimens from the Upper Ferruginous Series in the West Kimberley Area, Western Australia, referred to the genera Verbeekina and Neoschwagerina by Chapman and Parr (1937). These important foraminifera are recorded from Sumatra, India, China and Japan.

HISTORICAL NOTES.

The first reference to the presence of Permian foraminifera in Australia was made by Professor Rupert Jones in his Catalogue of the Fossil Foraminifera in the British Museum (1882). The locality was given as Piper River, Tasmania. Thos. Stephens (1889) published a note in the Royal Society of Tasmania on the discovery by E. R. Etheridge of Permo-Carboniferous foraminifera in a limestone from the "right bank of the Piper River, not very far from a place called Lilydale" (Howchin, 1894). Etheridge stated that this was the first record of the occurrence of foraminifera in the Permo-Carboniferous rocks of Australia and Tasmania. The Piper River material was further examined by Howchin (1894) when he recorded four species from thin sections of limestone.

In 1895 Howchin described four new species of foraminifera from the "Carboniferous" beds, Irwin River area, Western Australia. This work, together with that by Chapman and Howchin in 1905 on the Permo-Carboniferous foraminifera of New South Wales formed a basis for investigations on Permian foraminifera in Australia for many years. The nomenclature used by Chapman and Howchin in the latter paper (1905) was revised by those authors in collaboration with W. J. Parr in 1934.

In 1907, Etheridge Jnr., listed Permian foraminifera from a bore at Port Keats, Northern Territory.

In 1937, Chapman and Parr recorded the occurrence of two genera of Fusulinids in rocks from the West Kimberley area in Western Australia.

Two papers containing descriptions of new species appeared in 1940. One was by W. J. Parr and the writer on species of Permian foraminifera from New South Wales and the other by Parr on forms from Western Australia. The writer has recently published (1944) descriptions of four new species from Queensland and New South Wales.

DISTRIBUTION OF FORAMINIFERA IN THE PERMIAN ROCKS OF AUSTRALIA.

1. Queensland.

(a) General. Little micropalaeontological investigation has been undertaken on the Permian rocks of this State. The writer has examined fairly extensive collections of rocks from the Springsure area as well as samples from two deep bores, namely the Hutton Creek Bore, drilled to the depth of 4,688 feet and the Arcadia bore, to 6,036 feet. This material was submitted for examination by private companies engaged in the search for oil in Queensland.

(b) Distribution Table. The following table summarises the information available concerning the occurrence and distribution of foraminifera in the Middle and Lower Bowen Series of Queensland. Samples from all the localities listed have been examined by the writer. For convenience, letter designations are given to the localities which are listed below the table.

Foraminifera	Mid. Bowen Series				Lower Bowen Series												
	a.	b.	c.	d.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.
Ammodiscus multicinctus Crosp. & Parr	x	x	-	-	-	-	-	x	x	-	x	-	-	x	x	-	x	x
A. milletianus Chap.	-	x	x	x	x	-	-	-	-	x	-	x	-	-	-	x	-	-
Hyperamminoides acicula Parr	x	x	x	-	x	x	-	x	x	x	x	x	-	x	x	-	-	x
Calcitornella stephensi (Howchin)	-	-	-	-	x	x	-	-	x	-	-	-	-	-	-	-	-	-
Ammobaculites woolnoughi Crosp. & Parr	-	x	x	-	x	x	-	-	-	-	-	-	-	-	-	-	-	x
Digitina recurvata Crosp. & Parr	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Tetrataxis concava Ehr.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haplophragmoides sp.3	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
cf. Pelosina	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Trepeilopsis sp.	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Nodosinella sp.	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trochammina pulvillus Crosp. & Parr	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-
Trochammina cf. arenosa Cushman & Waters	-	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-
Trochamminoides anceps (Brady)	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Foraminifera	Mid. Bowen Series				Lower Bowen Series													
	a.	b.	c.	d.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.
Nodosaria serocoldensis Crespin	-	-	-	-	x	-	-	-	x	-	-	-	-	-	-	x	x	-
N. springsurensis Cresp.	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Dentalina grayi Cresp.	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Frondicularia parri Cresp.	-	-	-	-	x	x	x	x	-	-	-	-	-	-	-	-	-	-
Frondicularia woodwardi Howchin	-	x	-	-	x	x	x	x	x	x	-	-	x	x	-	x	-	-
Geinitzina triangularis Chapm. & Howchin	-	-	-	-	x	x	-	-	x	-	-	-	x	x	-	x	-	-

Localities referred to Middle Bowen Series.

a. Dry Creek, "Inglelara" property, Springsure.
b. Argus's Selection, Springsure.
c. Arcadia Bore from 1,800 feet down to 2,390 feet.
d. Hutton Creek Bore from 770-790 feet.

Localities referred to Lower Bowen Series.

A. N. bank, Cattle Creek, 14 miles S.E. of Springsure.
B. In Cattle Creek below Waterfall.
C. Watershed between Little Gorge and Cabbage Tree Creeks.
D. Watershed between Sandy and Dry Creeks, S. end of Serocold Structure.
E. Mr. Reid's Section through Mt. Hope, 20 miles S. of Springsure.
F. Staircase Gully just below Old Rolleston Road Crossing.
G. Staircase Gully.
H. 2.5 miles from Mantuan Downs Station, on Springsure Road.
I. Mantuan Downs Station.
J. 3 miles from Cracow on road to Theodore.
K. Quarry beside Banana-Biana road, 9.6 miles from Banana.
L. Ironbark or Little Gorge Creek, Springsure-Rolleston Road.
M. Staircase Creek at base of Mt. Sirius.
N. Aldebaran Creek, 4 miles N.E. of Mt. Catherine.

(c) Notes on the Assemblages. The outstanding assemblage of foraminifera which may be of zonal importance is that which contains Calcitornella stephensi, Nodosaria serocoldensis, Frondicularia parri, F. woodwardi and Geinitzina triangularis. This assemblage characterises the beds at the top of the Lower Bowen Series. As pointed out later in this paper, the majority of these species may constitute a distinct assemblage in the Lower Marine Series of New South Wales, and in the Callytharra limestone and Fossil Cliff beds in Western Australia which can be correlated with the Lower Marine Series of New South Wales, and the Lower Bowen Series of Queensland.

Of the above species, the only one which ranges up to the Middle Bowen Series is F. woodwardi. N. serocoldensis has only been described recently (1944). It is possible that this species may form a valuable addition to the Lower Bowen assemblage.

Most of the species listed from the Middle Bowen, range from the Lower Bowen to that Series. It will be necessary for further collections of sediments to be made from both Series before zoning of the Middle Bowen will be possible.

2. New South Wales.

(a) General. Geologists from Oil Search Limited and the Commonwealth Oil Refineries Limited made extensive collections of rocks in the Hunter River District in the hope that micro-faunal zones could be established. Material was also examined from the section at Victoria Pass, Mitchell Highway. Cores and cuttings from bores were also investigated. Samples from the Kulnura Bore, which is situated 15 miles northwest from Gosford, and which was drilled to the depth of 6,293 feet, were examined microscopically during the progress of drilling, and foraminifera were discovered at various depths, (Raggatt and Crespin, 1940). Foraminifera were also present in the Balmain Bore, Sydney, (Raggatt and Crespin, 1941) and in Bore J at Coorabin, 55 miles west of Albury (Crespin, 1943).

(b) Distribution Table. The following table summarises the information available concerning the occurrence and distribution of foraminifera in the Upper and Lower Marine Series of New South Wales. For convenience, letter designations are given to the localities which are listed below the table. The tabulation is based chiefly on the writer's examination of samples from the localities listed, but Chapman's and Howchin's results (1905) are also included. The localities from which their samples were obtained are indicated below.

Foraminifera	Upper Marine Series																					Lower Marine Series							
	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.	n.	o.	p.	q.	r.	s.	t.	u.	A.	B.	C.	D.	E.	F.	G.	H.
Ammodiscus millettianus Chap.	x	-	x	-	-	-	x	-	x	x	-	-	-	x	-	-	-	x	x	-	-	-	-	-	x	x	-	-	x
A.multicinctus Cresp.& Parr	x	-	-	x	-	-	x	-	x	x	x	x	x	-	x	-	-	x	x	-	-	-	-	-	-	-	-	-	x
A.ovalis Chapm.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
A.planoconvexus Chap.How.& Parr ..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Hyperamminoides acicula Parr	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	x	-	x	x	x
Calcitornella stephensi (How.) .	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	x	-	x	-
Tolypammina undulata Parr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-
T.vagans (Brady)	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-
Trepeilopsis sp. ..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Thurammina papillata Brady	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Reophax subasper Parr	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelospira hemisphaerica C.& H. .	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Ruditaxis cf. rhaetica Chap. ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Placopsilina tenuitesta C.& H..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Haplophragmoides neocomianus Chap..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
H. sp.	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammobaculites woolnoughi Cr.& P.	x	-	-	x	-	-	x	-	-	x	-	x	-	-	x	x	-	-	-	-	-	x	-	-	-	x	x	-	-
Ammobaculites sp. .	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Endothyra macella Brady	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
E.cf.bowmani Phil..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Globivalvulina bulloides (Brady).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Digitina recurvata Cres.& Parr...	x	-	-	x	-	-	x	-	x	x	x	-	-	-	-	-	-	x	x	-	-	-	-	-	x	x	x	-	-
Textularia eximia Eichw.	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	-	-	-	-	-	-	-
Spiroplectammina sp.	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trochammina cf. arenosa C. & W. ..	-	-	-	-	-	-	-	-	-	-	x	x	-	-	x	-	-	x	-	-	-	-	-	-	-	-	x	x	-

Foraminifera	Upper Marine Series																				Lower Marine Series							
	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.	n.	o.	p.	q.	r.	s.	t.	u.	A.	B.	C.	D.	E.	F.	G.	H.
T.pulvillus Crcs.& Parr.....	-	-	-	-	-	-	x	-	x	-	x	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-
Trochamminoides anceps (Brady) ...	x	-	-	-	-	x	-	-	x	x	x	x	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-
Nodosaria serocoldensis Cr.	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	-	-	-	x	-	-	-	-	-	-	-	x	-	x
N.irwinensis How. .	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
N. permiana (Spl.).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
N.?antiqua C.& H...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
N.pyramidis C.& H..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Dentalina bradyi Spandel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Lingulina davidi Chap.How.& Parr...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Frondicularia parri Cr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	x
F.woodwardi How. ..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	-	-	-	x	x	-	x	-
Geinitzina triangularis C. & H.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	x	-	x	-

Localities in the Hunter River District referred to the Upper Marine Series.

a. W.bank of railway cutting, W. of Minimbah.
b. Long Point, Hunter River near Singleton.
c. Box Tree Hill Cutting, Goorangoola Road, N. of Singleton.
d. McDougall's Hill, Singleton.
e. Padua Siding.
f. Mt. Thorley, Wardworth Road.
g. John Brown's Reservoir Section.
h. Branxton Railway Cutting, W. of Branxton.
i. Foster's Bridge Section.
j. Pothamma Siding.
k. Pelaw-Richmond Main Railway Section.
l. Saw Mill, Mulbring Creek.
m. Rix's Creek above Muree.
n. Rothsay to Black Creek.
o. Warkworth Stock Route, Loder Dome.
p. Bishop's Bridge to Sawyer Gully.
q. Wollong (Chapman and Howchin).

Other localities referred to the Upper Marine Series.

r. Foot of Victoria Pass, Mitchell Highway.
s. Kulnura Bore from 3,778 feet down to 4,490 feet.
t. Balmain Bore, Sydney, from 4,750 down to 4,760 feet.

Horizon Uncertain.

u. Bore J, Coorabin at 334 feet.

Localities in the Hunter River District referred to the Lower Marine Series.

A. Top of Farley beds, Farley Road, N.E. of railway station.
B. Railway cutting N. of Farley.
C. Half a mile S.E. of Jackson's Hill, Pokolbin.
D. Pokolbin (Chapman and Howchin).
E. Cranky Corner.
F. Harper's Hill.
G. Leconfield Section.

Other locality referred to the Lower Marine Series.

H. Kulnura Bore, 4667 feet down to 6,293 feet.

(c) Notes on the Assemblages. In New South Wales, the most distinctive assemblage of foraminifera is found in the beds at the top of the Lower Marine Series. It is similar to that recognised in the Lower Bowen Series of Queensland. The assemblage is dominated by Calcitornella stephensi, the associated species being Trepeilopsis sp., Nodosaria lorenensis, N.seroeldensis, Frondicularia parri, F.woodwardi and Geinitzina triangularis. The majority of these forms were described by Chapman and Howchin (1905) from Pokolbin. At the same time these workers described many other specimens from the limestone at Pokolbin, none of which, however, have been discovered elsewhere.

Two assemblages of foraminiferal species in the Upper Marine Series are recognised tentatively.

(i) The most characteristic assemblage of foraminifera in the rocks of the Hunter River District contains Hyperammoides reticula (abundant), Ammodiscus multicinctus, Ammobaculites woolnoughi, and Trochammina nulvillus. A.multicinctus is well distributed, but is not as common as H.reticula.

(ii) The second assemblage is found in the sediments at the foot of the Victoria Pass, Mitchell Highway, and is present in some of the beds in the Hunter River District. The species are Hyperammoides reticula, Ammodiscus multicinctus, Ammobaculites woolnoughi, Trochammina cf. arenosa, T.nulvillus, Textularia crinita and Digitina recurvata. A.multicinctus and H.reticula are less prominent.

The only species restricted to the Upper Marine Series in New South Wales is Trochammina nulvillus Crespin and Parr. This form is fairly well distributed and with further investigation may prove to be of zonal importance.

3. Tasmania.

Except for the foraminifera described by Howchin (1894) from the Piper River limestone near Karoola, there has been little investigation of the Permian rocks of Tasmania for micro-faunas, although the extent of the deposits is considerable. Howchin described Calcitornella stephensi from the Piper River limestone. He referred a milioline form to Spiroloculina ? planulata (Lam.), but from the figure this is probably a section through Hemicordius schlumbergeri (Howchin). His Nodosaria ? radicula (Linne) may be referable to Nodosaria permiana Spandel, recorded by Chapman and Howchin from a limestone at Pokolbin, New South Wales (1905). A recent examination of a thin section of the Piper River limestone has revealed the presence of Geinitzina triangularis. This limestone occurs at the top of the Lower Marine Series in Tasmania and the abundance of C.stephensi suggests that it is possibly the equivalent of that Series in New South Wales and of the Lower Bowen Series in Queensland.

4. Western Australia.

(a) General. The list of fossils hereunder is compiled from records of the Commonwealth Palaeontologist based on examination of samples submitted by various companies engaged in the search for oil and from records supplied by Mr. W. J. Parr. The species from the Wandagee beds described by Parr (1940-1941) are given as separate entries.

(b) Distribution Table. The following table summarises the information available concerning the occurrence and distribution of foraminifera in beds correlated with the Upper and Lower Marine Series of New South Wales. As indicated in the notes following the tabulation, the results of investigations by Parr (1940-41) and by Chapman and Parr (1937) are included, together with the writer's observations.

Foraminifera	Beds correlated with the Upper Marine Series, N.S.W.																Beds correlated with the Lower Marine Series, N.S.W.											
	a.	b.	c.	d.	e.	f.	g.	h.	i.	j.	k.	l.	m.	n.	o.	p.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.
Ammodiscus millettianus Chap.	-	-	-	-	X	-	-	X	-	X	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
A.multicinctus Cres.& Parr	-	-	-	X	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-
A.nitidus Parr	-	X	-	X	-	-	-	-	-	X	-	X	X	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-
A.wandagoensis Parr	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyperamminoides acicula Parr	X	X	X	X	-	-	X	X	-	X	-	X	X	X	X	-	-	-	-	-	-	-	X	X	X	X	X	X
H.coleyi Parr	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyperammina ? rudis Parr	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcitornella stephensi (How.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	X	X	X	X	-	X	-	X	X
Glomospira adherens Parr	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tolypammina undulata Parr	-	-	-	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trepeilopsis cf. grandis C.& W.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	X	X	X	-	-	X	X	X
Apertinella cf. grahamensis (Har.).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-
Psammosphaera pulsilla Parr	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thurammina papillata Brady	-	-	-	-	-	-	X	-	-	X	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crithionina teichorti Parr	-	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-
Reophax subasper Parr	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R.tricameratus P.	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemigordius schlumbergeri (How.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	X	-	-	-	X	X
Textrataxis concava Ehr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-
Haplophragmoides sp.1.	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H. sp.2.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
Endothyra media Waters	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Ammobaculites woolnoughi Cr. & P.	-	X	-	X	-	X	-	X	X	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Digitina recurvata Cr. & Parr	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Textularia eximia Eichw.	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Nodosinella sp.	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spiroplectammina sp.	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bigenerina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Trochammina subobtusa Parr	-	X	-	-	-	-	-	-	X	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Nodosaria irwinensis How.	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	-	-	-	-	-	X	-	X	X	X	-
N.serocoldensis Crespin	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
N. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-
Frondicularia parri Cresp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
F.woodwardi How.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	X	X	-
Geinitzina triangularis Ch.& H.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X	-	-	-	-	-	X	X	-	-
Neoschwagerina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
Verbeekina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-

Localities correlated with the Upper Marine Series of New South Wales.

I. Commonwealth Palaeontological Collection.

a. Junction of Vindabooka Creek and Gascoyne River.
b. Wandagee Station, ½ mile upstream from Garden Outcamp.
c. Wyndham River, 1 mile below Gap.
d. Gascoyne River, ½ mile below Hotel.
e. Gascoyne - Lyons Motor Road Crossing.
f. Hotel, Gascoyne Junction.
g. Left bank of Creek flowing into Gascoyne River at Loc. 9 (Waterford Loc.).
h. Right bank of Gascoyne River, 2 miles below Bidgemai Homestead.
i. 1 mile N.E. of Winnemia.
j. Minilya River, 3 mile upstream from Wandagee Homestead.

II. Localities given by Parr (1940-41).

k.(i) Nalbia Paddock about 110 chn.due E. of Trig.Stn., Wandagee Hill.
(ii) Coolkilyia Flat approx. 1 mile S. of Homestead-Garden road and 1 mile E. of Shed-Outcamp telephone line.

l.(i) S. of Minilya River.
(ii) Minilya Road, Coolkilyia Flat, E. limb of syncline N. of Wandagee Hill.
(iii) Burna Burna Paddock, Wandagee Station, on Wandagee-Mia Mia Road, about 3 miles in 231°5' from Burna Burna Hill.

m.(i) S.side of Minilya River, near Coolkilyia Pool, Wandagee Stn.
(ii) E. of Coolkilyia Paddock, 865 links W. of Teichert, Higgins and Utting's Station LII, traverse 20th May, 1939.
(iii) Extreme S.E. corner of Coolkilyia Paddock.

n. Gascoyne River at Jimba Jimba Homestead.

o. About 1 mile W. of Gundlego Well, Minilya River.

III. Localities given by Chapman and Parr (1937).

p.(i) 6 miles N.W. of North-West Hill, Kimberley.
(ii) S.W. corner of the North-east Structure at Bell's Ridge, Kimberley.

Localities correlated with the Lower Marine Series of New South Wales.

A. Fossil Cliff, Irwin River.
B. Pell's Crossing, Gascoyne River.
C. 2 miles N.E. of Lyons River Homestead.
D. 12 miles S. of Lyons River Homestead.
E. Minginoo Homestead, Gascoyne.
F. 5 miles N.E. of Dairy Creek Station.
G. 2 miles W. of Carey Downs turnoff, main Byro-Glenburg Road.
H. Grant Range.
I. Nerrima Bore, West Kimberley Area, from 39 down to 424 feet.
J. Bidgemai-Wyndham Gap.
K. Mouth of Salt Gully, Callytharra.
L. 4 to 8 miles N. of Arthur Valley, Gascoyne Area.

(c) Notes on the Assemblages. The assemblage dominated by Calcitornella stephensi is a feature of the Callytharra limestone of the North-West Division, of the Fossil Cliff beds, Irwin River and of the Nura Nura limestone in the Kimberley area. The associated species are Tremeilonsis cf. grandis, Nodosaria irwinensis, N.serocoldensis, Frondicularia parri, F.woodwardi, Geinitzina triangularis and Hemigordius schlumbergeri. The majority of these forms are present in many localities in the Gascoyne River area and in the Nerrima Bore in the West Kimberley area between the depths of 39 feet and 424 feet. This

assemblage is similar to that found in the Lower Marine Series in New South Wales and in the Lower Bowen Series in Queensland. Species restricted to this horizon in Western Australia include Tranciligmais cf. grandis, Hemicardium schlumbergeri, Frondicularia woodwardi, Tetrataxis conica and Geinitzina triangularis.

A study of the micro-faunal assemblages in the Permian deposits of Queensland, New South Wales and Western Australia suggests that the reference (unpublished reports by H. G. Raggatt and F. G. Forman) of the marine deposits met with in the Merrima Bore between 39 feet and 785 feet to the Nooncanbah Series may be incorrect. This Series is considered to be the equivalent of the Wandagee beds of the North-West Basin. The foraminiferal assemblage noted in samples from the Merrima Bore between the depths of 39 feet and 424 feet consists of Calcitornella stephensi, Anertinella cf. sphaerensis, Tetrataxis conica, Hodosaria irwinensis, Frondicularia parri, F.woodwardi and Geinitzina triangularis. Mega-fossils were recorded at 540 feet and 625 feet and there was no change in conditions of sedimentation until 810 feet. It is suggested that this portion of the section in the Merrima Bore should be correlated with the Nura Nura limestone of the West Kimberley area and not with the Nooncanbah. The reason for this suggestion will be appreciated by reference to the tabulations given above and to the preceding discussion. From 810 feet down to 4,271 feet, at which depth drilling was suspended, the bore was in non-fossiliferous beds and it is suggested that these belong to the Grant Series.

In the Western Australian strata, which can be correlated with the Upper Marine Series of New South Wales, there are two assemblages, (i) that described by Parr (1940-1941) from the Wandagee Beds and (ii) one similar to that found in the Upper Marine Series of New South Wales. The assemblage from the Wandagee beds contains many species of foraminifera new to the Australian Permian as well as some previously described forms as Ammodiscus multicinctus and Ammobaculites woolnoughi. The second assemblage includes Hyperamminoides solicula, Ammobaculites woolnoughi, Dicitina reservata and Textularia eximia.

One of the most important micro-faunal discoveries in the Permian rocks of Western Australia is that of the two genera of Fusulinids, Neoschwagerina and Verbeekina, (Chapman and Parr, 1937). These forms occur in the Kimberley area, in the topmost beds of the Upper Ferruginous Series (Wade, 1938), which is considered to be the equivalent of the highest beds in the Upper Marine Series of New South Wales.

5. Northern Territory.

Rocks of Permian age were described from the Port Keats Bore by Etheridge Jnr. (1907) who recorded and figured Calcitornella stephensi from samples obtained between the depths of 554 and 574 feet. The beds are correlated with those at the top of the Lower Marine Series in New South Wales and Tasmania, the Lower Bowen Series in Queensland and with those in Western Australia, which are considered as representing these Series in that State.

CONDITIONS DURING SEDIMENTATION OF THE PERMIAN ROCKS.

The foraminiferal assemblages indicated in the tabulations in Section 3, point to differences in climatic and bathymetric conditions under which the Permian deposits of Australia were laid down.

1. The assemblage, which is dominated by Calcitornella stephensi and which is characteristic of the Lower Marine Series and its correlates in all States, suggests the existence of shallow, warm conditions at that time.

2. The foraminiferal assemblages in the Upper Marine Series contain many genera which are living in the seas at the present day and an ecological study of these forms gives a fairly reliable indication of climatic and bathymetric conditions during the deposition of the beds

comprising the Upper Marine Series. All forms suggest lower temperatures and slightly deeper water conditions than experienced during the deposition of the upper part of the Lower Marine Series.

3. The presence of fusulinids in sediments high in the Permian sequence in Western Australia, suggests the return in that State at least, of warmer and shallower water conditions towards the close of that period.

NOTES ON SOME OF THE FORAMINIFERAL SPECIES.

It is not intended in this paper to describe any species of Permian foraminifera from Australian deposits, but short notes are given on the more distinctive forms already known. The majority of the foraminifera belong to genera whose tests are arenaceous. Amongst these the commonest genera are: Ammodiscus, Hyperamminoides, Textularia, Digitina, Ammobaculites and Trochammina. The most important hyaline genera are Nodosaria, Frondicularia and Geinitzina.

One of the most important species, which is widespread in distribution in the Permian rocks of Australia, but which, on present evidence is restricted in vertical range, is Calcitornella stephensi, Howchin. This calcareous and adherent species was described by Howchin in 1894 from a limestone from the Piper River near Karoola, Tasmania. It is abundant in the Callytharra limestone and Fossil Cliff beds, Western Australia. It is common at Pokolbin, New South Wales, and is found in sediments in the Springsure area in Queensland. It is recorded from the Port Keats Bore, Northern Territory.

Nodosaria irwinensis was described by Howchin (1895) from Fossil Cliff, Irwin River, Western Australia. It is not a common form and the only record in the Eastern States is from the Lower Marine Series at Pokolbin, New South Wales.

Geinitzina triangularis Chapman and Howchin is usually found associated with Calcitornella stephensi. It was originally described from the Pokolbin limestone. Although it is found in Western Australia and Queensland as well as in New South Wales, it is a comparatively rare species. It is recorded from the Lower Bowen Series in the Springsure area in Queensland, from localities in the Lower Marine Series in the Hunter River District in New South Wales, from Fossil Cliff and from the Cascoyne area in Western Australia.

Frondicularia woodwardi described by Howchin (1895) from Fossil Cliff, Irwin River, Western Australia, is widely distributed in the Permian rocks of Australia. In New South Wales its vertical range is restricted to the basal portion of the Upper Marine Series and the top of the Lower Marine Series. In the Springsure area, Queensland, there is one record of F.woodwardi in the Middle Bowen Series, but large tests are common in some of the deposits referred to the Lower Bowen. In Western Australia, it is restricted to the horizon represented by the Fossil Cliff beds and the Callytharra limestone.

Frondicularia parri was recently (1944) described by the writer from the Kulnura Bore in New South Wales from the depth of 4,203 feet in sediments referable to the Upper Marine Series (Raggatt and Crespin, 1940). The only other occurrences of this species in New South Wales are also from the Kulnura Bore between the depths of 4,020 feet and 4,268 feet. F.parri is recorded from sediments in the Lower Bowen Series in Queensland. It is present in the Nerrima Bore, West Kimberley area, Western Australia between the depths of 39 feet and 272 feet, where it is associated with a foraminiferal assemblage similar to that of the Callytharra limestone.

Species with a more extensive vertical range are more numerous than those already noted and belong chiefly to arenaceous genera.

The most widely distributed foraminiferal species in the Permian rocks of Australia is Hyperamminoides aciculus described by Parr (1940) from the Wandagee beds near Coolkilya Pool,

Wandagee Station, Western Australia. H.acicula is fairly common in Western Australia in those beds which can be correlated with the Upper Marine Series of New South Wales, but is rare in the lower horizon represented by the Callytharra limestone and the Fossil Cliff beds. This elongate, tapering foraminifer is very common in both the Upper and Lower Marine Series in the Hunter River District, New South Wales. It is also well represented in the Middle and Lower Bowen Series in the Springsure area, Queensland. Parr records specimens of H.acicula up to 20 mm. in length, but the majority of specimens are usually fragmentary. In some of the bore samples and in many of the rocks from the Hunter River District, this species is the only foraminifer present.

Ammodiscus multicinctus described by Crespin and Parr (1940) from beds in the Upper Marine Series in the Hunter River District, is a common species in that Series in New South Wales. The only record of its occurrence in the Lower Marine Series is in the Kulnura Bore at depths below 4,667 feet. The species is found in both the Middle and Lower Bowen Series in the Springsure area, and in Western Australia in beds which are referable to both the Upper and Lower Marine Series of New South Wales.

A widely distributed form is Ammobaculites woolnoughi described by Crespin and Parr (1940) from beds in the Upper Marine Series in the Hunter River District. This species is most abundant in the Upper Marine Series, but it is recorded from two localities belonging to the Lower Marine Series. In Queensland, it is present in both the Middle and Lower Bowen Series, but in Western Australia, it is known only from the beds which can be correlated with the Upper Marine Series of New South Wales.

NOTES ON CORRELATION.

Basing his conclusions partly on evidence derived from the mega-fossils and partly on conditions of sedimentation, Teichert (1941) "proposed to correlate in a general way all Western Australian Series up to and including the Fossil Cliff, Callytharra and Nura Nura Series with the Lower Marine Series of New South Wales..... the Irwin River "Upper Marine", the Upper Byro, Cundlego, Wandagee, Nooncanbah, and Upper Perruginous Series with the Upper Marine.....". It is believed that this scheme of correlation finds general acceptance in Australia. The study of the micro-fossils from these deposits tends to support this correlation, which can be carried still further to include Queensland, Tasmania and Northern Territory. (A drafting error in Teichert's Correlation Table on p.399 may be noted. In this table it is not made clear that the Farley Stage is part of the Lower Marine Series).

The distribution of the foraminifera in the Permian of Australia suggests the following correlations:

1. The assemblage dominated by Calcitornella stephensi:

   (a) The Lower Marine Series of New South Wales as developed in the Hunter River District.

   (b) The Lower Bowen Series of Queensland as developed in the Springsure area.

   (c) The Lower Marine Series of Tasmania as represented by the Piper River limestone.

   (d) Callytharra limestone, Fossil Cliff beds and Nura Nura limestone of Western Australia.

   (e) The Port Keats Bore section, Northern Territory at 554-574 feet.

2. The assemblage consisting of Ammodiscus multicinctus, Hyperamminoides acicula, Ammobaculites woolnoughi, Trochammina nuvilliae, and in certain deposits, Textularia eximia and Digitina recurvata:

(a) The Upper Marine Series of New South Wales as developed in the Hunter River District; Victoria Pass Section, Mitchell Highway.

(b) The Middle Bowen Series of Queensland as developed in the Springsure area.

(c) Certain deposits in the Gascoyne River area including the Wandagee Beds in Western Australia.

The above considerations, based on the foraminifera, suggest that beds equivalent in age to the Lower Marine Series and Upper Marine Series of New South Wales, occur also in Queensland and Western Australia, and that deposits referable to the Lower Marine Series are present in Tasmania and in a bore in the Northern Territory. It is possible that when further research has been carried out on the Permian rocks of Tasmania, foraminifera characteristic of the Upper Marine Series of New South Wales will be discovered.

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